Essays on International Trade and International Political Economy

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Abstract

Essays on International Trade and Political Economy

Thomas Zylkin

My graduate research has been organized around two main themes: (i) the causes and consequences of trade integration and (ii) the strategic nature of armed conflict. The expansion of international trade over the past sixty years has played a major role in determining the fates of nations, both for better and for worse, and likewise has the potential to shape our futures in ways we need to be able to anticipate. Similarly, the death, destruction, and diversion of productive resources associated with violent conflict continue to present a critical obstacle to shared prosperity. The papers I am presenting as the chapters of my dissertation are representative of the contributions I am interested in making in these important research areas.

My research on trade integration spans both the micro-level of what forms trade integration may take as well as higher level concerns about how freer trade will affect both the world economy as well as the individual economies within it. Two chapters of my dissertation, “Beyond Tariffs: Quantifying Heterogeneity in the Effects of Free Trade Agreements” and “Finding the Influence of Communication on Trade” are devoted to this subject. In “Beyond Tariffs”, for example, I show, using NAFTA as an empirical case study, that the effects of free trade agreements on individual nations may not be what we might expect to observe ex ante based on tariffs. Relying solely on tariffs to project NAFTA’s effects not only greatly underestimates the overall welfare increases for all three NAFTA countries—Mexico’s in particular—but also overstates the positive effects of NAFTA on U.S. producer prices. It follows that “heterogeneity” in the effects of free trade agreements, both within and across agreements, may not be well-understood.

In “Finding the Influence of Communication”, I investigate whether the sharing of a common language promotes trade in a way similar to trade policy and, if so, what the consequences of increased language learning will be for global trade. Most notably, I find the effect of communication in native languages on trade tends to be underestimated in the absence of controls for communication in non-native languages. Surprisingly, while
I find strong evidence for the causal impact of foreign language acquisition on manufacturing trade, I do not find similarly strong evidence for services trade. I also find that, unsurprisingly, adding to the world’s population of English speakers has by far the largest impact on trade of any major world language. Interestingly, however, when I remove all non-language barriers to trade, I find the forces of geography and history may have greatly impeded the relative appeal of Chinese as a competing global language.

The third chapter of my dissertation, “The Problem of Peace: A Story of Corruption, Destruction, and Rebellion”, joint with Constantinos Syropoulos, deals with a different kind of question: what are the economic incentives that drive the emergence of destructive conflicts, and of intra-state conflicts (“civil conflicts”) in particular? Specifically, we investigate how the central presence of state (fiscal) institutions in civil conflicts generates unique explanations for the emergence of conflict itself. International trade plays an important role in this chapter as well, but mainly as a backdrop for illustrating the unique trade-offs between “peace” and “welfare” that may arise in this context. It is possible for changes in international prices to move in favor of promoting settlements, but such settlements can be associated with (socially wasteful) increases in arming and/or taxation. We also explore, among other things, how limiting the government’s fiscal capacity may tilt the balance towards peaceful settlement.
Part 1

Beyond Tariffs: Quantifying Heterogeneity in the Effects of Free Trade Agreements

1.1 Introduction

We do not really understand the mechanisms by which free trade agreements (FTAs) impact trade barriers between member nations. How much will the proposed Trans-Atlantic Trade and Investment Partnership (TTIP) between the U.S. and E.U. increase trade relative to other FTAs? How will the consequences be different for individuals living in Bulgaria as opposed to those living in the U.K. or in the U.S.? Despite the trade literature’s longstanding, consistent interest in the general equilibrium welfare effects of trade integration,\(^1\) the answers to these questions remain elusive. There is no consistent way of characterizing how successful other FTAs with similar provisions to TTIP have been at promoting trade, let alone how a given FTA might affect trade barriers differently for different members.

This chapter works towards addressing these issues by offering a tractable methodology by which general “heterogeneity” in the effects of FTAs, both within and across agreements, can be identified and analyzed. Using a structural estimation of changes in trade costs over time, I am able to infer directly from the trade data, *ex post*, what effects a particular FTA has had on trade barriers for each of its member countries. Similar *ex post* approaches, starting with seminal empirical work by Baier & Bergstrand (2007), have illustrated many new facts about FTAs in recent years, with an increasing focus on identifying sources of heterogeneity. These contributions have included findings on how average FTA effects differ across industries (Anderson & Yotov, 2012), how the average effect differs based on the type of agreement (Baier, Bergstrand, & Feng, 2014), and how FTAs with

different provisions may affect trade differently (Kohl, Brakman, & Garretsen, 2013).

This literature has not yet considered the substantial directional heterogeneity that may exist within the very same agreement, however—i.e. cases where one member country receives more access to another country’s market than it grants in return. Using NAFTA as my illustrating example,\(^2\) I show that this latter source of heterogeneity in particular may not be well understood. Even within a given FTA, there can exist significant asymmetries in implied trade barrier reductions which have not been studied and have important implications for the gains from trade.

Specifically, I use the case of NAFTA to ask two broad questions about the implications of allowing for asymmetries in FTA effects. First, how much might directional heterogeneity in the effects of free trade agreements differ from what we might expect to observe? It turns out that, in the specific example of NAFTA, the answer is “a lot”. The idea that a free trade agreement may have different effect on trade barriers for different countries is not necessarily surprising; we know offhand that some countries can often have very different trade barriers \textit{ex ante} and thus we would expect them to be affected differently by an agreement. The typical perspective in the literature for analyzing the effects of individual agreements, and the effects of NAFTA in particular, has been to assume these differences can be summarized by differences in the agreed-upon \textit{ex ante} tariff reductions.\(^3\) I show, however, that the \textit{ex post} realization of effects associated with NAFTA differs substantially from expectations based on tariffs; I also observe some suggestive evidence from the broader data on FTAs that a plausible, under-appreciated source of asymmetries within NAFTA may be the difference in the level of development between the U.S. and Mexico.

Second, I also wish to know: how important are these asymmetries? Or, more specifically, what insights into the gains from trade integration are we missing out on by not incorporating them? Using a series of simple simulation experiments, I show that prevailing approaches to identifying the welfare benefits of FTAs (and the welfare benefits of NAFTA in particular) would tend to mischaracterize NAFTA’s benefits in large, important ways.


\(^3\)Shikher, 2012\(^a\) is an important exception, as noted below.
For my empirical approach, I estimate FTA effects using a “structural gravity” model, which in plain terms is a very general structural trade model which accounts how changes in trade costs affect supply and demand conditions in every industry in every country. The key for my purposes is that structural gravity provides a clear logic for identifying the role of trade barriers in determining trade between countries, which generalizes across a very wide range of trade models. This logic is as follows: suppose that country A trades with two other destinations, B and C, that are similar in every respect—same distance from country A, same size economy, etc. If A is observed to trade relatively more with B than with C, the logic goes, it must be the case that trade is more costly between A and C than between A and B. Time-variation in relative trade flows between countries can then be used to identify how an FTA affects trade costs. In this context, my innovation is that I allow the effect of an FTA to vary both at the level of the individual agreement (such that NAFTA affects trade differently from other FTAs) and at the level of the direction of trade (such that NAFTA does not, for example, affect the U.S. imports from Mexico the same way it does U.S. exports to Mexico).

My empirical findings for NAFTA confirm the presence of substantial heterogeneity in FTA effects, both between NAFTA and other FTAs and within NAFTA itself. For example, I find strong evidence that NAFTA has promoted trade significantly more than other FTAs have. Furthermore, I establish that NAFTA has had strongly asymmetric effects on trade barriers, both for aggregate trade and within individual industries, and I cleanly distinguish these observed asymmetries from notions of comparative advantage or any other tendency towards trade not directly related to trade costs. To name two examples: Mexico’s Metals producers have received substantially more access to Canadian and U.S. import markets than U.S. and Canadian Metals producers have received in return; whereas

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4“Gravity” is a general empirical model for estimating trade frictions that is ubiquitous in both the empirical trade literature and in current general equilibrium analyses of “gains from trade”. Head & Mayer (2014) provide a comprehensive background.

5Kohl (2014) has previously considered heterogeneity in FTA effects at the level of the individual agreement. I introduce some small innovation relative to Kohl (2014) on this point because I allow for general differences between NAFTA and other FTAs to differ across industries.

6Cipollina & Salvatici (2010) and Kohl (2014) each document similar findings for NAFTA versus other FTAs.

7In the estimation, these considerations are controlled for explicitly through the use of time-varying exporter- and importer- fixed effects.
in the Food sector, the opposite has occurred. Lastly, I document that these asymmetries differ significantly from what would have been expected to happen based on observed tariff reductions.

In addition, evidence from the broader universe of FTAs strongly suggests that NAFTA is not a unique outlier in this context. Contrary to expectations, FTA pairings between highly developed and less developed economies (such as the U.S. and Mexico in the case of NAFTA) generally favor the exports of the less developed partner, despite the fact that less developed countries tend to have higher initial tariffs. It follows that so-called “non-tariff barriers” have played a large, under-appreciated role in determining how FTAs shape the pattern of global trade (and how NAFTA specifically has shaped North American trade).

This last set of findings is particularly notable in light of current trade debates. Other work that has tried to evaluate each country’s benefits from NAFTA has tended to place too much emphasis on pre-NAFTA tariff differences between the U.S. and Mexico. Whereas projections based on tariffs alone would have suggested that U.S. producers should have gained much more access to Mexican import markets than they received in return, the actual changes in trade frictions I identify tell a different story. Overall, NAFTA coincided with sizable 63.1% decrease in barriers to U.S. import markets for Mexico’s exporters, compared with a 45.9% decrease in barriers against U.S. products headed in the other direction. This under-appreciated growth in imports from Mexico may be contributing to current skepticism towards free trade deals in the U.S. “In all the time I’ve been in Congress, I’ve never seen a trade bill that benefits the American producer or the American worker,” U.S. Congresswoman Louise Slaughter (D-NY) recently declared. “People are sick and tired of the one way trade deal.”

My results do not support these complaints of “one way trade” per se, but they do strongly suggest that the realization of NAFTA has differed substantially from the prevailing narratives available at the time.

For my welfare analysis, I adhere to a highly general modeling perspective. I assume a simple multi-sector endowment economy setting, such that all welfare effects occur strictly through first-order effects on prices for both buyers and sellers. These first-order price effects I obtain in turn have direct implications for additional welfare channels in many more

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elaborate trade models that share the same essential structure.\footnote{Table 1 in Head & Mayer (2014) provides a (non-exhaustive) overview of these “more elaborate” models. These frameworks include allowances for monopolistic competition and increasing returns (Krugman, 1980; Wei, 1996), endogenous firm-level export entry (Melitz, 2003; Helpman, Melitz, & Rubinstein, 2008), trade in intermediates (Eaton & Kortum, 2002; Caliendo & Parro, 2015), and variable firm mark-ups (Melitz & Ottaviano, 2008; Arkolakis, Costinot, Donaldson, & Rodríguez-Clare, 2012; Behrens, Mion, Murata, & Südekum, 2014). Costinot & Rodríguez-Clare (2014) demonstrate how many of these elements can be combined within a single framework.} The endowment economy setting reveals the following: i) implied welfare gains for all three NAFTA members are 50% to 100% as large as would be implied by an average FTA effect and three times as large as would be found using tariff reductions; ii) the size of Mexico’s implied gains from NAFTA in particular (3.63% vs. 12.32%)\footnote{As is often discussed in the trade literature (see Arkolakis, Costinot, & Rodríguez-Clare, 2012), the magnitudes obtained for “gains from trade” are highly sensitive to the assumptions used for the “trade elasticity” (i.e. the sensitivity of trade to changes in trade costs). I use values from Broda, Greenfield, & Weinstein (2006) for these elasticities. Using other elasticity values would affect absolute magnitudes of welfare gains but would not significantly affect relative magnitudes across the different ways of measuring NAFTA’s effects. I stand on the latter as my main result.} are underestimated using tariffs; iii) tariff changes tend to obscure the nature of the U.S.’s gains from NAFTA: the U.S. has benefited mostly from an increased ability to buy goods from Canada and Mexico (i.e. lower buyer prices), not from being better able to sell its own goods to the other two markets (i.e. higher producer prices).

Because NAFTA has long remained controversial in North American politics, it has motivated a substantial literature dedicated to analyzing its effects on trade, welfare, and other outcome variables. The following section will touch specifically on how this chapter fits within and informs this literature. In subsequent sections, I present the empirical analysis, offer some discussion of how to explain the patterns of asymmetry I observe in NAFTA’s effects, and demonstrate implications for welfare analysis. The last section adds concluding remarks.

1.2 Looking Back at NAFTA and Looking Ahead to Future FTAs

Due to my focus on NAFTA in particular, my findings resonate with the recent literature that has tried to re-evaluate the policy impact of NAFTA using progressively more updated tools for analyzing gains from trade. Caliendo & Parro (2015) for example simulate the effects of NAFTA in a calibrated model with cross-sectoral input linkages that explains
a significant portion of the aggregate changes in country-level exports and imports that occurred post-NAFTA. Their work builds on the analyses performed by Anderson & van Wincoop (2001), Romalis (2007), Shikher (2012a), and others to try to characterize NAFTA’s imprint on each member’s welfare. These papers generally do not look at how bilateral frictions between members may have been affected along other dimensions besides tariffs.11

One feature of the trade data that cannot easily be explained based on tariffs alone is how the U.S.’s trade balance with respect to Mexico changed during the mid-1990s. Agama & McDaniel (2002) document this curiosity in their overview of the data: despite the presence of already-existing U.S. tariff preferences on imports from Mexico (on the order of about 3% pre-NAFTA), the large growth in U.S.-Mexico trade in the mid-90s and early-2000s tended to favor imports from Mexico to the U.S. rather than U.S. exports to Mexico (though both increased substantially). The surprisingly large increase in U.S. imports from Mexico in particular invites consideration of how NAFTA may have affected trade barriers beyond tariffs.12

Nevertheless, there are valid reasons why simulations of FTA effects have continued to limit their attention to tariffs. Tariff changes associated with FTAs are known *ex ante* and easily observable *ex post*. Pure econometric estimates of changes in trade cannot necessarily disentangle the direct effects of an FTA from other concurrent factors that may have affected trade barriers. In the case of NAFTA, Krueger (1999) and Agama & McDaniel (2002) each cite Mexico’s peso devaluation in the mid-1990s as an important difficulty in identifying NAFTA’s effects *ex post*. Notably, Krueger (1999) provides a useful reasoning by which these two competing narratives can be evaluated. In the discussion following my results, I describe how my econometric design incorporates this reasoning and discuss how and why I reach a different conclusion than that of Krueger (1999).

Naturally, other competing explanations also need to be discussed in this context, some

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11 Shikher (2012a) is an important exception in that he infers tariff equivalents of non-tariff barriers using the Nicita & Olarreaga (2007) “Trade, Production, and Protection” database. However, his estimates still show much higher initial liberalization for Mexican imports than for Mexican exports, which is contrary to the results I obtain for NAFTA’s trade impact *ex post*.

12 Agama & McDaniel (2002) offer as a possible explanation for these findings the idea that import markets for the U.S. and Mexico may have featured very different elasticities of demand.
of which can be incorporated in the structural model and some of which cannot. In addition to the discussion of currency volatility, I also discuss how the model accounts for the effects of comparative advantage across industries as well as for trade in intermediates along global supply chains. The extent that the actual behavior of individual firms within the supply chain may differ from the assumed behavior implied by this class of models is a possible concern that needs to be highlighted, however.

The choice to focus on NAFTA reflects the usefulness of NAFTA as a representative example for illustrating issues that are important for characterizing the impact of modern FTAs. Since NAFTA, FTAs have been becoming increasingly expansive with regards to hard-to-quantify non-tariff provisions. An appraisal of “NAFTA at 20” earlier this year by the U.S. Congressional Research Service (Villareal & Fergusson, 2014) reserves special praise for the lasting influence NAFTA has left on a “new generation of trade agreements” as a model for how to incorporate, among other things, guarantees on freedom of investment, intellectual property rights, and investment property rights, and increased cooperation on the setting of regulatory standards and customs procedures.

In these terms, the major planned FTAs of the near future, TTIP and TPP, will likely mark even bolder landmarks. CEPII’s recent study on TTIP (Fontagné, Gourdon, & Jean, 2013), for example, notes that average tariffs between the U.S. and E.U. are currently only around 2%-3% to start with; clearly both entities envision considerable gains from reducing “unnecessary regulatory differences”, “restrictive licensing”, barriers to trade in services (especially financial services), and other non-tariff barriers to trade.13 Anticipating what these stated goals may mean for trade requires more focused tools for analyzing trade integration: Egger, Francois, Manchin, & Nelson (2014) and Felbermayr, Heid, Larch, & Yalcin (2014) have each recently made headway in this direction by explicitly considering how the effects of future FTAs may reflect those of similar agreements signed in the past. What my findings suggest in relation to this emerging literature is that there also exists important, under-appreciated variation in how the same agreement may affect different countries differently.14

13See USTR (2014) for a full list of these and other stated objectives for the U.S. with respect to TTIP.
14Ongoing work in the same vein as this chapter continues this suggested line of research by considering how FTA effects may vary depending on the characteristics of the countries that sign them.
1.3 Estimation Approach

1.3.1 Methodology

The “structural gravity” equation, as generalized by Head & Mayer (2014), naturally motivates a panel fixed effects estimation strategy for identifying the impact of free trade agreements on trade. Fixed effects gravity models of this type have been widely used in the literature for estimating the effects of FTAs. The general framework assumes an $R$ country world with $K$ sectors and costly trade in differentiated goods within each sector. Exports from $i$ to $j$ in sector $k$ ($X^k_{ij}$) then can be expressed via the following gravity equation, which will explicitly motivate the estimation that follows:

$$X^k_{ij} = \frac{Y_i^k}{\Omega_i^k} \cdot \frac{E_j^k}{\Phi_j^k} \cdot \phi_{ij}^k.$$  

($E_j^k$ and $Y_i^k$ here are, respectively, $j$’s expenditure on industry $k$ and the value of $i$’s production in $k$. The longstanding logic of “gravity”, which dates back to Tinbergen (1962), is that trade is increasing in the size of the two countries (i.e. $E$ and $Y$) and decreasing in the trade costs between them, which here would be reflected in the bilateral parameter $\phi_{ij}^k$. To complete the analogy to Newtonian gravity, $\phi_{ij}^k$ can be said to vary inversely with how far apart $i$ and $j$ are geographically.

Also playing an important role in (1) however are $\Phi_j^k$ and $\Omega_i^k$, which themselves have the following structural interpretations:

$$\Phi_j^k = \sum_i \frac{\phi_{ij}^k}{\Omega_i^k} \cdot Y_i^k$$

(2)

$$\Omega_i^k = \sum_j \frac{\phi_{ij}^k}{\Phi_j^k} \cdot E_j^k.$$  

(3)

Intuitively, these so-called “multilateral resistance” terms index the total incidence of trade costs on an individual country’s ability to access world markets, both on the buyer side (in the case of $\Phi_j^k$) and on the seller side (in the case of $\Omega_i^k$). The more easily a producer in $i$ is able to sell to world markets in general, the less inclined he will be to sell to any one
particular destination \(j\) for any given level of bilateral trade costs \(\phi_{ij}^k\). A similar logic applies for buyers: better access to sellers around the world all else equal makes them less likely to buy from any one particular exporter \(i\). These structural terms were originally introduced in Anderson & van Wincoop (2003), but are common to a surprisingly wide class of models that fall under the heading “structural gravity” and have different structural interpretations in each case.\(^{15}\)

The advantage of presenting the trade model in this way is that it is very general; thus it will allow me to make claims about both identification and welfare implications that will generalize across many different theoretical settings. In particular, I will use a multi-sector “Armington” model (with nationally differentiated products) in order to simulate general equilibrium outcomes. However, the system defined by (1)-(3) can also be used to describe other gravity models founded on (for instance) within-industry comparative advantage (Eaton & Kortum, 2002), monopolistic competition (Krugman; Wei), or variable firm productivity and endogenous export entry (Melitz, 2003).\(^{16}\)

For empirical purposes, my main parameter of interest is \(\phi_{ij}^k\), the parameter reflecting how trade costs directly affect trade between \(i\) and \(j\). Without loss of generality \(\phi_{ij}^k \in (0, 1)\) can be thought of as the amount of “market access” that sellers in \(i\) enjoy when attempting to sell their variety of good \(k\) to import market \(j\): when trade integration lowers trade barriers, \(\phi_{ij}^k\) increases and trade in turn increases proportionately with the change in market access, all else equal. The empirical question I am looking to examine is how bilateral market access depends on the presence of a free trade agreement between \(i\) and \(j\), and how these market access effects may vary within the same agreement. I will refer continually in this chapter to \(\% \Delta \phi_{ij}^k - 1\) as the “amount by which market access increased” in industry \(k\) as the result of an agreement. Without loss of generality, I can also call \(1 - \% \Delta \left(1 / \phi_{ij}^k\right)\) as the “amount by which barriers to market access fell”.

An important point about estimating values for \(\phi_{ij}^k\) in this setting is that the combined

\(^{15}\)The expression for \(\Omega_{ij}^k\), (3), is usually not shown in the presentation of these other models. Nonetheless, Head and Mayer (2014) show it is a general result that follows from an accounting identify for any model where (1) and (3) already hold.

\(^{16}\)The derivation of “gravity” from the Melitz (2003) theoretical model was first shown in Arkolakis, Demidova, Klenow, & Rodríguez-Clare (2008). Chaney (2008) and Helpman, Melitz, & Rubinstein (2008) have each offered alternative gravity frameworks drawing on key elements of Melitz’s theory.
system (1)-(3) is “modular” (or “separable”). That is, even though the values for production and expenditure for each sector $Y^k_i$ and $E^k_j$ depend on what occurs across all sectors in general equilibrium, if I simply take these terms as given, it follows from (1)-(3) that I can treat the $\phi^k_{ij}$’s in each individual industry $k$ as an independent set of parameters to be estimated separately, with no cross-equation restrictions across industries. That is not to say that I am in any way restricting values for $Y$ and $E$ to be fixed, only that the modularity of these structural gravity models allows for production and budgeting decisions to be made at an “upper level” of the model, such that decisions over where and how to source varieties within an industry can take those values as given. I explain how the use of time-varying exporter- and importer- fixed effects allows me to focus on this “lower level” of the purchasing problem in my development of the econometric specification below.

Let $\phi^k_{ij,t}$ indicate the value of $\phi^k_{ij}$ at time $t$. Following Baier & Bergstrand (2007), I assume $\phi^k_{ij,t}$ can be specified in the following manner for each sector:

$$
\phi^k_{ij,t} = e^{\delta_k Z_{ij} + \beta_k FTA_{ij,t}},
$$

(4)

where $FTA_{ij,t}$ is an indicator variable (or set of indicator variables) reflecting whether $i$ and $j$ have an FTA at time $t$ and $Z_{ij}$ is a set of controls for inherent bilateral characteristics assumed to have some effect on trade (e.g. the distance between $i$ and $j$, whether they share a common language, whether they have a prior colonial relationship, presence of a common border, etc.). Together, (1) and (4) specify my baseline estimating equation for trade in each industry $k$:

$$
X^k_{ij,t} = \exp \left( \zeta^k_{i,t} + \psi^k_{j,t} + \eta^k_{ij} + \beta^k FTA_{ij,t} \right) + \epsilon^k_{ij,t}.
$$

(5)

$\zeta^k_{i,t}$ and $\psi^k_{j,t}$ are exporter and importer fixed effects that control for all market-level variables that affect trade in industry $k$ through channels other than through the amount of direct bilateral market access. Note that these terms need to be time-varying: as noted, the $\Phi^k_j$ and $\Omega^k_i$ terms in the structural model depend endogenously on the system of $\phi^k_{ij}$ terms in equilibrium via (2)-(3). Furthermore, since these terms reflect buyer and seller
prices, they in turn will have implications for $E^k_j$ and $Y^k_i$ as well.\textsuperscript{17} It is important then that changes in $\phi^k_{ij}$ are identified not just by changes in bilateral trade flows, but rather by changes in bilateral trade flows relative to changes in each country’s unilateral tendency towards exporting and importing goods of type $k$. When a country shifts resources towards production of good $k$ for example, that shift should generate increased exports of $k$ to all destinations, not to any one destination in particular.

The (symmetric) pair-specific fixed effect term $\eta^k_{ij}$ is meant to capture all time-invariant bilateral relationships between $i$ and $j$ that influence trade (effectively absorbing $\delta^k Z^k_{ij}$ in (4)).\textsuperscript{18} In panel estimation terms, due to the presence of $\eta^k_{ij}$, $\beta^k$ essentially serves as a “within” fixed effects estimator for the effect of an FTA on exports from $i$ to $j$ for goods of type $k$.\textsuperscript{19} As Baier & Bergstrand (2007) demonstrate—adapting the panel identification methods discussed in Wooldridge (2002)—the use of pair-specific fixed effects in a panel gravity setting is a simple-to-apply procedure for identifying the average treatment effect of FTAs and this approach has become standard in the literature. In accordance with Santos Silva & Tenreyro’s (2006) recommendations for minimizing bias in gravity estimations, I will use the Poisson Pseudo-Maximum Likelihood (PPML) estimator to estimate (5).\textsuperscript{20}

Breaking with the Baier and Bergstrand approach, however, for my main results I will allow $FTA_{ij,t}$ to vary by agreement and, subsequently, by the direction of trade flows. Specifically, I focus on NAFTA as a suitable example to show that the effect of an FTA be conditional on the direction of trade. To do this, I split the single $FTA_{ij,t}$ term in (5) into a set of variables, as shown below:

$$X^k_{ij,t} = \exp \left( \xi^k_{ij,t} + \psi^k_{ij,t} + \eta^k_{ij} + \beta^{0,k} FTA^0_{ij,t} + \beta^{N,k} NAFTA_{ij,t} \right) + \epsilon^k_{ij,t}.$$  \textsuperscript{(6)}

\textsuperscript{17}I characterize these linkages in more detail when I discuss welfare implications later in the paper.
\textsuperscript{18}Baier & Bergstrand specifically motivate $\eta^k_{ij}$ as controlling for the propensity of $i$ and $j$ to “select endogenously” into an FTA. The key point however is that cross-sectional estimates of FTA effects are biased because $i$ and $j$’s propensity to form an FTA may be correlated with unobservable aspects of the trade costs between them. $\eta^k_{ij}$ resolves the endogeneity problem by explicitly controlling for these unobservable trade costs.
\textsuperscript{19}By construction, these pair fixed effects are symmetric. I relax this restriction later when I introduce direction-specific effects.
\textsuperscript{20}A more natural approach would seemingly be to estimate (5) via OLS. Santos Silva & Tenreyro however show that log-linearizing (5) introduces an important source of bias due to heteroskedasticity in $e_{ij}$ and measurement error in trade flows, which PPML estimation helps to minimize. Furthermore, as shown in Fally (2014), the PPML estimator is especially suitable for “structural” gravity estimation in particular, since using PPML to estimate (5) implicitly imposes that the structural equations (2) and (3) hold with equality.
Here, the superscript “0” on $FTA_{ij,t}^0$ is meant to indicate that $\beta_{0,k}$ is now measuring the average effect of all FTAs aside from NAFTA. $\beta_{N,k}$ is then measuring all FTA effects that are associated specifically with NAFTA. I can then split the $NAFTA_{ij,t}$ variable even further in order to isolate directional effects. For example, I will allow $NAFTA_{CANMEX,t}$ to be a single dummy for post-NAFTA exports from Canada to Mexico and $NAFTA_{MEXCAN,t}$ to be a separate dummy for post-NAFTA flows in the other direction. NAFTA is a three country agreement, so there will be 6 directional NAFTA effects to measure in all for each sector, plus the $FTA_{ij,t}^0$ term to control for the average effect of all other FTAs in effect. The directional asymmetries in trade barrier reductions these $\vec{\beta}_{N,k}$ terms reveal can then be compared with what one might expect to observe based on tariff reductions associated with NAFTA.

In this last case, I need to be careful. The pair-wise fixed effect $\eta_{ij}^k$ is intended to identify the average effect of an FTA on average trade barriers in industry $k$ for a given pair. However when I allow NAFTA’s effects to be directional I am now (for example) interested in the specific effect of NAFTA on trade frictions for Canadian Food producers trying to sell in US markets, and vice versa. If trade barriers for Canadian Food producers selling in the US are different than those faced by US producers trying to sell in Canada, then $\vec{\beta}_{USCAN}^N$ and $\vec{\beta}_{CANUS}^N$ will in part reflect this initial difference in trade barriers, rather than identifying the differences in how the FTA played out.

As such, I write down this last empirical model as follows,

$$X_{ij,t}^k = \exp \left( \xi_{ij,t}^k + \psi_{ij,t}^k + \eta_{ij}^k + \vec{\eta}_{ij}^k + \beta_{0,k} FTA_{ij,t}^0 + \vec{\beta}_{N,k} NAFTA_{ij,t} + \epsilon_{ij,t}^k \right),$$

where the “arrow” superscript indicates a set of effects that is allowed to vary by direction. The additional (asymmetric) pair effects $\vec{\eta}_{ij}^k$ are only in play for flows between the US, Canada, and Mexico. $\vec{\beta}_{N,k}$, the set of directional NAFTA effects, by definition also varies with the direction of flows.

This same simple procedure could be easily repeated for any FTA or set of FTAs in order to identify direction-specific effects. NAFTA is an especially useful illustrating example for my purposes however, not just because of its continuing notoriety in current
trade policy debates, but also because its three country structure will offer the opportunity to make unique inferences about the observable patterns of FTA effects within industries. Furthermore, as we will see, NAFTA serves as a useful example for demonstrating how asymmetric effects within FTAs may differ from what we might expect to observe.

1.3.2 Data

The data used here builds on the data set used in Anderson & Yotov (2012). This data set spans the period 1990 until 2002 for a sample of 40 individual countries plus an aggregate “Rest of the World”, for a total of 41 trading regions in all. The main source for trade flows is the CEPII “TradeProd” data base, supplemented with data on exports from UN COMTRADE accessed using the WITS World Bank trade service. The original data uses observed trade flows from every 4 years only—that is, 1990, 1994, 1998, and 2002. I then add additional data—referring to the original sources and construction methods, and using the Anderson & Yotov (2012) data to interpolate missing and unreasonable values where possible—for the years 1992, 1996, and 2000, such that the full data set is for every two years. The reason why I do not include every year is because, as Cheng & Wall (2005) point out, performing fixed effects gravity estimations over consecutive years may fail to address the fact that trade patterns may not adjust right away to changes in trade costs.21

The number of observations for each of the main results shown then is 11,765—i.e. 1,681 trading pairs (the square of the number of regions) times 7, the number of years in the data.

The level of aggregation for the sectoral results is the ISIC (Revision 2) 2 digit level, which is comprised of 9 2 digit manufacturing industry classifications: 31. Food and Beverages, 32. Textiles, 33. Wood Products, 34. Paper Products, 35. Chemicals, 36. Minerals, 37. Metals, 38. Machinery, and 39. Other Manufacturing. However since some countries report some Machinery products under Other Manufacturing and vice versa in their output data, these two sectors are combined into a single “Manufacturing” category in the final trade data.

21For this reason, it is worth mentioning that the results I show in this chapter are robust to using four year intervals.
A key feature of this data is the inclusion of internal trade flows. The inclusion of internal trade values is crucial for my purposes because one cannot perform a true general equilibrium analysis without some form of accounting for how domestic sales will respond to changes in trade costs. These flows are constructed as the difference between total sectoral output and total sectoral exports to all trading partners. Because exports are measured on a “gross” (rather than value-added) basis, the data likewise uses gross output data for these purposes. Like the trade data, the output data is mainly taken from TradeProd and then supplemented with another source, in this case the United Nations UNIDO Industrial Statistics (“IndStat”) database. Missing internal trade values have been extrapolated by comparing the share of internal trade with respect to output in non-missing sectors and non-missing years.\footnote{Anderson & Yotov (2010b) describe how to impute missing internal trade values.} Each country’s total expenditure on a given industry, which plays a role in the welfare analysis, can then be calculated by adding together internal trade and total imports.

The data on FTAs is based mainly on the original Baier & Bergstrand (2007) data set, which is updated with some data on additional agreements taken from the WTO’s web site. Because the trade data begins in 1990, only FTAs that entered into effect after that year are coded. NAFTA, which went into effect in 1994, is obviously included, but the Canada-U.S. Free Trade Agreement of 1988 (which preceded NAFTA) is not.\footnote{See Table 1 in Anderson & Yotov (2012) for details on the FTAs included.} Overall, there are 252 country pairs in the data that entered into either a free trade agreement or customs union during the period under study.\footnote{Customs Unions are included as FTAs for these purposes.}

1.4 Empirical Findings

1.4.1 Industry-Level Analysis

I present my main evidence in Tables 1.1 and 1.2. First, in Table 1.1, Panel A, I estimate average sectoral FTA effects using equation (5) in order to document how the effects of FTAs generally vary significantly across industries.\footnote{Qualitatively, the results are virtually identical to Anderson & Yotov’s (2012) results for this same specification, and differ only because I include additional years in the data.} Notably there are two sectors, Wood
Table 1.1: Industry-Level Results: NAFTA vs. Other FTAs

<table>
<thead>
<tr>
<th></th>
<th>Food</th>
<th>Textile</th>
<th>Wood</th>
<th>Paper</th>
<th>Chemicals</th>
<th>Minerals</th>
<th>Metals</th>
<th>Machinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Sectoral FTA Estimates</td>
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<tr>
<td>All FTAs</td>
<td>0.451</td>
<td>0.713</td>
<td>0.006</td>
<td>-0.017</td>
<td>0.228</td>
<td>0.192</td>
<td>0.447</td>
<td>0.467</td>
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<td></td>
<td>(0.076)</td>
<td>(0.120)</td>
<td>(0.072)</td>
<td>(0.057)</td>
<td>(0.041)</td>
<td>(0.065)</td>
<td>(0.062)</td>
<td>(0.118)</td>
</tr>
<tr>
<td>B. Individual FTA Estimates (NAFTA vs. All Other FTAs)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAFTA</td>
<td>0.504</td>
<td>1.166</td>
<td>0.140</td>
<td>0.371</td>
<td>0.462</td>
<td>0.604</td>
<td>0.339</td>
<td>0.613</td>
</tr>
<tr>
<td></td>
<td>(0.067)</td>
<td>(0.063)</td>
<td>(0.095)</td>
<td>(0.032)</td>
<td>(0.030)</td>
<td>(0.051)</td>
<td>(0.136)</td>
<td>(0.144)</td>
</tr>
<tr>
<td>All Other FTAs</td>
<td>0.465</td>
<td>0.646</td>
<td>-0.038</td>
<td>-0.050</td>
<td>0.183</td>
<td>0.133</td>
<td>0.405</td>
<td>0.371</td>
</tr>
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<td></td>
<td>(0.082)</td>
<td>(0.118)</td>
<td>(0.068)</td>
<td>(0.052)</td>
<td>(0.032)</td>
<td>(0.056)</td>
<td>(0.060)</td>
<td>(0.082)</td>
</tr>
<tr>
<td>C. Significance Tests (NAFTA vs. the Average FTA)</td>
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</tr>
<tr>
<td>NAFTA vs. Average</td>
<td>0.040</td>
<td>0.520</td>
<td>0.177</td>
<td>0.422</td>
<td>0.280</td>
<td>0.471</td>
<td>-0.067</td>
<td>0.242</td>
</tr>
<tr>
<td></td>
<td>(0.103)</td>
<td>(0.107)</td>
<td>(0.117)</td>
<td>(0.062)</td>
<td>(0.038)</td>
<td>(0.076)</td>
<td>(0.150)</td>
<td>(0.125)</td>
</tr>
</tbody>
</table>

Sectoral trade for 41 trading regions from 1990-2002, every 2 years (41^2 - 7 = 11,765 observations per sector.)
Robust standard errors, clustered by pair, are reported in parentheses. + p < 0.10 , * p < .05 , ** p < .01 .
All estimates are obtained with Santos-Silva and Tenreyro’s (2006) Poisson Pseudo-Maximum Likelihood estimator. Following Baier and Bergstrand (2007), pair fixed effects are used to account for FTA endogeneity. Time-varying exporter and importer fixed effects are used to control for the multilateral resistances.

Panels B and C then explore the implications of allowing for more specific FTA effects. In Panel B, following equation (6), I separate out the individual effect of NAFTA from all other FTAs. In both cases I control for the presence of all other FTAs. The estimates from Panel B reveal that the effects of NAFTA are quite different from both the average sectoral FTA estimates from Panel A and from the estimates of effects of all other FTAs, excluding NAFTA (the “All Other FTAs” term in Panel B). For example, I find that NAFTA has led to a significant increase in trade in Paper products among the three NAFTA members, while the effect of all other FTAs is still negative, small, and marginally significant. Panel C confirms the significance of these differences. These results support the hypothesis that individual FTAs can have very different effects across industries.

Then, in Table 1.2, I allow for country-specific and directional differences in the effects of NAFTA, as in (7). Based on these estimates, I conclude that FTA effects can indeed be strongly directional. For example, my estimates for Food reveal that NAFTA had strong positive effects on Canadian exports to Mexico (NAFTA Can-Mex= 1.614, std.err 0.165) and on U.S. exports to Mexico (NAFTA U.S.-Mex=1.000, std.err 0.163). However, I do not...
Table 1.2: Industry-Level Results: Directional NAFTA Effects

<table>
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<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>1.614</td>
<td>-0.249</td>
<td>0.595</td>
<td>0.510</td>
<td>(0.067)**</td>
<td>(0.162)**</td>
<td>(0.081)**</td>
</tr>
<tr>
<td>Textile</td>
<td>1.725</td>
<td>1.544</td>
<td>1.348</td>
<td>0.832</td>
<td>(0.104)**</td>
<td>(0.128)**</td>
<td>(0.118)**</td>
</tr>
<tr>
<td>Wood</td>
<td>1.850</td>
<td>0.754</td>
<td>0.209</td>
<td>-0.197</td>
<td>(0.182)</td>
<td>(0.176)**</td>
<td>(0.068)</td>
</tr>
<tr>
<td>Paper</td>
<td>0.517</td>
<td>1.769</td>
<td>0.081</td>
<td>0.767</td>
<td>(0.079)**</td>
<td>(0.104)**</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Chemicals</td>
<td>1.163</td>
<td>1.931</td>
<td>0.412</td>
<td>0.457</td>
<td>(0.078)**</td>
<td>(0.064)**</td>
<td>(0.032)**</td>
</tr>
<tr>
<td>Minerals</td>
<td>1.806</td>
<td>1.472</td>
<td>0.643</td>
<td>0.667</td>
<td>(0.101)**</td>
<td>(0.102)**</td>
<td>(0.056)*</td>
</tr>
<tr>
<td>Metals</td>
<td>0.587</td>
<td>1.674</td>
<td>0.330</td>
<td>-0.028</td>
<td>(0.095)</td>
<td>(0.098)**</td>
<td>(0.060)**</td>
</tr>
<tr>
<td>Machinery</td>
<td>1.400</td>
<td>1.291</td>
<td>0.441</td>
<td>0.481</td>
<td>(1.098)</td>
<td>(0.064)**</td>
<td>(0.045)**</td>
</tr>
</tbody>
</table>

DirActional FTA Estimates (NAFTA)

Sectoral trade for 41 trading regions from 1990-2002, every 2 years (41 x 7 = 11,765 observations per sector.)
Robust standard errors, clustered by pair, are reported in parentheses. + p < 0.10, * p < 0.05, ** p < 0.01.
All estimates are obtained with Santos-Silva and Tenreyro’s (2006) Poisson Pseudo-Maximum Likelihood estimator.
Following Baier and Bergstrand (2007), pair fixed effects are used to account for FTA endogeneity.
Time-varying exporter and importer fixed effects are used to control for the multilateral resistances.

obtain statistically significant estimates of the effects of NAFTA on Mexico’s exports to Canada; Furthermore, Mexico’s exports to the U.S. actually seem to have been negatively affected.26

The estimates for Food in Table 1.2 are also useful for pointing out a broader regularity in the data that I wish to focus on. The NAFTA effects for U.S.-Mexico and Canada-Mexico trade are much larger in magnitude than the effects for U.S. exports to Canada and vice versa. This pattern suggests a loose correspondence between how much market access a country has gained as exporter vs. how much access to its own markets it offers in return. Here, the U.S. and Canada both realize generally strong gains in market access on the export side, while we cannot say NAFTA has done much for Mexican Food exporters.

Estimates from several other sectors suggest the same sort of regularity, with different orderings. Mexican Paper exports to Canada increase a prodigious amount, whereas other countries’ exports expand more modestly. We also see this same kind of pattern where one country seems to generally gain the most access to the other two markets in Metals and

26Trade barriers for Food are often dealt with separately and given special exemptions in the negotiation of free trade agreements and NAFTA is no exception. See Avery (1998) for an overview of the bargaining process that went on between negotiators and agricultural special interests in solidifying the agreement.
Machinery (again Mexico in both cases).

I focus on illustrating these patterns to make an important point regarding the identification: one might be tempted to call the differences in how much trade increases I am identifying as reflecting some measure of “comparative advantage”. Maybe these results are due to the U.S. and Canada having comparative advantage in Food, Mexico having comparative advantage in Machinery, and so on, the reasoning might go. Again, however, I call attention to the presence of time-varying exporter and importer fixed effects in my empirical specification. There is little question that trade liberalization impacts relative prices across industries and that changes in relative prices in turn cause factors of production to be re-allocated. But the structural model in (1) explicitly controls for the endogeneity of production and prices with respect to trade costs. Furthermore, the modularity of the model allows me to separate the estimation of trade costs from these endogenous cross-sectoral linkages. These estimates I am showing are indeed changes in market access as defined in the structural model, controlling for all endogenous responses to trade within each country. This includes notions of comparative advantage.27

1.4.2 A “One Way” Trade Deal?

What can we say then about the possibility of “one way” effects in general? The industry-level data is suggestive of certain patterns at a high level—Mexico seems to have had especially strong gains as an exporter for instance (especially in the Textiles, Wood, Metals, and Machinery sectors). However, to really make concrete statements one way or the other, it is necessary to examine results for aggregate trade. In Table 1.3, I show a number of specifications meant to highlight the broad heterogeneity in FTA effects both between NAFTA and other FTAs and within NAFTA itself.

In column 1, I document that the average effect of FTAs on trade in my sample, across

\[ \text{Note that this same argument also rules out any other type of general equilibrium response to trade cost reductions as the source of these particular variations. Take Caliendo & Parro's (2015) model with cross-sectoral input sourcing linkages as an example. In such a model, a trade shock affects prices, which in turn feeds back into the quantity demanded for products of a certain type. Once again, these linkages are captured in the structural model through the explicit representation of production, expenditure, and prices, with all of these factors in turn being absorbed in the econometric model via the use of time-varying exporter and importer fixed effects. The empirics do not distinguish between trade flows in intermediates versus trade in final goods, however; such distinctions require a more detailed structural model.} \]
Table 1.3: NAFTA Effects, Aggregate Trade

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<thead>
<tr>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<tr>
<td>Average FTA Effect</td>
<td>0.401</td>
<td>0.320</td>
<td></td>
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<tr>
<td></td>
<td>(0.065)**</td>
<td>(0.042)**</td>
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<tr>
<td>All Other FTAs</td>
<td>0.319</td>
<td>0.318</td>
<td>0.317</td>
<td>0.321</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(0.042)**</td>
<td>(0.042)**</td>
<td>(0.042)**</td>
<td>(0.042)**</td>
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<tr>
<td></td>
<td>(0.095)**</td>
<td>(0.100)**</td>
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<tr>
<td>NAFTA Can-Mex</td>
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<td></td>
<td>(0.073)**</td>
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<tr>
<td>NAFTA Mex.-Can.</td>
<td>1.099</td>
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<tr>
<td></td>
<td>(0.074)**</td>
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<tr>
<td>NAFTA U.S.-Can</td>
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<tr>
<td></td>
<td>(0.044)**</td>
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<tr>
<td>NAFTA Can-U.S.</td>
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<td></td>
<td>(0.044)**</td>
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<tr>
<td>NAFTA Mex.-U.S.</td>
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<td>NAFTA U.S.-Mex</td>
<td>0.615</td>
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<td></td>
<td>(0.069)**</td>
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<tr>
<td>NAFTA (Canadian exports)</td>
<td></td>
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<td>0.443</td>
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<tr>
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<td>(0.042)**</td>
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<tr>
<td>NAFTA (Mexican exports)</td>
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<td>1.076</td>
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<tr>
<td></td>
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<td>(0.066)**</td>
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<td>(0.044)**</td>
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<tr>
<td>NAFTA (Canadian imports)</td>
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<td></td>
<td></td>
<td>(0.064)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAFTA (Mexican imports)</td>
<td></td>
<td></td>
<td></td>
<td>0.845</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.103)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAFTA (U.S. imports)</td>
<td></td>
<td></td>
<td></td>
<td>0.586</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.080)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Aggregate manuf. trade for 41 trading regions from 1990-2002, every 2 years \((41^2 \cdot 7 = 11,765\) observations.)

Robust standard errors, clustered by pair, are reported in parentheses. + \(p < 0.10\), * \(p < 0.05\), ** \(p < 0.01\).


Following Baier and Bergstrand (2007), pair fixed effects are used to account for FTA endogeneity.

Time-varying exporter and importer fixed effects are used to control for the multilateral resistances.
all industries combined is 0.401, which corresponds to an average increase in market access of $e^{0.401} - 1 = 49.3\%$. Column 2 then replicates the specification from Table 1.1 Panel B. Unsurprisingly, NAFTA appears to have promoted trade much more overall than the other FTAs in my sample—about twice as much in fact.\textsuperscript{28} Furthermore, as I show explicitly in Column 3, the difference between NAFTA and the average FTA is itself significant at the 5\% level.

Columns 4 to 6 then isolate the directional impact of NAFTA on aggregate trade flows. The patterns seen here for combined trade feature less pronounced asymmetries than we saw in the industry-level results. While there is some definite variation across pairs (trade between Mexico and Canada vs. trade between the U.S. and Canada), the asymmetry seen within pairs is muted. In columns 5 and 6, we see for instance that each country generally tended to receive more or less the same amount of access to its import markets that it offered to its partners in return. One exception here—where we are able to say there have been some asymmetric effects—is the effect of NAFTA on trade between the U.S. and Mexico. The results in column 4 show that Mexico overall has received a $e^{0.999} - 1 = 171\%$ increase in access to U.S. markets, whereas the U.S. has received an $e^{0.615} - 1 = 85.0\%$ increase in return.\textsuperscript{29} This last result is particularly interesting because it goes directly against what would have been predicted to happen based on tariffs. As was well-publicized by the pro-NAFTA campaign at the time,\textsuperscript{30} Mexico’s tariffs on U.S. products were about two-and-a-half times those on products shipped in the other direction. It would seem then that focusing on tariff provisions does not necessarily do a good job of explaining how much market access will change in response to the signing of a free trade agreement; I return to this theme in the ensuing discussion in section 1.5.

To summarize, the key finding from comparing average FTA effects with average NAFTA effects, and then in turn with directional NAFTA effects, is not so much that any one country experienced one way effects overall (although the U.S. did indeed grant more market access to Mexico than it gained). Really, what is more useful to observe here is that in-

\textsuperscript{28}e^{0.580} - 1 = 78.6\%, e^{0.319} - 1 = 37.6\%.

\textsuperscript{29}These increases in market access can also be described as a 63.2\% decrease in US import barriers for Mexican products vs. a 45.9\% decrease in Mexican import barriers for U.S. products, as stated in the opening remarks.

Individual FTAs can have their own unique effects on trade, and that even within a given FTA, there are widespread directional asymmetries, especially at the industry-level. We also saw some evidence that what we would expect to happen *ex ante* based on tariffs is not always what actually occurs when the FTA goes into effect. The following sections will discuss the possible causes of the asymmetries as well as their implications, both for further work on trade agreements, and for how we estimate the welfare impact of FTAs.

1.5 Discussion

I wish to consider various intuitive explanations for why one might expect to observe asymmetric effects from an FTA. It is important to verify, for example, that my results are not simply reflecting pre-existing patterns of comparative advantage within NAFTA countries. A particularly important competing narrative in this context of course is the currency volatility that occurred within Mexico during this period. The question of what role trade in intermediate inputs may play in the analysis also needs to be examined.

Fortunately, the use of time-varying exporter and importer-fixed effects motivated by the structural model ensures a strong degree of control over these issues. It follows then that a reasonable interpretation of my estimates, especially in light of discrepancies with the tariff data, is that they imply a large, relatively unexplored role for so-called “non-tariff barriers” in explaining NAFTA’s effects. It also follows that broader definitions of these barriers may be needed in order to explain the magnitude of these effects.

1.5.1 Some Competing Narratives

*Comparative Advantage*. I have already discussed how the use of time-varying country-level fixed effects already controls for the endogenous response of prices and overall production patterns in each country to trade liberalization. Thus, econometrically speaking, I can safely say my results do not reflect comparative advantage in the classical sense.\(^{31}\) The structural model instead suggests that these coefficients are instead capturing direct

\(^{31}\text{See Costinot, Donaldson, & Komunjer (2012) for a thorough illustration of how comparative advantage contributes to gains from trade in a structural gravity setting.}\)
Table 1.4: Measures of Revealed Comparative Advantage, NAFTA countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Food</th>
<th>Textiles</th>
<th>Wood</th>
<th>Paper</th>
<th>Chemicals</th>
<th>Minerals</th>
<th>Metals</th>
<th>Machinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leromain and Orefice (2013) RCA index, 2010 trade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1.07</td>
<td>0.88</td>
<td>1.21</td>
<td>1.07</td>
<td>0.85</td>
<td>1.14</td>
<td>1.03</td>
<td>1</td>
</tr>
<tr>
<td>Mexico</td>
<td>1</td>
<td>0.86</td>
<td>0.78</td>
<td>1.07</td>
<td>0.98</td>
<td>0.82</td>
<td>0.98</td>
<td>0.9</td>
</tr>
<tr>
<td>U.S.</td>
<td>1.02</td>
<td>0.86</td>
<td>1.13</td>
<td>1.07</td>
<td>1.06</td>
<td>1.02</td>
<td>0.98</td>
<td>1.07</td>
</tr>
</tbody>
</table>

The index values for the Leromain and Orefice (2014) RCA measure are based on the Costinot, Donaldson, and Komunjer (2012) structural estimation procedure. Values > 1 indicate better than average productivity in a given sector relative to the rest of the world.

reductions in bilateral trade frictions that seem to favor certain countries over others across different sectors.

Nonetheless, it still might conceivably be the case that having comparative advantage in a particular sector somehow also directly benefits that sector on a bilateral basis relative to an FTA partner country. I examine this hypothesis by comparing my estimation results with empirical estimates of “revealed comparative advantage” for the three NAFTA countries taken from Leromain & Orefice (2014). I show these latter estimates in Table 1.4.

The evidence for this possibility is mixed. To illustrate, let us focus on the cases I noted in reviewing the directional results in Table 1.2. For the Food sector, we saw the U.S. and Canada realizing large market access gains with Mexico not seeming to make any. Interestingly, the U.S. and Canada do indeed seem to have genuine comparative advantage over Mexico in Food.

My results for Wood are contrary however: Mexico clearly does not have comparative advantage over the U.S. in Wood, as might be suggested based on Table 1.2. The RCA numbers also fail to predict Mexico’s large gains in Metals and Machinery.

Overall, I fail to find robust correspondence between RCA and my directional estimates in Table 1.2 in seven out of the eight sectors, with Food as the only convincing exception.

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32 Leromain & Orefice (2014) adapt their methodology from a structural estimation approach devised by Costinot, Donaldson, & Komunjer (2012). The main advantage of this method is its consistency with Ricardian theory. As Leromain & Orefice explain, comparative advantage is an ex ante characteristic of a country, whereas the Balassa formula is based on ex post realizations of trade flows, which may depend on other factors besides comparative advantage. Costinot, Donaldson, & Komunjer’s procedure corrects this issue by recovering revealed measures of Ricardian productivity from a structural model.

33 An equivalent comparison can be performed using Balassa’s (1965) original methodology for computing RCA.

34 It is important to note that neither of these measures take into account the influence of agricultural policy, which most likely plays a role in these figures (as well as in my own results for Food). Rather they are inferred from trade data.
plot of these RCA estimates directly against my industry-level NAFTA estimates, shown in Fig. 1.5.1, does reveal a (slight) positive correlation, albeit a noisy one. I conclude that my findings of discrepancies in bilateral trade gains from NAFTA do not merely reflect patterns of comparative advantage, though comparative advantage could still have some meaningful correlation (perhaps via the design of the agreement).

**Exchange rate volatility.** Another important factor that comes to mind in the case of NAFTA is the sharp devaluation of the Mexican peso that began in December 1994. How can NAFTA’s effect be separated from the dramatic change in U.S.-Mexico exchange rate?

Krueger (1999) also considers this question in her own *ex post* analysis of NAFTA. By comparing changes in Mexican export shares to U.S. and Canadian markets vs. changes in its share as exporter to non-NAFTA import markets, she observes that NAFTA did not significantly promote Mexican exports to the U.S. moreso than it did its exports to non-NAFTA destinations; she concludes that Mexico’s currency devaluation was the main contributing cause of the increase in Mexico-U.S. exports during the period.

In my approach, which directly incorporates the reasoning of Krueger (1999), the use of time-varying exporter- and importer- fixed effects again plays a crucial role. It is undeniable that overall Mexican exports grew strongly during the period, likely in no small part due to the peso. Other countries’ currencies likewise fluctuated in value during the period. The time-varying country fixed effects in the specification should be absorbing how
these fluctuations would generally change each country’s disposition toward trade, both as an importer and as an exporter (and across the different industries for the industry-level analysis). Even in the presence of these controls, I still find an asymmetry within NAFTA that favors Mexico.

**Trade in intermediate inputs.** Even at the industry-level, the data used in this study does not provide substantial information regarding trade in “intermediate inputs” versus trade in “final output”. Given the well-known production-sharing arrangements between the U.S. and Mexico (and Canada for that matter) across certain industries (automobiles for instance), it is important to consider how the segmentation of production is accounted for by the model.

Structural gravity frameworks which incorporate trade in intermediates, beginning with Eaton & Kortum (2002),⁵ can be used to account for how different types of trade may analyzed together based on aggregated data. The structure of these models (which is embedded in the empirical design described above) dictates that cheaper access to intermediate inputs, regardless of their origin, should generally lower production costs for importing firms and therefore promote more exports to all destinations, not just the original supplier of their inputs.

Admittedly, however, firm-to-firm relationships in reality may not always adhere to the structure imposed on aggregated trade flows by current modeling approaches. Firms who operate within well-defined bilateral production-sharing relationships could conceivably benefit from liberalization of imported inputs moreso than other firms who serve as general export platforms.

Under this alternative perspective, reducing tariffs on imports of intermediates from an original supplier could (seemingly paradoxically) show up in the data as promoting a country’s exports back to the original supplier moreso than imports from that supplier. This logic would follow because the goods being returned to the original supplier of intermediates are presumably higher in the value chain and therefore represent a larger nominal quantity of trade in the data. Further consideration of this interesting possibility using

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⁵For more recent examples of structural gravity models with trade in intermediates, see Redding & Venables (2004), Shikher (2012b), Caliendo & Parro (2015), and Costinot & Rodríguez-Clare (2014).
Table 1.5: Tariffs, before and after NAFTA

<table>
<thead>
<tr>
<th>Exporter</th>
<th>Importer</th>
<th>Food</th>
<th>Textiles</th>
<th>Wood</th>
<th>Paper</th>
<th>Chemicals</th>
<th>Minerals</th>
<th>Metals</th>
<th>Machinery</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 1989-1991 Import Tariffs (ad valorem, Effectively Applied)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Mexico*</td>
<td>10.02</td>
<td>15.29</td>
<td>14.95</td>
<td>5.17</td>
<td>10.09</td>
<td>13.72</td>
<td>7.14</td>
<td>14.08</td>
<td>9.62</td>
</tr>
<tr>
<td>Canada</td>
<td>U.S.</td>
<td>2.40</td>
<td>7.52</td>
<td>1.11</td>
<td>0.28</td>
<td>3.79</td>
<td>1.56</td>
<td>1.93</td>
<td>0.38</td>
<td>0.96</td>
</tr>
<tr>
<td>Mexico</td>
<td>Canada</td>
<td>5.32</td>
<td>13.67</td>
<td>13.18</td>
<td>3.14</td>
<td>6.39</td>
<td>3.32</td>
<td>0.71</td>
<td>4.14</td>
<td>3.88</td>
</tr>
<tr>
<td>Mexico</td>
<td>U.S.</td>
<td>6.20</td>
<td>13.16</td>
<td>4.05</td>
<td>3.57</td>
<td>5.07</td>
<td>5.83</td>
<td>3.38</td>
<td>3.81</td>
<td>4.31</td>
</tr>
<tr>
<td>U.S.</td>
<td>Canada</td>
<td>5.24</td>
<td>16.5</td>
<td>6.98</td>
<td>3.19</td>
<td>7.50</td>
<td>6.44</td>
<td>4.31</td>
<td>5.40</td>
<td>5.55</td>
</tr>
<tr>
<td>B. 1999 Import Tariffs (ad valorem, Effectively Applied)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Mexico</td>
<td>27.47</td>
<td>8.05</td>
<td>4.80</td>
<td>4.43</td>
<td>5.06</td>
<td>3.44</td>
<td>3.97</td>
<td>3.54</td>
<td>5.87</td>
</tr>
<tr>
<td>Canada</td>
<td>U.S.</td>
<td>2.76</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.51</td>
</tr>
<tr>
<td>Mexico</td>
<td>Canada</td>
<td>11.78</td>
<td>5.82</td>
<td>0.10</td>
<td>0.27</td>
<td>0.48</td>
<td>0.23</td>
<td>1.37</td>
<td>0.33</td>
<td>4.03</td>
</tr>
<tr>
<td>Mexico</td>
<td>U.S.</td>
<td>3.41</td>
<td>1.08</td>
<td>0.01</td>
<td>0.00</td>
<td>0.31</td>
<td>1.43</td>
<td>1.01</td>
<td>0.14</td>
<td>0.34</td>
</tr>
<tr>
<td>U.S.</td>
<td>Canada</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.51</td>
</tr>
<tr>
<td>U.S.</td>
<td>Mexico</td>
<td>20.19</td>
<td>4.22</td>
<td>3.98</td>
<td>5.03</td>
<td>4.77</td>
<td>3.76</td>
<td>4.41</td>
<td>2.93</td>
<td>4.47</td>
</tr>
</tbody>
</table>

Weighted average tariffs computed by World Bank WITS software using UNCTAD TRAINS tariff database.

* Mexican tariffs only available for 1991 in Panel A. All other Panel A tariffs from 1989.

more disaggregated data is reserved for future work.

1.5.2 Tariffs Before and After NAFTA

A standard expectation is that asymmetries in NAFTA’s effects on trade barriers should broadly reflect the underlying patterns of tariff liberalization associated with NAFTA. In Table 1.5, I show representative ad valorem “effectively applied” tariff levels for each country pair from before and after NAFTA, using data from the UNCTAD TRAINS tariff database, accessed using the World Bank WITS interface. These tariff changes are shown both at the industry-level and for aggregate trade. For pre-NAFTA tariffs (Panel A), all values shown are from the year 1989, with the exception of Canadian exports to Mexico, which use 1991 tariffs because of missing data for 1989. The “after NAFTA” tariffs (Panel B) are all from 1999. While it is not appropriate to use raw tariff changes to compare implications for trade across sectors—because different sectors have different trade elasticities—within a given sector, one might expect larger tariff changes to correspond with larger trade increases.

The first point to document concerns the aggregate tariff levels in the right-most column of Table 1.5. Based on these tariffs, we would have expected, if anything, trade barriers to fall the most for Mexico’s import markets, since Mexico had by far the highest tariffs
to start with and also reduced its tariffs by the largest amount amount overall.\footnote{This second point is less obvious, since Mexico has the largest tariffs in both panels of Table 1.5. But since these are AVE tariffs, a reduction from 11.74 to 4.47, for example, should be considered larger than a reduction from 4.31 to 0.34 (in the case of U.S.-Mexico trade).} Clearly, however, this expectation is not borne out in my estimates.

Turning to the industry-level tariffs, one can find some cases where tariffs line up more closely with the estimates reported above. In the Wood sector, for example, the U.S. only had a 1.11\% tariff on Canadian Wood products before NAFTA—whereas Mexico’s was 14.95\%—and indeed Canada’s Wood exports to Mexico increased by more than its exports to the U.S. did. The Wood example is by no means representative, however. Most interestingly, in the Food sector, in the Food sector, for instance, the incidence of Mexican import tariffs actually increased in the post-NAFTA period,\footnote{As documented in Carlberg & Rude (2004), Mexico actually raised tariffs on meat products significantly just before the signing of NAFTA. If anything this should have downward-biased the estimates for Mexican Food imports in Table 1.2. Effective increases in tariff incidence can also occur when newly traded products appear in the data post-NAFTA along the highest tariff lines. Krueger (1999) also notes these phenomena in the NAFTA tariff data.} yet these increases have failed to deter the flow of Food imports into Mexico overall. A close reading of the tariffs in other sectors helps explain some of the overall discrepancies at the aggregate level.

Indeed, generally speaking, there is major variation in the effects of NAFTA that cannot be explained based on tariffs. In the Metals sector, for instance, we cannot however rationalize Mexico’s large gains in market access as an exporter of Metals ($\beta_{N,\text{Metals}}^{MEX,\text{CAN}} = 1.674$ in Table 1.2) based on tariffs alone. There is no likewise no clear reason to be gleaned from Table 1.5 why the magnitudes for NAFTA’s effects on Textile trade would be as large as they are, or why Canada’s import markets for Minerals seemed to open up more than Mexico’s did. As noted above, competing interpretations exist for these results exist that cannot be ruled out completely. If we take structural gravity seriously, however, we are left with one conclusion: free trade agreements can influence trade along other channels besides tariff liberalization and the majority of the variation in directional NAFTA effects I observe would seem to be occurring along these “other” channels.\footnote{Powers (2007) explicitly tests (and generally confirms) the hypothesis that FTAs may have additional positive effects on trade beyond their underlying tariff reductions.}
1.5.3 Broader Implications

An interesting puzzle remains: what might be the sources of this directional variation in NAFTA effects we are seeing in the data? Generally, when we find impediments to trade other than tariffs that could still be influenced by policy, we invoke the term “non-tariff barriers”, but what is the nature of these barriers?

Data on quantifiable non-tariff measures does exist and can potentially be applied using estimated tariff equivalents; Shikher (2012a) demonstrates how this data can be applied in the case of NAFTA specifically. However, again, this additional data still supports the general conclusion that Mexico should have experienced the largest trade barrier reduction of the three NAFTA countries. To reconcile these discrepancies, I argue that it is necessary to appreciate that what we consider “trade costs” in the empirical trade literature is actually a very expansive category with a large, difficult-to-quantify “conceptual” dimension. As a second recent paper by Head & Mayer (2013) has documented, trade costs in depend majorly on abstract concepts such as information asymmetries, cultural biases, lack of common legal institutions, and general difficulties forming cross-border business relationships.

Indeed, this latter potential source of non-tariff barriers to trade (institutional and cultural frictions) has been known at least since Deardorff & Stern (1985) to be “especially difficult to measure”. Using ex post analysis of the effects of FTAs that share particular provisions may offer a promising opportunity for making informed statements about this hard-to-measure component of non-tariff barriers. Several recent findings suggest these institutional frictions weigh particularly on exports from less-developed countries. Levchenko (2007) shows that countries with weak legal institutions tend to specialize in exporting goods which are less dependent on strong contract enforcement. Manova (2013) demonstrates a similar result for countries with weak financial institutions. Waugh (2010) also notes that less-developed nations generally face higher trade costs as exporters than developed nations.

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39 Recent work by Egger, Francois, Manchin, & Nelson (2014) and Felbermayr, Heid, Larch, & Yalcin (2014) has made progress in exactly this direction. Relative to these new approaches, what my findings for NAFTA suggest is that we should also consider how the same sets of provisions may have different effects on non-tariff barriers for different countries.
Drawing on these findings, and motivated by my own findings for NAFTA’s effect on U.S./Mexico trade, a plausible hypothesis to test in this context then is that countries with less-developed institutions (in this example, Mexico) may benefit relatively more as exporters, on a bilateral basis, when they sign FTAs with highly developed nations (such as the U.S.). To briefly explore this hypothesis, I estimate an additional specification for aggregate trade flows along the lines of (5), only with an added interaction term between the $FTA_{ij,t}$ dummy and the difference in (log) 1990 GDP/capita for the exporter and importer countries. The results of this basic test are shown in Table 1.6, column 1.

Table 1.6: FTA Effects for Developed/Less Developed Pairs

<table>
<thead>
<tr>
<th>Average FTA Effects on Aggregate Trade (PPML)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FTA dummy</td>
<td>0.412</td>
</tr>
<tr>
<td>(0.069)**</td>
<td>0.766</td>
</tr>
<tr>
<td>FTA dummy * (ln $y_i$ – ln $y_j$)</td>
<td>-0.103</td>
</tr>
<tr>
<td>(0.018)**</td>
<td>-0.199</td>
</tr>
<tr>
<td>FTA dummy * (ln $\tau_i$ – ln $\tau_j$)</td>
<td>2.051</td>
</tr>
<tr>
<td>(0.632)**</td>
<td>-0.543</td>
</tr>
</tbody>
</table>

N obs. 11,765 5,887 5,887

Fixed Effects (i, t); (j, t); (i, j)

Standard Errors robust; clustered by pair

$y_i$: exp. GDP/capita; $y_j$: imp. GDP/capita

$\tau_i, \tau_j$: “1 + tariff” for exp. and imp. respectively.

+ $p < 0.10$, * $p < .05$, ** $p < .01$.

Strikingly, the results for all FTAs in my sample are very much consistent with my results for NAFTA. The negative and (strongly) significant coefficient on the interaction term confirms that FTAs between developed/less-developed pairs tend to favor exports more for less-developed partners. Furthermore, it is notable that this result again contradicts what we would expect based on the logic of tariffs, since the degree of tariff protection is known to vary inversely with the degree of development.

Drawing on this interesting contradiction, Column 2 then explicitly considers how the difference in initial tariffs between FTA partners may lead to asymmetric effects within agreements. Intriguingly, I find that the FTA partner with the higher tariff actually gains

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40 GDP/capita data is taken from the CEPII “gravity” dataset made available in conjunction with Head & Mayer (2014).

41 Again, I use “effectively applied” tariffs from the TRAINS database. Unfortunately, the tariff data is only
more access to the import market of the country with the lower tariff than vice versa. This finding in isolation is puzzling. Again, however, controlling for differences in development provides an important clue. In column 3, the significance of the tariff interaction term disappears when I re-introduce the interaction between the $FTA_{ijt}$ dummy and the difference in GDP/capita. Furthermore, this latter variable remains significant at the $p < .01$ level. Collectively, these results suggest very general forces at work when less-developed countries partner with developed economies that tend to confound expectations based on tariffs.

This basic analysis obviously could be extended to explore richer interactions between institutional indicators and specific features of FTAs (how Investor Settlement Dispute mechanisms may affect the enforcement of contracts, for example). My intent here though is to document some suggestive evidence for why the effects I observe in NAFTA differ from expectations based on quantifiable policy measures; sharper characterizations of how FTAs interact with institutions to produce asymmetric effects are reserved for future work.

I also wish to explore how important accounting for directional asymmetries in FTA effects may be for quantifying the welfare gains from trade integration. In general, the models we use to simulate the general equilibrium effects of trade policy shocks are sophisticated enough to give us very detailed answers regarding what effect a given shock will have throughout the broader economy. Caliendo & Parro (2015) for instance combine notions of comparative advantage, inter-firm trade, input utilization differences across sectors, and non-traded goods within a structural general equilibrium gravity model to construct a very comprehensive, yet very coherent, picture of the different channels by which trade liberalization can affect welfare in a static setting. Taking things a step further, computational general equilibrium (CGE) models, such as the ones used by both Fontagné, Gourdon, & Jean (2013) and Egger, Francois, Manchin, & Nelson (2014) to forecast the effects of TTIP, are widely regarded for their deep complexity and ability to analyze a wide range of outcome vectors in general equilibrium.

However, as I will try to make as clear in my welfare analysis that follows, the results these richly-featured general equilibrium models can produce will tend to be significantly available for 29 countries, hence the decline in the number of observations.
constrained by how one models the underlying trade shock, i.e. what initially happens to trade costs to set off the endogenous responses implied by the model. Caliendo & Parro (2015) for instance use tariff changes to simulate NAFTA’s effects. Fontagné, Gourdon, & Jean (2013) acknowledge that tariffs are likely to be a small component of TTIP’s trade gains, but mainly deal with non-tariff barriers by assuming an across-the-board 25% reduction. Egger, Francois, Manchin, & Nelson (2014) and Felbermayr, Heid, Larch, & Yalcin (2014) each draw inferences for non-tariff barrier reductions from U.S./E.U. past experience from signing FTAs, but this approach again implies uniform effects on such barriers across partner countries. As the following section demonstrates, better accounting for these asymmetries in FTA effects can be important for how we project and assign the welfare benefits from FTA formation.

1.6 Welfare Analysis

In this section, I illustrate that these large directional differences in direct FTA effects in turn can also have important implications for general equilibrium welfare analysis of FTA formation. The simulation structure I use here is the same as in Anderson & Yotov (2012), where welfare effects occur strictly through changes in buyer and producer prices and accordingly may be thought of as “terms of trade effects”. This particular simulation method is especially suitable for demonstration purposes here for two main reasons: (i) because the impact of trade agreements on domestic producers specifically is often a key issue in trade policy debates, and (ii) because the first-order price effects it identifies would hold important implications for the additional welfare channels addressed in other quantitative models.

1.6.1 Model

I start by specifying a multi-sector Armington (1969) trade model where all products are differentiated based on the country of origin. Each industry in each country possesses an endowment of a differentiated good \( q^k_i \), which it sells to the world at factory gate price \( p^*_{ik} \). Consumers have common CES preferences over the set of nationally-differentiated
varieties within each industry, with elasticity parameter $\sigma^k$. It follows that nominal exports from $i$ to $j$ of goods of type $k$ can be written as

$$X_{ij}^k = \left(\frac{\beta_i^k p_i^{*k} t_{ij}^k}{P_j^k}\right)^{1-\sigma^k} E_j^k,$$  \hspace{1cm} (8)

with $t_{ij}^k$ the standard “iceberg cost” of transporting goods of type $k$ from $i$ to $j$ and $P_j^k \equiv \sum_i(\beta_i^k p_i^{*k} t_{ij}^k)^{1-\sigma^k}$ the CES price index for buyers in $j$. $\beta_i^k$ is the standard “Armington” demand shifter for products from a certain origin.

It is straightforward to re-write the CES Demand function in (8) in the form of a structural gravity equation as in (1) by adjusting the notation. Let $\phi_{ij}^k \equiv (t_{ij}^k)^{1-\sigma^k}$ serve as the parameter measuring of bilateral market access and let $\Phi_j^k \equiv (P_j^k)^{1-\sigma^k}$. It follows then from an accounting identity that

$$\beta_i^k p_i^{*k} = Y_i^k / \Omega_i^k,$$  \hspace{1cm} (9)

where $\bar{\beta}_i^k = (\beta_i^k)^{1-\sigma^k} (q_i^k)^{-1-\sigma^k}$ is a combined parameter describing how prices reflect the quantity and quality of $i$’s endowment in industry $k$, varying negatively with the size of its overall supply, $q_i^k$, but positively with its embedded demand shifter, $(\beta_i^k)^{1-\sigma^k}$.

Note that, by the duality between $\Phi_j^k$ and the buyer price index, and by the dependence of wages on $\Omega_i^k$ in (9), we have the following intuitive relationships between price changes:

Note that, by the duality between $\Phi_j^k$ and the buyer price index, and by the dependence of wages on $\Omega_i^k$ in (9), we have the following intuitive relationships between price changes:

\footnote{\cite{Note1} $\bar{\beta}_i^k$ is typically interpreted as (an inverse measure of) the “embedded quality” of $i$’s production technology for products of type $k$.}

\footnote{\cite{Note2} Specifically, if $Y_i = \sum X_{ij} = S_i \left( \sum_j \phi_{ij} E_j / \Phi_j \right)$, then $S_i = Y_i / \Omega_i$ follows directly.}
and access to world markets:

\[
\Delta \ln p^*_{ik} = \frac{1}{\sigma^k} \Delta \ln \Omega^k_i \quad \quad \quad \Delta \ln P^k_j = \frac{1}{1 - \sigma^k} \Delta \ln \Phi^k_{ij}
\]

That is, sellers face higher aggregate demand for their products when they are more able to reach world markets (higher \(\Omega^k_i\)) and, by \(\sigma^k > 1\), buyers likewise enjoy lower prices when there is more competition in their import markets (higher \(\Phi^k_{ij}\)). Regarded separately, these two effects allow for a simple decomposition of how trade integration affects buyers vs. producers in each economy. Regarded together, the combined effect provides a useful notion of the “terms of trade” effects from liberalization.

Adapting Anderson & Yotov’s method, I generate a solvable \(R\)-by-\(K\) system of equations for factory gate prices \(\{p^*_{ik}\}\) by summing (8) over \(j\) and dividing by world output. The resulting expression is

\[
\frac{Y^k_i}{Y^k} = \sum_j \left( \beta^k_i p^k_i \right)^{1-\sigma^k} \frac{\phi^k_{ij}}{\Phi^k_j} E^k_j \frac{Y^k}{Y^k}
\]

where \(Y^k_i, E^k_j, Y^k,\) and \(\Phi^k_j\) are each themselves functions of prices. To close the model, I assume that each country’s expenditure on manufacturing goods is a constant share \(\delta_j\) of its total manufacturing income \(\sum_k Y^k_i\) and that buyers in each country allocate expenditure across sectors according to a Cobb-Douglas function with common share parameters \(\{\alpha^k\}\).

To simulate general equilibrium FTA effects within this structure, I impose the normalization that all initial seller prices \(p^*_{ik}\) are equal to one, such that all endowments \(\{q^k_i\}\) are given by initial 1990 output levels; that is, \(q^k_i = Y^k_i_{1990}\). By then introducing a new system of \(\phi^k_{ij}\)’s reflecting NAFTA, I can recover changes in buyer and producer prices, terms of trade, and welfare using the linkages implied by the structural model.\(^{44}\) Specifically, I solve (10)

\(^{44}\)For the initial \(\phi^k_{ij}\)’s, I follow Anderson & Yotov (2012) in using the pair fixed effects from gravity estimation (\(\eta^k_{ij}\)’s). Specifically, I use the \(\eta^k_{ij}\)’s recovered from estimating equation (7).
for \( \{ p_i^* \} \) subject to the following:

\[
\begin{align*}
\frac{Y_i^k}{Y^k} &= \frac{p_i^* q_i^k}{\sum_k p_i^k q_i^k} \\
E_j^k &= \frac{\delta_j \sum_k p_i^* q_i^k}{\sum_j \delta_j \sum_k p_i^k q_j^k} \\
\Phi_j^k &= \sum_j \left( \frac{p_i^k q_i^k}{p_i^* q_i^k} \right)^{1-\sigma_j^k} \phi_{ij}^k.
\end{align*}
\]

(11) (12) (13)

In practice, I solve (10)-(13) twice: once with 1990 trade costs and all \( p_i^* = 1 \) in order to recover initial values the combined \( \{(\beta_j^k)^{1-\sigma_j^k}\} \) terms, and then again for new wages using new post-NAFTA \( \phi_{ij}^k \)’s. In addition, I take values for elasticity parameters \( \{\sigma_j^k\} \) from data compiled by Broda, Greenfield, & Weinstein (2006). I also construct expenditure share parameters \( \{\delta_j\} \) and \( \{\alpha_j^k\} \) from 1990 trade and output data.\(^{45}\)

Finally, I construct aggregate measures for changes in buyer prices, seller prices, and welfare in each country \( i \). Aggregate buyer prices in \( i \) (“\( P_i \)”) are simply a function of aggregate access to world markets in each individual industry, aggregated by expenditure shares. That is, \( P_i \equiv \prod_k (\Phi_j^k)^{\alpha_j^k/1-\sigma_j^k} \). Country \( i \)’s welfare, \( W_i \equiv P_i^{-1} \sum_k p_i^* q_i^k \), is then directly analogous to its real income. Intuitively, national welfare increases with seller prices (as the price of one’s own endowments increases) and decreases with buyer prices (as access to other countries’ endowments improves). To compute aggregate changes in national supplier prices (”\( p_i \)”), I simply compare \( \sum_k q_i^k \) with \( \sum_k p_i^* q_i^k \).\(^{46}\) The overall change in welfare can thus be neatly decomposed into buyer- and seller-side effects on domestic prices: \( \Delta \ln W_i = \Delta \ln p_i - \Delta \ln P_i \).

1.6.2 NAFTA’s Terms of Trade Effects

The first three panels of Table 1.7 then show the simulation results for the effects of NAFTA on price indices and welfare for each of the three specifications shown in Tables 1.1 and 1.2 for each NAFTA country and for an aggregate non-NAFTA group. All changes shown

\(^{45}\)Note that all \( \alpha_j^k \) terms cancel out of (12). However these terms will still be needed for constructing aggregate buyer prices and welfare.

\(^{46}\)Note that one last normalization is needed when we endogenize \( Y \) and \( E \) because the system in (10) is homogeneous of degree zero. So I impose \( \sum_i p_i^k q_i^k = \frac{Y^k}{Y_{1990}} \) both pre- and post-NAFTA, such that total nominal production in each sector stays the same over time.
Table 1.7: Initial Terms of Trade Effects (NAFTA only)

<table>
<thead>
<tr>
<th>Supplier Prices</th>
<th>Buyer Prices</th>
<th>Welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Δ</td>
<td>%Δ</td>
<td>%Δ</td>
</tr>
<tr>
<td>Canada</td>
<td>1.54</td>
<td>-0.69</td>
</tr>
<tr>
<td>Mexico</td>
<td>3.15</td>
<td>-1.96</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.08</td>
<td>-0.15</td>
</tr>
<tr>
<td>ROW</td>
<td>-0.10</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier Prices</th>
<th>Buyer Prices</th>
<th>Welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td>%Δ</td>
<td>%Δ</td>
<td>%Δ</td>
</tr>
<tr>
<td>Canada</td>
<td>1.62</td>
<td>-1.09</td>
</tr>
<tr>
<td>Mexico</td>
<td>7.47</td>
<td>-4.32</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.12</td>
<td>-0.21</td>
</tr>
<tr>
<td>ROW</td>
<td>-0.15</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

Supplier prices and welfare for the ROW region aggregated by output shares.
Buyer prices for ROW aggregated by expenditure shares.
All changes relative to 1990 price and welfare levels, assuming fixed supply quantities.

are relative to the 1990 baseline year. Price and welfare changes for the non-NAFTA group are aggregated by expenditure shares. To establish a baseline, I first note the main features of Panel A, which assumes NAFTA has been no different than any other FTA. Notably, Mexico and Canada show larger net positive benefits from NAFTA than the U.S. This result is intuitive because Canada and Mexico are both relatively small countries compared with the U.S., with Mexico seeing the largest gains because it is the smallest of the three. The Rest of the World, which is also very large, only suffers very mildly from trade diversion.

When I allow for NAFTA to have its own distinct effect on trade costs however (Panel B), we see favorable differences for both buyers and sellers in all three NAFTA countries, with each country realizing roughly 50% larger implied gains than in the baseline case. These results not only re-affirm the message of Panel B in Table 1.1—that NAFTA has been significantly more effective than the average FTA in promoting trade—but also quantify that message in terms of real income effects. What this approach reveals is that using the simplifying assumption of a single average FTA effect across all agreements can greatly distort the true welfare gains from trade liberalization for individual countries, even large ones. NAFTA, of course, is just one example; focusing on other agreements instead would likely reveal further large differences, both positive and negative.

Panel C displays price and welfare results implied by the asymmetric NAFTA effects from Table 1.2. Noting that Mexico had the largest gains in both exports and imports in
Table 1.3, it is unsurprising that the differences in welfare changes between Panels B and C heavily favor Mexico, and that these gains are especially large for Mexican sellers in particular. Clearly, Mexico has benefited the most from NAFTA out of the three countries. It is also reasonable that these gains have come largely at the expense of Canada, who has had the smallest overall increase in market integration from NAFTA, again going by columns 5 and 6 of Table 1.3.

Outcomes for the U.S. and the Rest of the World, however, are much less sensitive to these asymmetries. In part, this lack of an effect is simply due to the fact that the U.S. and ROW are both very big regions. But given the politicization of NAFTA as a supposed “one way” trade deal, the lack of an apparent difference across Panels B and C for either U.S. buyers and U.S. sellers overall is notable. Clearly, as one can infer from Table 1.2, asymmetries within NAFTA work in favor of U.S. seller prices in some industries (e.g. Food, Paper, Chemicals), but fall for others (e.g. Textiles, Wood, Metals). That the differences in the overall price indices turn out to be negligible reflects the observation made in Section 1.4.2 that analyzing asymmetries at the aggregate level understates the heterogeneity in FTA effects that occurs across different industries.

The more interesting comparison, though, is with what would have been expected to happen based on tariff changes. The last panel of Table 1.7 shows the counterfactual for prices and welfare if changes in trade costs were driven solely by the tariff changes shown in Table 1.5.

As we can see, estimating welfare effects based on tariff changes not only greatly underestimates the the magnitudes of the overall gains from NAFTA for all three countries, it also tends to mischaracterizes the composition of each country’s gains. As Panel D shows, estimates based on tariffs alone would suggest U.S. producers benefited from NAFTA at the expense of producers in the other two countries, as well as at the expense of U.S. buyers. Based on Table 1.5, the reason for the large difference in the results between Panel D and the other three panels (particularly Panels B and C) is straightforward: projections based on tariffs alone would suggest that, contrary to the econometric estimates, the U.S. sellers should have gained a relatively large increase in access to the other two NAFTA markets (not just Mexico’s import market, but Canada’s as well).
Thus, welfare benefits from NAFTA, and the attribution of those benefits, unsurprisingly turn out to be very sensitive to the underlying trade cost changes used to estimate them. The asymmetries I have identified in NAFTA’s effects have generally favored Mexico’s terms of trade at the expense of Canada’s, while not necessarily having much of an affect (on average) on either buyers or sellers in the U.S. A particularly dramatic difference can be seen between the price and welfare effects implied by the tariff changes associated with NAFTA versus those implied by ex post estimates. It follows that tariffs may do a poor job of predicting how FTAs shape the gains from trade and that more work should be done understanding other means by which FTAs can affect trade.

1.7 Closing Remarks

The question of how much free trade agreements actually increase trade between countries remains an important, actively studied topic in the trade literature. While most empirical work has focused on identifying how different types of agreements affect trade on average, my refined approach makes it plain that some FTAs increase trade more than others and furthermore that the effects of FTAs are not necessarily symmetric between partners within a particular sector. Accounting for NAFTA’s particular effects on trade in a general equilibrium simulation setting reveals quantifiably large implications for welfare: ignoring these variations both understates the overall gains from trade and also misses important differences in the incidence of price effects for buyers vs. sellers in each country.

A particularly notable empirical finding is that the patterns of market liberalization I identify within NAFTA do not correspond with what would have been expected to happen based on tariffs. This finding turns out to be quite general; differences in the level of development between partner countries have played an important, overlooked role in determining asymmetric effects within FTAs. It is not surprising then that basing welfare predictions on tariff reductions seems to fundamentally mischaracterize NAFTA’s first-order effects on prices. In particular, I show that US sellers did not realize the benefits that would be predicted based on tariffs; these predicted benefits for the U.S. instead accrued (and then some) to U.S. buyers.
I envision there being significant potential for future work both expanding on the approach I have pursued in this chapter and examining the reasons for the differences I obtain. My findings for trade within NAFTA motivate a larger-scale project geared towards characterizing how FTAs with particular provisions tend to affect trade differently for countries with different observable characteristics. For example, further work may consider how FTAs with strong investment provisions may affect trade barriers differently depending on differences in the level of financial development across member countries. It is also worth knowing whether some countries simply tend to gain more market access as a result of FTAs than others, all else equal. These unsettled issues aside, the main messages that this chapter intends to communicate are: (i) directional heterogeneity in FTA effects may differ substantially from what we might expect based on tariffs alone; and (ii) accounting for heterogeneity in FTA effects, especially directional heterogeneity within FTAs, can have important implications for how we quantify the gains from trade.
Part 2

Finding the Influence of Communication on Trade

2.1 Introduction

How much weight should we place on the ability to communicate in a common language as a pre-requisite for economic exchange? Common sense says “a lot”, yet, by and large, empirical studies of the determinants of international trade have traditionally failed to assign much importance to the sharing of common languages. As summarized in Egger & Lassmann (2012), traditional gravity estimates have generally found that not having a shared official language in common can explain about 12% of existing trade frictions between countries.\(^{47}\)

More recent work, epitomized by contributions from Melitz (2008) and Melitz & Toubal (2014, henceforth “Melitz & Toubal”) has explored how introducing more specific data on common spoken languages might reveal a more important role for communication. Melitz (2008), for example, augments the traditional specification of language effects—usually a single dummy variable for the sharing of a “common official language”—with a continuous measure of the combined size of shared native language populations across countries. Melitz & Toubal take this approach one step further by adding further continuous measures for communication in all spoken languages (including non-native languages) as well as for linguistic similarities across non-shared languages. Both studies succeed in finding substantially larger roles for language communication in promoting trade than has been typically estimated using the traditional dummy variable approach.

Nonetheless, other findings in the related literature have given reason to call the interpretation of these findings into question. In another recent paper, Egger & Lassmann

\(^{47}\)As explained in Section 5, this calculation assumes that the elasticity of trade with respect to trade costs equals \(-4\). Egger & Lassmann (2012) specifically find that the partial elasticity of trade with respect to sharing a common language is usually measured to be about 0.44.
(2013) conclude that longstanding cultural frictions between different historical language
groups in Switzerland can explain a large portion of the observed effect of language shar-
ing on Switzerland’s choice of trade partners. In addition, Ginsburgh, Melitz, & Toubal
(2014) offer evidence that it may be exposure to trade that spurs language acquisition,
rather than the other way around. Other recent findings in the more general literature on
shared culture and trade—see, for example, Guiso, Sapienza, & Zingales (2009) and Fel-
bermayr & Toubal (2010)—find that sharing a common language maintains its significance
in presence of controls for cultural biases in some cases, but not in others.

In light of this ambiguity, this chapter seeks to lay out some basic experiments meant
to clarify the relationship between language communication and trade using the gravity
model. Using data on trade and language sharing between 40 countries, I examine
whether estimates of language effects generally behave in a way consistent with the idea
that sharing a common language directly promotes trade through improved communica-
tion channels. In the case of manufacturing trade, I find evidence that shared language ties
do indeed promote trade by facilitating communication. For services trade, however, the
evidence is mixed.

These distinctions may matter significantly for the future of trade. Survey results ob-
tained by the European Commission show that multilingualism in Europe is increasingly
found in, and valued by, younger cohorts in their 20s and 30s relative to the general popu-
lation.48 As these younger generations come of age, the potential improvement in spoken
language communication across countries could affect trade in ways quantifiably similar
to changes in trade policy. Indeed, to the extent a country may choose its language edu-
cation policies strategically, acquiring languages spoken in other countries may actually
be a relatively unique form of trade policy, in that one country may essentially be able to
opt for freer trade without the consent of the other (unlike with, for instance, the bilateral
process usually needed to mutually lower tariffs).

To explore the policy implications of language acquisition, I consider the question of
how language affects the growth of global trade in general equilibrium. This general equi-

48This finding comes from a special edition of Eurobarometer called “Europeans and their Languages”, pub-
ished in 2006. This edition of Eurobarometer is also a primary source for data on spoken language knowledge,
as discussed below.
librium perspective grants me the opportunity to confirm a natural hypothesis that other empirical studies have not quite managed to find evidence for, that English is by far the language that seems to promote trade the most of any other language. Interestingly, I also find evidence that the ranking of other world languages in this context—and of Chinese in particular—might be greatly influenced by the presence of other, non-language barriers to trade having to do with geography and history.

In the remainder of this section, I describe the two main exercises performed in this chapter in more detail. I start by developing my empirical strategy; I then turn to summarizing my findings from the related simulations.

Three hypotheses to test. If we take seriously the idea that sharing common languages promotes trade through the facilitation of communication, there are some natural patterns we should expect to observe in the data. Specifically, I test—and find evidence for—the following three hypotheses regarding how estimates of different combinations of language variables should behave, and under what circumstances.

1. The measured importance of native language ties should increase in the presence of foreign language ties. A key focus of this chapter is how the presence or absence of shared foreign language communication as an additional language regressor fundamentally changes how we should interpret standard variables for measuring common language ties.

Consider, for the sake of illustration, the typical single “common official language” dummy often used in gravity estimation to proxy for the trade-facilitating effects of communication. The standard interpretation of this variable is that it captures the difference between pairs of countries that are able to communicate in native languages versus those that are not. But what does it really mean in this context to not share a common native language? In the absence of a control for shared non-native languages, it may not necessarily mean that much; surely, it is not the case that native English speakers in Australia find it significantly more difficult to understand the English spoken in highly multilingual societies like Denmark or the Netherlands.

When additional controls for the possibility of non-native language communication are present, however, the original dummy representing shared native language communica-
tion suddenly takes on a more concrete interpretation. In this case, the original native language dummy now captures the difference between being able to communicate in native languages and not being able to communicate at all, in any language. Accordingly, if it really is the importance of communication that drives the observed relationship between shared language ties and trade, it is natural to expect that adding foreign language ties to the specification should result in the following: (i) the variable representing foreign language ties itself should be a significant predictor of bilateral trade; (ii) the original variable representing the sharing of a native language should increase in magnitude.\(^{49}\)

My benchmark estimates confirm this basic pattern in the data, using the continuous measures for native and spoken language introduced in Melitz (2008) and Melitz & Toubal. The effect of native language communication increases in magnitude in the presence of foreign language communication, in accordance with the idea that both variables do indeed represent the importance of communication. The increase in the magnitude of native languages is especially pronounced when I allow for the possibility of diminishing returns to communication in manufacturing trade. The presence of these diminishing returns also seems to have an intuitive explanation, as I discuss in the context of point 2 below.

2. The degree of communication should be associated with trade in tangible goods versus trade in services in very different ways. As Timmer (2012) discusses, trade in manufactured goods is fundamentally different from trade in services in that, among other things, trade in services often require a much more intimate relationship between the producer in one country and the end-consumer in another. Put another way, typical service transactions—such as doctor’s visits, patronizing a hotel or restaurant, or attending a university—are much more likely to be characterized by one-on-one interactions rather than the firm-to-firm interactions that typically characterize manufacturing trade.

Indeed, my empirical results suggest several important differences how common languages affect manufacturing trade vs. services trade. For example, my benchmark estimations show that sharing a common language, native or otherwise, seems to exhibit a

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\(^{49}\)Obviously, the process of foreign language acquisition itself is likely subject to cultural influences. Nonetheless, I would argue that, since foreign language ties across countries are much more recently formed than native language ties, they should be more likely to reflect the direct, practical benefits of benefits of communication. Furthermore, the category “foreign language communication” also includes many cases where two countries happen to coordinate independently on acquiring the same language (usually English).
stronger relationship overall with services trade than manufacturing trade. At the same time, I also find that the effect of shared language communication in the data tends to exhibit “diminishing returns” for manufacturing, but not for services. That is, the marginal effect of common language ties for manufacturing seems to be large initially, but diminishing in magnitude as the degree of language ties becomes stronger. For services trade, however, the relationship between common spoken languages and trade seems to be much more linear by comparison.

A seemingly intuitive explanation for this latter difference is that manufacturing trade exhibits what Melitz (2008) calls “translation effects”. In other words, trade in goods might benefit disproportionately from the presence of relatively small bilingual populations who can specialize in the intermediation of cross-border relationships. Services trade, by its own nature, would seem to offer fewer opportunities for specialization and intermediation.

3. **The relationship between shared foreign languages and trade should be robust to concerns about reverse causality and omitted variable bias.** An important issue with the cross-country data on foreign language knowledge is that it is mainly cross-sectional; thus it is difficult to observe how trade has evolved over time in response to the acquisition of foreign languages.

   Using a set of instruments inspired by the recent literature—linguistic proximity, past cold war divisions, and shared exposure to the native languages of third countries—I find mixed evidence for the causal effect of foreign language communication on trade. On the one hand, my IV estimates for manufacturing trade do tend to find significant causal effects for shared languages; indeed, they actually suggest that estimates that treat foreign languages as exogenous tend to exhibit a downward bias, rather than an upward bias.

   Interestingly, my IV estimates for services do not identify a significant causal effect for communication. Drawing on the discussion underneath point 2 above, a potential explanation is that, because services trade is more dependent on individual consumer decisions, it also may be especially sensitive to individual cultural biases, which may be an especially

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50 Ku & Zussman (2010) use the combined linguistic similarity with English for non-English speaking pairs as an instrument for English proficiency. Fidrmuc & Fidrmuc (2014) consider an experiment where they estimate language effects only for trade flows that cross between Eastern and Western Europe. Both find significant causal effects for language proficiency on manufacturing trade. The question of whether causal effects can be identified for services trade has not been explored.
important omitted variable for services trade relative to manufacturing trade.

In addition, there is an important corollary worth noting that follows directly from the first point emphasized above: the magnitude of the coefficient obtained for native language ties should generally move in sympathy with the coefficient obtained for foreign language ties. If the effect of foreign language communication on trade is downward biased due to trade, estimates of the native language effect should exhibit that same bias. My IV estimates for manufacturing do indeed exhibit this same general pattern, as does the specification with diminishing returns discussed above.

**Total Language Effects.** A related question that comes up frequently in this literature is, “which languages promote trade the most?” Or, more narrowly, “does English promote trade the most of any language?”

A standard approach to answering these questions is to focus on how communication in English (or in other major European languages) might reduce bilateral trade frictions moreso than communication in other languages. Melitz (2008), for example, finds some evidence that native language communication in European languages promotes bilateral trade more strongly than in non-European languages; Melitz & Toubal, however, find that the evidence is mixed when non-native language communication is taken into account.\(^{51}\)

In contrast to these existing studies, I try to adopt a complementary approach. I start from the general principle that, in the abstract, the ability to communicate in a common language should generally reduce trade frictions between two countries in more or less the same way, regardless of the underlying language. Because the countries of the world differ both in economic size and in the languages they already speak, motivations for learning different languages can be divined simply based on which ones offer the largest increases in overall access to world markets.

To determine these “Total Language Effects”, I examine how increasing the world’s language knowledge promotes overall openness to trade via reduced trading frictions in general equilibrium. Unsurprisingly, English is reasonably unchallenged as the language that promotes trade the most in general equilibrium; this result follows directly from the

\(^{51}\) Also see Fidrmuc & Fidrmuc (2014) for a comparison of the effects of different European languages on an individual basis and Ku & Zussman (2010) for detailed examination of English in particular.
number and size of the countries that already speak English, natively or otherwise.

What is surprising, however, is the degree to which the ranking of other languages is conditional on the existence of large non-language trade barriers having to do with the forces of history and geography (e.g. bilateral distance between countries, the presence of a former colonial relationship, etc.). In simulations based on my gravity estimates for trade costs, the other major non-English languages I consider seem to have more or less the same overall effects on globalization. When I remove all non-language barriers, however, Chinese suddenly figures much more prominently as a competitor to English as a competing language for promoting world manufacturing trade. It follows that the forces of geography and history that have forged trade ties over time have also likely had the effect of limiting Chinese’s appeal as a global language. Perhaps in the future, as these other barriers fade with time, foreign language learning in non-European languages besides English may fade in favor of Chinese.

The structure of this chapter is as follows. Section 2.2 describes the empirical implementation of the structural gravity model, which will be applied to estimate trade costs both for manufacturing trade and for services trade. Section 2.3 describes data sources and construction methods for trade, language, and other co-variates. In Section 2.4, I present and discuss the empirical results. Section 2.5 explores Total Language Effects. Section 3.5 then concludes.

### 2.2 Gravity estimation

The general theoretical gravity model assumes an $N$ country world with costly trade in differentiated goods and countries that differ in their productive abilities. Exports from exporting country $i$ to importing $j$ (denoted $X_{ij}$) can be written simply as

$$X_{ij} = \tilde{S}_i p_i^\theta \Phi_j^\theta \cdot E_j,$$

where $\tilde{S}_i$ is a country-specific productivity parameter, $p_i$ is the supply price for producers in $i$, and $E_j$ denotes aggregate expenditure in $j$. The trade elasticity, $\theta$, is assumed to be less
than $-1$, such that $t^\theta_{ij} \in (0, 1]$ is decreasing in the degree of “trade costs”, $t_{ij}$. $\Phi_j \equiv \sum \tilde{S}_i p^\theta_i t^\theta_{ij}$ then aggregates country $j$’s ability to access world markets in general as a buyer of goods (and therefore doubles as a notion of $j$’s overall price index).\(^{52}\)

To make more explicit the analogy with Newtonian gravity (such that both country sizes enter directly), (14) can be re-written as

$$X_{ij} = \frac{Y_i}{\Omega_i} \frac{E_j}{\Phi_j} t^\theta_{ij},$$

(15)

where $Y_i = \sum_j X_{ij}$ gives total production by country $i$ across all destinations and $\Omega_i \equiv \sum_j E_j t^\theta_{ij}/\Phi_j$, an analogue to $\Phi_j$, aggregates country $i$’s access to world markets as a seller of goods.\(^{53}\) Following Anderson & van Wincoop (2003), the structural terms $\Omega_i$ and $\Phi_j$ are commonly referred to as “multilateral resistances”, in that they collectively describe how trade between any pair of countries is influenced not only by the direct cost of trade with one another, but also by each country’s ability to access world markets in general.

For estimation purposes, $t^\theta_{ij}$ is the clear parameter of interest. When two countries have stronger shared language ties with one another, all else equal, $t^\theta_{ij}$ should be larger, such that inferred trade costs are effectively smaller.\(^{54}\) The remainder of this section is devoted to developing the empirical methodology used to test this general hypothesis, as well as the more specific hypotheses highlighted in the introduction. As explained below, I will proceed by using Poisson PML estimation as a benchmark and by also then considering various instrumental variables approaches.

\(^{52}\)The generalized presentation of the gravity model used here is adapted from Head & Mayer (2014). Presenting gravity in this way is intended to emphasize that many different theoretical motivations for gravity converge to this same essential structure. For example, in Anderson & van Wincoop (2003), “$\tilde{S}_i p^\theta_i$” is written instead as “$(\beta_i p_i)^{1-\sigma}$”. More generally, the $t^\theta_{ij}$ term could be replaced with $\phi_{ij} \equiv t^\phi_{ij} f^\phi_{ij}$, in recognition of the idea that bilateral trade costs can have variable as well as fixed cost components, as in gravity models based on Melitz (2003).

\(^{53}\)This substitution—$\tilde{S}_i p^\theta_i = Y_i/\Omega_i$—follows directly from the accounting identity $Y_i = \sum_j X_{ij}$.

\(^{54}\)In this way, I am abstracting from the distinction between “intensive” and “extensive” margins of trade emphasized in Helpman, Melitz, & Rubinstein (2008). The two empirical approaches are equivalent provided that the (Pareto) distribution of firm productivities is unbounded, as in Chaney (2008).
2.2.1 Implementing gravity

As is standard in the gravity literature, I assume that the trade cost term $t_{ij}^\theta$ can be specified as an exponential function of a set of covariates of interest. Let $d_{ij}$ denote a typical set of controls for geographical, historical, and/or cultural influences on trade costs and let $LANG_{ij}$ be a vector of language-specific variables. To anticipate concerns regarding bias due to endogeneity, as well as due to other estimation issues, I also assume the presence of a (multiplicative) error term, $\omega_{ij}$, which follows an unknown distribution and may or may not contain omitted regressors correlated with $LANG_{ij}$.

The trade cost term $t_{ij}^\theta$ can thus be parameterized as

$$t_{ij}^\theta = \exp (d_{ij}\beta + \delta LANG_{ij}) \cdot \omega_{ij}, \quad (16)$$

where the exact contents of $d_{ij}$ and $LANG_{ij}$ will be specified shortly. To fix ideas, consider that geographic distance between pairs (which is exogenous) is an important component of $d_{ij}$ and that communication in learned foreign languages (which may or may not be endogenous) is an important component of $LANG_{ij}$.

Combining (14) and (16), and also introducing exporter- and importer- fixed effects terms, yields the following estimating equation for trade as a function of $d_{ij}$ and $LANG_{ij}$:

$$X_{ij} = \exp (FE_i + FE_j + d_{ij}\beta + \delta LANG_{ij}) \cdot \omega_{ij}, \quad (17)$$

which can also be expressed as

$$X_{ij} = \exp (FE_i + FE_j + d_{ij}\beta + \delta LANG_{ij}) + \nu_{ij} \quad (18)$$

under the (more common) assumption of an “additive” error term $\nu_{ij} \equiv (\omega_{ij} - 1) \cdot \exp (FE_i + FE_j + d_{ij}\beta + \delta LANG_{ij})$. In either presentation, note that the fixed effects terms $FE_i$ and $FE_j$ effectively absorb all influences on trade not directly related to bilateral trade costs in (14) (and likewise in (15)). Therefore, the correct interpretation of $\delta$—noting that $FE_i$ and $FE_j$ both depend endogenously on $t_{ij}^\theta$—is as the partial effect of $LANG_{ij}$ on $X_{ij}$, via its direct
effect on $t_{ij}$.\textsuperscript{55}

Suppose for now that $\text{LANG}_{ij}$ can be treated as exogenous. Consistent estimation of $\delta$ (and $\beta$ for that matter) can still depend non-trivially on the behavior of the error term $v_{ij}$. As Santos Silva and Tenreyro (2006) point out, if there is heteroskedasticity in the data, a log-linearized OLS estimation equation based on (17) will only give consistent parameter estimates under certain restrictions on the distribution of the error. Specifically, OLS is only consistent if the variance of $v_{ij}$ is proportional to the square of the conditional mean. Put another way, just because $E(\omega|x) = 1$ does not necessarily imply that $E(\ln \omega|x) = 0$.

As an alternative to OLS, Santos Silva and Tenreyro recommend the use of Poisson Pseudo-maximum Likelihood (or “PPML”) for obtaining gravity estimates.\textsuperscript{56} The idea behind PPML is to estimate the nonlinear expression in (18) directly, under the assumption that the variance of $v_{ij}$ is directly proportional to the conditional mean, rather than to its square. Because PPML is a nonlinear estimator, it will produce consistent estimates even if this assumption is not met. Furthermore, Santos Silva and Tenreyro show that PPML is relatively robust to small-sample bias when the distribution of the error term is misspecified, as well as when the dependent variable features systematic rounding errors (such as those found in trade data).\textsuperscript{57} Accordingly, I follow their recommendations in using PPML to obtain benchmark estimates.

Of course, the adoption of PPML does not fully address concerns related to consistency when one or more of the regressors is endogenous. In the discussion that follows, I develop an instrumental variables strategy that should obtain consistent estimates of the nonlinear gravity model in the presence of endogenous regressors. Later in the paper, I also take the opportunity to compare my benchmark PPML estimates with those that would be obtained using OLS, in addition to those that would follow from both linear and nonlinear instrumental variables approaches.

\textsuperscript{55}In order to obtain the full effect of $\text{LANG}_{ij}$ on trade in a given pair, it is necessary to re-constitute its influence on the whole system of $p_i$, $E_i$, and $\Phi_j$ terms using the structural model. Section 5 adds discussion on these general equilibrium linkages.

\textsuperscript{56}Further arguments in favor of PPML have been put forward in recent years by Santos Silva & Tenreyro (2011), Fally (2014), and Egger & Staub (2014). Head & Mayer (2014) offer a dissenting view.

\textsuperscript{57}Another motivation that is often given for using PPML is the prevalence of “zeros” in the trade data, especially for trade data featuring many small countries or highly disaggregated industry-level flows. While the services trade data I use does feature some zeros (roughly 1.2% of the observations), the manufacturing trade data does not feature any.
2.2.2 IV estimation

To simplify discussion of the potential endogeneity to trade of shared non-native languages, I will treat all such potential endogeneity as occurring due to an "omitted variable" problem. Obviously, the possibility of "reverse causality" is one logical reason why estimates of $\delta$ in (18) may be biased. Indeed, a recent paper by Ginsburgh, Melitz, & Toubal (2014) finds that trade may have an important causal effect on language learning. Put in terms of omitted variables, there may exist unaccounted-for historical and/or cultural determinants of trade relationships which have promoted foreign language acquisition in the past through increased exposure to trade. Since these unmodeled determinants of trade appear in the error term, positive association between $\omega_{ij}$ and $LANG_{ij}$ would cause benchmark estimates of $\delta$ to exhibit an upward bias.

On the other hand, if foreign language does indeed have its own independent causal effect on trade, it could conceivably be the case that $LANG_{ij}$ might be negatively correlated with the error term; in which case, benchmark estimates of $\delta$ would actually exhibit a downward bias. That is to say, countries that face higher omitted trade barriers may be more likely to invest in language learning as a way of gaining better access to world markets. For example, Slovenia and Australia can be fairly said to have minimal cultural or historical ties, yet they have very strong shared language ties because of the large number of Slovenians that speak English non-natively. This latter type of argument is standard in the empirical trade policy literature; Baier & Bergstrand (2007), for instance, find that the causal effects of free trade agreements tend to be underestimated for a very similar reason.

Because the series on language data is purely cross-sectional, it is necessary to introduce an instrumental variables (IV) estimator, with well-chosen instruments, in order to obtain consistent estimates of $\delta$. Specifically, I adopt the "IV-T" Generalized Method of Moments (GMM) estimator proposed by Mullahy (1997) for use with non-linear models of the type shown in (17).\(^{58}\) Essentially, the IV-T estimator requires that a set of instruments

\(^{58}\)The "T" in IV-T stands for "transformation". It is so called because the standard (additive) residual must first be transformed into a multiplicative term (as in (17)) before moment conditions are imposed in order to obtain consistent estimates.
$Z$ must be chosen such that

$$E[\omega|Z] = 1, \quad (19)$$

where $\omega$ again represents the multiplicative residual from (17) and may be thought to obtain omitted regressors. Standard moment conditions based on (19) can then be used to construct a GMM estimator which will give consistent inferences for both $\beta$ and $\delta$.\(^{59}\)

The IV-T estimator has two primary advantages in this context. First, it preserves the nonlinear structure of (17), without requiring linear transformations which may introduce additional sources of bias. Second, it specifically addresses the possible presence of an omitted regressor contained within the multiplicative error term $\omega$. Other nonlinear IV-GMM strategies based on the assumption of an additive error term, as in (18), are by construction less suited to deal with omitted regressors that enter the model in the same fashion as the included regressors.\(^{61}\)

For comparison’s sake, I also wish to consider the canonical two-stage least squares (2SLS) estimator as an alternative IV strategy. Obviously, 2SLS requires a linear model; thus the original model in (17) must be transformed and expressed instead as

$$\ln X_{ij} = FE_i + FE_j + d_{ij}\beta + \delta LD_{ij} + \ln \omega_{ij},$$

Given a set of instruments $Z$, the relevant orthogonality condition for identification in this case is

$$E[\ln \omega|Z] = 0. \quad (20)$$

\(^{59}\)In general, consistent estimation could follow from requiring $E[\omega|Z]$ be equal to any constant. I follow Mullaha (1997) in using 1 as a normalization.

\(^{60}\)In practice, the IV-T estimator can be easily computed in Stata, as of Stata v. 13, using the -ivpoisson gmm- command with the “multiplicative” option specified. The weighting matrix needed to construct the GMM objective function is constructed using the standard “two step” procedure, with $(Z'Z)^{-1}$ as the initial weighting matrix. As with all GMM estimators, consistency follows from a standard set of regularity conditions; see Davidson & MacKinnon (1993), ch. 17, for a reference.

\(^{61}\)Another gravity paper that deals with a similar issue is Egger, Larch, Staub, & Winkelmann (2011), who use a special estimator devised by Terza (1998) for nonlinear regressions with a binary endogenous variable (in their case, the presence of a preferential trading agreement). The unique challenge here is that the endogenous variable of interest is treated as continuous. Thus, as far as I am aware, this work is the first to apply the IV-T estimator specifically to gravity estimation.
At this point, it is worth emphasizing that, conditional on the existence a set of instruments $Z$ such that (20) can be satisfied, the 2SLS estimator will indeed deliver consistent parameter estimates, despite the linear transformation of the original model. This argument simply follows from the standard motivation for using 2SLS when there is expected correlation between the error term and one of the regressors, and where valid instruments are in place.

In practice, however, regardless of the “instruments” chosen specifically to control for the endogeneity of $LANG_{ij}$, the full instrument set $Z$ will typically also include the “exogenous” regressors $d_{ij}$. The inclusion of $d_{ij}$ is potentially problematic here since, by the argument described above, the linear transformation of (17) may result in unwanted correlation between $d_{ij}$ and $\ln \omega_{ij}$ (on top of the presumed correlation between $LANG_{ij}$ and $\ln \omega_{ij}$ due to endogeneity). Therefore, one would not generally expect 2SLS to give consistent inference of $\delta$, except under the special circumstances noted above. Nonetheless, comparing IV-T and 2SLS results, and in turn comparing each with their respective counterparts (PPML and OLS) should provide an informal ranking of the different potential sources of bias (i.e. endogeneity vs. specification error).

Naturally, regardless of the underlying IV estimator, valid parameter inference fundamentally requires the selection and verification of appropriate instruments for foreign language acquisition. I defer this discussion as part of the next section, which describes all data to be included in estimation.

2.3 Data

2.3.1 Trade

For trade data, I use trade values from the 2006 World Input-Output Table from the World Input-Output Database (henceforth, “WIOT”).\textsuperscript{62} WIOT features production, expenditure, and trade flow patterns for 41 trading regions across 35 ISIC rev. 2 sectors (summarized below). The underlying raw data for trade in manufactured goods is taken from UN

\textsuperscript{62}See Timmer (2012) for a complete reference on the contents of the WIOT data set. Also see the WIOD website, www.wiod.org, for examples of recent trade papers that have used WIOT data for empirical gravity analysis.
COMTRADE, supplemented with additional data from both the OECD and from national sources. For trade in services, WIOT combines independent data sets from the UN, the IMF, the OECD, as well as Eurostat.\(^63\)

The 2006 WIOT data has three main advantages for these particular purposes. First, it notably includes values for each country’s “internal trade” (a.k.a. “domestic sales”, constructed as gross output less total exports). As argued in Anderson and van Wincoop (2003, 2004), it is relative trade barriers (rather than absolute trade barriers) that determine the pattern of trade; the inclusion of internal trade observations thus provides a basis against which the determinants of international trade flows can be isolated. Furthermore, the inclusion of internal trade is required for performing general equilibrium simulation exercises, such as those performed in Section 5.

Second, the countries included in the data notably cover all 29 countries surveyed in the 2006 *Eurobarometer* study on foreign language knowledge among European citizens (described more below). The emphasis on this particular data source is warranted because it is arguably the most comprehensive source of foreign language knowledge among the different sources consulted by Melitz & Toubal. Naturally, I choose to work with 2006 trade flows in order for the trade data to be contemporaneous with the data collected for this study.

Third, the inclusion of trade in services is also worth emphasizing because, as argued at the outset, shared language ties could conceivably have different effects on services trade than on other types of trade. In addition, because data on services trade has only been made available relatively recently, the potential effects of shared languages specifically on services have not been thoroughly studied.

**Manufacturing vs. services.** To draw a fundamental distinction between trade in “manufacturing” and trade in “services”, I group the different industries in the data according to the breakdown shown in Table 2.1.

As can be seen from the different groupings, international flows in services are concep-

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\(^63\) As noted in Timmer (2012), these different data sources frequently suffer from inconsistencies. The trade data for services thus reflects “extensive adjustments” should therefore be thought of as a “best possible approximation”, especially relative to the manufactured goods trade data, which is mainly drawn from a standard source.
Table 2.1: WIOT Industry Groups

<table>
<thead>
<tr>
<th>Industry group</th>
<th>Included industries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturing</strong></td>
<td>Agriculture, Forestry, and Fishing; Mining and Quarrying; Food, Beverages, and Tobacco; Textiles and Textile Products; Leather, Leather and Footwear; Wood and Cork Products; Pulp, Paper, Printing and Publishing; Coke, Refined Petroleum and Nuclear Fuel; Chemicals and Chemical Products; Rubber and Plastics; Other Non-Metallic Minerals; Basic Metals and Fabricated Metal; Machinery, n.e.c.; Electrical and Optical Equipment; Transport Equipment; Manufacturing, n.e.c. (incl. Recycling)</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Electricity, Gas, and Water Supply; Construction; Sale, Maintenance, and Repair of Motor Vehicles (incl. Retail Sale of Fuel); Wholesale Trade and Commission Trade (exc. Motor Vehicles); Retail trade (exc. of Motor Vehicles, includes Repair of Household Goods); Hotels and Restaurants; Inland Transport; Water Transport; Air Transport; Other Transport Activities (incl. Travel Agencies); Post and Telecommunications; Financial Intermediation; Real Estate Activities; Renting of Machinery and Equipment; Public Administration; Education; Health and Social Work; Other Social Services; Private Households with Employed Persons.</td>
</tr>
</tbody>
</table>

WIOT industry classifications are based on standard CPA and NACE rev. 1 (ISIC rev. 2) industry classifications.

Tuitually very different than trade flows in manufactured goods. A given country’s “exports” of a service can include services provided within one’s own borders to foreign nationals, such as the patronage of that country’s hotels and restaurants, as well as the provision of services by its own nationals within another country’s borders, such as financial services and the establishment of local retail operations. Naturally, they can also include direct cross-border services as well, such as transportation and telecommunications.

The “manufacturing” industry grouping, by contrast, can be more clearly characterized by the movement of physical goods from a producing party in one country to a purchasing party in another country. Traditionally, gravity estimation of “trade flows” has focused mainly on goods of this type, with the exception of agriculture and mining, which are not always included.

**Finalizing the number of countries.** Explicitly, the 41 trading regions in the WIOT data are: Australia, Austria, Bulgaria, Belgium, Brazil, Canada, China, Cyprus, the Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, South Korea, Lithuania, Latvia, Luxembourg, Mexico, Malta, Netherlands, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Sweden, Turkey, Taiwan, the United Kingdom, the United States, and an aggregate “Rest of the World” region.
Since Melitz & Toubal combine Belgium and Luxembourg into a single region in their language data (“Belgium-Luxembourg”), I do the same here. I also omit the “Rest of the World” (RoW) since, once internal trade has been imputed for every country in the data, the key variables of interest can be identified without including it based on variation across the remaining countries in the sample. The resulting sample is a square block of 39 countries by 39 countries (= 1,521 observations) each for both manufacturing and services trade. As noted above, the estimation will include both language covariates as well as other standard gravity controls; I now turn to describing the origin of these variables.

2.3.2 Language variables

Data on the languages of each country (both natively spoken and non-natively spoken) are taken mainly from Melitz & Toubal’s appendix, augmented in some special cases as noted below. Melitz & Toubal’s language data draws on several different sources, which are of different utility depending on whether the variable of interest is the number of native language speakers or the number of non-native language speakers. I also follow Melitz & Toubal’s characterization of each country’s “official” languages.

Spoken language data. Data on foreign language speaking is generally more difficult to obtain than data on the prevalence of native languages. The best source for foreign language knowledge, prominently used in both Melitz & Toubal as well as Fidrmuc and Fidrmuc (2014), is a special edition of Eurobarometer published by the European Commission in 2006 with explicit survey data on language speaking (for both native and foreign languages) for 29 different European countries. An important contribution of Melitz & Toubal then is to augment the Eurobarometer survey with other sources to develop a fuller data set for foreign language knowledge. These sources are mainly studies and encyclopedia entries that focus on the prevalence of particular major European languages (e.g.

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64 Nonetheless, it is possible to obtain estimates for trade costs between the Rest of the World and any other region using fixed effects for RoW-trade in the estimation. This fixed effects approach does not affect the estimates of the covariates of interest, nor does it add any degrees of freedom. It does allow me to include RoW in my general equilibrium experiments, however.

65 The actual survey data was collected in November and December of 2005. The specific question asked for the survey is “Which languages do you speak well enough to have a conversation, excluding your mother tongue?” (Multiple answers are permitted.)
English, French) in countries that do not speak these languages natively.\textsuperscript{66}

However, a notable limitation of these data sources is that they do not provide information on the number of English speakers for several countries where English is known to be a commonly-pursued second language. For this particular sample, the affected countries are Brazil, China, Indonesia, South Korea, and Taiwan. To address this shortcoming, I follow Ku & Zussman (2010) in using a country’s TOEFL scores as an indication of its overall English speaking ability. Comparing TOEFL scores for countries with data on English speakers versus those without then allows me to infer the number of English speakers for these remaining countries.\textsuperscript{67}

For native language speaking, reliable data sources do exist for the number of native language speakers of many different languages across many different countries, most notably Ethnologue (2009) and the CIA World Factbook.\textsuperscript{68} Melitz & Toubal’s native language data combines additional survey data from Eurobarometer (“What is your maternal language?”) with these other sources, as well as the same supplemental sources used for foreign language knowledge.\textsuperscript{69} Adding together the percentage of a country’s population that speaks a particular natively with those that speak it non-natively then gives the total percentage of speakers in that country.

**Construction of language variables.** An ideal index for communication in spoken languages should reflect the probability that two people chosen randomly from different countries both speak the same language. Melitz (2008) establishes a protocol for obtaining such an index for native language communication, which I will abbreviate as “NL”, by summing the products of the percentage of speakers of each language that is spoken by at least 4% of the population in each country.

\textsuperscript{66}See the data appendix included with Melitz & Toubal for a full description of their sources and methods.

\textsuperscript{67}Specifically, I use the TOEFL Test Score and Data Summary, made available by ETS, for tests taken between July 2005 and June 2006. To construct fitted values, I performed a regression of the percentage of each country’s population that speaks English (using Melitz & Toubal’s data) on country-level TOEFL scores (weighting by the number of test-takers in each country). The resulting values are as follows. Brazil: .2; China: .13; South Korea: .13; Indonesia: .12; Taiwan: .11. I would still obtain qualitatively similar results without including the number of English speakers for these countries; their inclusion does noticeably improve the fit of the model, however.

\textsuperscript{68}Melitz (2008) relies principally on these two sources.

\textsuperscript{69}I also update the native language data from these same sources in some isolated cases. For example, Melitz & Toubal leave out the percentage of Estonians who report Estonian as a maternal language on the basis that it is not widely spoken outside of Estonia.
This indexing method generally gives values between 0 and 1 for native language communication. For spoken language communication, however (which includes communication in learned foreign languages), the double-counting of multilingual populations becomes an issue and the Melitz (2008) method thus may result in values greater than 1 for some country pairs (such as the Netherlands and Belgium, for example).

Accordingly, Melitz & Toubal devise an updated method for indexing the degree of spoken language communication between two countries. Let $S_l^i$ be the percentage of the population in country $i$ that speak language $l$ (either natively or non-natively). In addition, define $\alpha_{ij} = S_l^i \cdot S_j^l$ as the product of population shares that speak language $l$ for country pair $(i, j)$, such that $\alpha_{ij} = \sum_l \alpha_{ij}^l$ gives the communication index that would be computed under the Melitz (2008) indexing method. The Melitz & Toubal “common spoken language” index, which I will refer to as “$SL$”, is then given by

$$SL_{ij} = \max_l (\alpha_{ij}^l) + \left( \alpha_{ij} - \max_l (\alpha_{ij}^l) \right) \left( 1 - \max_l (\alpha_{ij}^l) \right). \quad (21)$$

Intuitively, whenever spoken language communication is predominantly through one language, $\max_l (\alpha_{ij}^l)$ and $\alpha_{ij}$ will be similar and there will be very little difference between the Melitz (2008) and Melitz & Toubal indexing methods. The Melitz & Toubal method operates by placing more weight on secondary language ties if $\max_l (\alpha_{ij}^l)$ is significantly different than 1; if it is not, these additional language ties are assumed to reflect the common presence of multilingual speakers in each country. In practice, this method succeeds at providing a full range of values for $SL$ that fall between 0 and 1.

However, my main object of interest is not actually “spoken language communication” as in Melitz & Toubal, but rather “foreign language communication” specifically. To construct this latter variable, I construct series for both native language ties ($NL$) and spoken language ties ($SL$) using the Melitz & Toubal method described above. I then construct a new variable for foreign language communication, which I term “$FL$”, as the difference between these two series (that is, $FL \equiv SL - NL$).  

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70This approach differs slightly from Melitz & Toubal, who stick with the original Melitz (2008) methodology for constructing their native language communication index. I use the same method for both $NL$ and $SL$ so that the decomposition of $SL$ into $NL$ and $FL$ is consistently defined.

71As such, $FL$ reflects cases where one country has learned the native language of the other as well as cases
Finally, in addition to NL and FL, I also include a dummy variable for the sharing of a “common official language”. This variable is again sourced from Melitz & Toubal. As the inclusion of a common official language dummy is standard in the gravity literature, I will generally place more emphasis on the results regarding the continuous measures of shared language ties, NL and FL. A reasonable expectation regarding these three variables collectively is that NL and FL should serve as more specific measures of the effect of shared languages on trade; therefore, “common official language” should diminish in importance in the presence of the other two variables.

### 2.3.3 Other controls

For the non-language controls, I have again tried to adhere closely to the same empirical design found in Melitz & Toubal. The resulting set of covariates thus includes several standard controls for both geographical ties between countries—i.e. the log of bilateral distance and a dummy variable the sharing of a common border—as well as for past historical ties between countries—i.e. dummy variables for a former colonial relationship as well as for the sharing of a common colonizer. These standard covariates are taken from the CEPII Gravity database, which was first established in a paper by Head, Mayer, & Ries (2010).

In addition, Melitz & Toubal also carefully construct several additional variables to help proxy for other potential sources of historical and/or cultural ties between countries that might be correlated with language ties. These additional variables include the following:

- A dummy variable for the sharing of a common legal system (in this case either Common Law or Civil Law), constructed using the JuriGlobe database.\(^{72}\)

- A continuous variable for the sharing of similar religions. Melitz & Toubal construct this variable in a similar fashion to their language variables (i.e. using common pop-

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\(^{72}\)The WIOT sample includes mainly Common Law or Civil Law countries. The exceptions are China, Cyprus, Japan, Malta, and South Korea, which each have their own idiosyncratic designations.
ulation shares) using a variety of sources for religious populations across different countries.\footnote{These sources are: The CIA World Factbook, the International Religious Freedom Report (U.S. Department of State, 2007), the World Christian Database (Spomer, 2014), and the Pew Forum (2009).}

- A continuous variable indexing the amount of time two countries have spent at war with one another since 1823. This variable is constructed using the Correlates of War Project (COW) Inter-State War database v. 4.0.

Lastly, I also include a dummy variable for internal trade (i.e. for a country’s sales in its own market). Including this variable is a useful way of recognizing that countries tend to exhibit strong “home bias” in production; that is, relatively little of what they produce actually crosses international borders. The inclusion of this dummy is also relatively standard for gravity estimation with square datasets; see, for example, Anderson & Yotov (2010a).

Drawing on (18), I can describe a detailed specification of the gravity equation as follows:

\[
X_{ij} = \exp(\text{FE}_i + \text{FE}_j + \beta_1 \log \text{of distance}_{ij} + \beta_2 \text{Common border}_{ij} + \beta_3 \text{Ex colonizer/colony}_{ij} + \beta_4 \text{Common religion}_{ij} + \beta_5 \text{Common legal}_{ij} + \beta_6 \text{Years at war}_{ij} + \beta_7 \text{Internal trade}_{ij} + \delta_{OL} \text{Common official language}_{ij} + \delta_{NL} \text{NL}_{ij} + \delta_{FL} \text{FL}_{ij}) + \nu_{ij}
\]  

(22)

As noted above, I estimate (22) using PPML in order to obtain benchmark estimates for both the language and non-language covariates. Addressing the potential endogeneity of \(FL\) (using the IV-T estimator) requires selecting good instruments for \(FL\) which not otherwise related with trade, which here is not an easy task; I discuss the difficulties of finding good instruments in the discussion that follows.

2.3.4 Instruments

It cannot be helped that language ties and trade relationships have each formed over a long period of time through closely-intertwined historical processes. The nature of the data is strictly cross-sectional; thus, the ideal goal of finding instruments which are purely
exogenous to trade, such that one can perform a true “natural experiment”, most likely is not feasible.\(^{74}\) Instead, I focus on finding instruments that meet the (weaker) standard of partial exogeneity. That is, I am interested in additional bilateral covariates whose own direct influence on trade seems to be reasonably controlled for by the existing controls already included in the baseline regression (including the exporter- and importer-specific fixed effects).

Take the degree of similarity between differing national languages, which I consider below as a possible instrument. Several studies have found “linguistic proximity” (or “LP”) to be significant as an independent predictor of trade frictions; see, for example, Hutchinson (2005), Ispphording & Otten (2013), as well as Melitz & Toubal. I do not intend to argue that trade does not vary with linguistic proximity. Rather, the relevant argument is that linguistic distance itself may be sufficiently correlated with the non-language covariates specified above such that linguistic distance’s partial effect on trade barriers (other than through their effect on foreign language ties) may be negligible.\(^{75}\)

In addition to linguistic proximity, the other two instrumental variables I consider involve past cold war divisions as well as common spoken language ties with outside countries. Below, I describe the construction of each of these variables. I also describe the approach I take to examining instrument validity.

**Linguistic proximity.** Alongside their new data on shared languages, Melitz & Toubal also introduce an innovative new series on linguistic proximity across languages, constructed using similarities of individual words scored by the Automated Simulated Judgment Program, or ASJP.\(^{76}\) As Melitz & Toubal argue, the effect of LP on trade should reflect the ease of

\(^{74}\)Fidrmuc & Fidrmuc (2014) propose focusing on pairs that were formerly on opposite sides of the cold war as a possible “natural experiment” in this context. Accordingly, I adopt cold war divisions as a possible instrument in this context and discuss its merits below.

\(^{75}\)It may be reasonable to expect, for example, linguistic distance’s independent effect on trade could be partially controlled for by the geographic distance between countries and/or the presence of a common border. I do show in the results that follow that the independent effect of linguistic proximity is very nearly zero in my PPML regressions, both for manufacturing and for services.

\(^{76}\)See Brown, Holman, Wichmann, & Velupillai (2008). Basically, for any two languages, the ASJP program selects a list of 100 words with similar pronunciations across both languages and registers whether the similarly-pronounced word pairings also tend to have similar meanings. An alternative approach, which Melitz & Toubal also consider, is to calculate LP based on whether or not two languages belong to the same “language tree” (and, in turn, to the same branch within that tree) according to the Ethnologue classification of language families.
of translating from one language to another, which in turn should imply that $LP$ and $FL$ should be at least somewhat related.

**Cold war divisions.** For cold war divisions, I try to exploit the idea that language education programs in “East”-aligned countries were subject to fundamentally different influences during the cold war vs. after the cold war.\(^{77}\) As Fodor & Peluau (2003) document, Soviet-influenced governments in Eastern and Central Europe deliberately undermined language education in Western European languages in favor of promoting Russian as a compulsory second language. With the decline of communism in the 1990s, however, these countries again began to invest heavily in educating their pupils in Western languages. It follows then that, despite the post-1989 resurgence in diversified language education in these countries, language ties between East and West countries should be systematically lower than for other trading pairs.

For the instrument itself, I generate a dummy called $EW_{ij}$ which equals 1 for trade between countries that were aligned with different blocs during the cold war. In addition to Eastern and Western Europe, I also include other countries in the sample that took sides one way or the other. Australia, Canada, Japan, South Korea, Taiwan, and the U.S. are considered part of the “West”, for example, and China are India are considered part of the “East”.

**Common language ties with outside countries.** I also wish to capture the idea that two countries that are each independently exposed to third countries that speak a particular language will themselves tend to speak that same language. Denmark and Estonia, for example, have strong foreign language ties through both English and German. As Ginsburgh, Melitz, & Toubal (2014) might argue, these ties have likely arisen because trade with English- and German-speaking countries has driven language acquisition choices in each of these countries. Alternatively, it could instead be that opportunities for trade with these outside countries have guided these choices. Either way, it would seem unlikely that either country acquired these languages specifically with the other in mind.

\(^{77}\)Fidrmuc & Fidrmuc (2014) have recently argued that, because past trade between Eastern and Western Europe was significantly dampened by the cold war, the observed effects of language ties on trade specifically between “East” and “West” countries should be less subject to concerns about “reverse causality” than other pairs. My identification strategy considers past cold war divisions from a different perspective than theirs.
To incorporate this logic, I construct an additional instrument as follows: for each language \( l \), I compute a weighted sum of each country’s exposure to outside countries that speak that language, using the inverse of distance (a natural, exogenous proxy for language exposure) as a weighting parameter. Multiplying these weighted sums together then gives their predicted level of communication in language \( l \). For each pair of countries \((i, j)\), the resulting variable is

\[
\hat{\alpha}_{ij}^l = \left( \frac{\sum_{k \neq j} S_k^l \cdot e^{-\ln \text{dist}_{ik}}}{\sum_{k \neq j} e^{-\ln \text{dist}_{ik}}} \right) \left( \frac{\sum_{k \neq i} S_k^l \cdot e^{-\ln \text{dist}_{jk}}}{\sum_{k \neq i} e^{-\ln \text{dist}_{jk}}} \right),
\]

where \( \hat{\alpha}_{ij}^l \) is a “predicted” analogue for the \( \alpha_{ij}^l \) term used in (21) and \( S_k^l \) is the share of the population in outside country \( k \) that speaks language \( l \).

I then in turn construct a predicted version for \( SL_{ij} \), which I call \( \hat{SL}_{ij} \), via the same procedure described in (21), only using the predicted \( \hat{\alpha}_{ij}^l \) values instead of the actual \( \alpha_{ij}^l \)’s from the data. To proxy for foreign language ties specifically, rather than for spoken language ties generally, the variable I ultimately use as an instrument is \( \hat{FL}_{ij} = \max(\hat{SL}_{ij} - NL_{ij}, 0) \).

To verify the validity of these instruments, I try to adopt a conservative approach. The IV-T estimator described above will produce a standard Hansen (1982) \( J \)-statistic to test for overidentification. However, an important caveat regarding such tests is that they implicitly presume (in the case of a single endogenous variable) that at least one of the instruments used is already valid. Therefore, to err on the safe side, I also verify that “just-identified” IV-T results (i.e. estimates using any any one instrument) are similar to the results using the overidentified model and that the instruments used do not enter significantly into the benchmark PPML model in the presence of the other regressors.

For concerns regarding underidentification, I perform a simple “first stage” linear regression with \( FL \) as the dependent variable, as is standard.\(^{78}\) I also include 2SLS estimates as an additional basis for comparison, as discussed above.

\(^{78}\)Note that since IV-T is a GMM estimator, it does not actually require that the instruments be associated linearly with the endogenous variables as in a two stage estimator.
2.4 Estimation Results

In this section, I estimate the effects of language ties on trade according to the gravity estimation approaches described above. PPML results are shown first, followed by a consideration of IV-based estimators and their implications for causal inference. All results are computed differently for “manufacturing” vs. “services” trade.

2.4.1 Preliminary Estimates

Table 2.2 presents results for a PPML estimation of the model given by (18), using different ways of specifying the included language variables. Columns 1-4 show results for manufacturing, whereas columns 5-8 are for services trade. In both cases, I build up a full specification of language effects on trade in incremental steps, paying close attention both to how introducing foreign language ties affects the estimates for native language ties as well as how language effects for manufacturing trade differ from those for services trade.

I start by considering the effect of $NL$, in combination with the controls described above, which include the standard “common official language” dummy variable. Notably, $NL$ is not significant in either column 1 (for manufacturing) or for column 5 (for services). It would seem based on this initial specification that “Common official language” performs adequately in capturing the effects of shared languages on trade; introducing Melitz & Toubal’s preferred variable for direct native language communication does not seem to add useful information here.\footnote{Indeed, results for these same controls when excluding $NL$ (ommitted to save space) are virtually identical in both cases.}

With regards to the other controls, I mostly observe findings that are in accordance with typical expectations, albeit with some notable exceptions. The estimates of these controls differ somewhat for manufacturing vs. services trade, so I will summarize the findings for manufacturing first and then provide a brief comparison with those for services. For manufacturing, the effect of distance on trade is negative as expected and in the neighborhood of about $-0.9$ (again as one might expect to observe). The positive coefficients on the presence of a common border and on that of a shared colonizer are not surprising. Nor is the (large) positive coefficient for the “Internal trade” dummy, reflecting the strong...
Table 2.2: PPML Results for Language Effects

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing trade</th>
<th>Services trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>-0.895***</td>
<td>-0.877***</td>
</tr>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Common official language</td>
<td>0.545***</td>
<td>0.552***</td>
</tr>
<tr>
<td></td>
<td>(0.150)</td>
<td>(0.146)</td>
</tr>
<tr>
<td>Common border</td>
<td>0.388***</td>
<td>0.392***</td>
</tr>
<tr>
<td></td>
<td>(0.120)</td>
<td>(0.116)</td>
</tr>
<tr>
<td>Common colonizer</td>
<td>0.766***</td>
<td>0.888***</td>
</tr>
<tr>
<td></td>
<td>(0.236)</td>
<td>(0.232)</td>
</tr>
<tr>
<td>Ex colonizer/colony</td>
<td>0.085</td>
<td>0.223</td>
</tr>
<tr>
<td></td>
<td>(0.246)</td>
<td>(0.248)</td>
</tr>
<tr>
<td>Common religion</td>
<td>0.337**</td>
<td>0.145</td>
</tr>
<tr>
<td></td>
<td>(0.150)</td>
<td>(0.152)</td>
</tr>
<tr>
<td>Common legal system</td>
<td>-0.026</td>
<td>-0.046</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.083)</td>
</tr>
<tr>
<td>Years at war</td>
<td>0.245*</td>
<td>0.264**</td>
</tr>
<tr>
<td></td>
<td>(0.127)</td>
<td>(0.121)</td>
</tr>
<tr>
<td>Internal trade</td>
<td>1.999***</td>
<td>1.993***</td>
</tr>
<tr>
<td></td>
<td>(0.161)</td>
<td>(0.158)</td>
</tr>
<tr>
<td>NL</td>
<td>-0.095</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>(0.215)</td>
<td>(0.215)</td>
</tr>
<tr>
<td>Linguistic proximity (LP)</td>
<td>0.110***</td>
<td>-0.008</td>
</tr>
<tr>
<td></td>
<td>(0.036)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>FL</td>
<td>1.197***</td>
<td>2.839***</td>
</tr>
<tr>
<td></td>
<td>(0.219)</td>
<td>(0.351)</td>
</tr>
</tbody>
</table>

The number of observations in all cases is $39^2 = 1,521$.

Exporter and importer FEs are used to control for $Y_i/\Omega_i$ and $E_j/\Phi_j$ (respectively) in (15).

Robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < .01$. 
preference to make purchases from one’s own domestic suppliers. The observed positive coefficient on “years at war” contradicts expectations, however. As we will see later, this seemingly puzzling result seems to be particular to the PPML estimation approach; the IV specifications discussed above do not find this variable to be significant.

Turning to services trade, I again note a negative coefficient for distance, only here it is smaller in magnitude than for manufacturing (−0.512 vs. −0.895). This finding should not be interpreted to mean services trade is in any way more “open” than manufacturing trade, however; the effect of one’s own borders (through the “Internal trade” variable) is more than twice as large for services than it is for manufacturing (which itself was already “large” to begin with). The most surprising finding in this case is the negative coefficient on “common colonizer”. A possible interpretation is that pairs of smaller, less-developed countries may face harder challenges in establishing trade in services than other types of pairs. Again, however, as with the number of years at war, this finding seems to be particular to the PPML estimates.

In Columns 2 and 6, I continue to follow Melitz & Toubal by considering the effect of “Linguistic proximity” (LP) alongside that of NL. LP is significant in both cases. We also see a (small) positive change in NL in columns 2 and 6 compared with columns 1 and 5, with NL becoming marginally significant for services trade. According to Melitz & Toubal, countries with more closely related languages face lower costs of “translation” from one language to another and therefore lower costs of trading. The significance of linguistic proximity disappears, however, upon the introduction of the FL variable in columns 3 and 7. These results support the logic that lower translation costs via LP do not affect trade independently of the ability to communicate in shared spoken languages; this finding thus would seem to help validate the use of LP as an instrument for FL communication in the IV estimation analysis that follows.

Columns 3 and 7 also reveal that the FL variable itself is strongly significant and positive for both manufacturing and services. Furthermore, in accordance with the argument laid out in the introduction, the magnitude of the estimated NL coefficient increases in the presence of the FL variable. The NL coefficient for services trade (0.888) is now measured as strongly significant (p < .01). However, while the NL coefficient exhibits the same
general pattern of increasing across columns 1-3, it remains only marginally significant.

We do find some confirmation then that, as hypothesized, estimates for NL are biased downward in the absence of FL. We also find, intuitively enough, that the magnitude of “common official language” falls mildly when more importance is assigned to the NL variable, which is presumed to be a more specific measure of native language ties. These encouraging findings are somewhat tempered, however, by the observation that FL’s effect on trade is measured to be stronger than that of NL. This discrepancy seems odd, especially for manufacturing trade, where FL is associated with strong statistical significance and NL is not. Why would communication in foreign languages (seemingly) promote trade moreso than communication in native languages?

One attractive explanation, explored in columns 4 and 8, is that the effect of spoken language communication on trade might subject to “diminishing returns”. Melitz (2008), for example, finds (using a threshold dummy variable) that the effect of native language communication on trade falls off after a certain level. Intuitively speaking, the sharing of common languages will have a larger effect on trade initially if multilingual speakers in the population are able to specialize in the intermediation of transactions. I test for these possible “translation effects” by adding the square of “spoken language communication” (SL²) to the previous specification. Surely enough, manufacturing trade does appear to exhibit diminishing returns with respect to language ties. Furthermore, we not only again see a jump in the magnitude of the NL coefficient, but we also observe that NL and FL are very similar in magnitude. Taken at face value, these results suggest native language communication and foreign language communication affect trade through the same channel and that much of the earlier discrepancy in magnitudes in column 3 is due to the presence of diminishing returns to spoken language communication.

For services trade, however, we do not find evidence of diminishing returns. The results for the nonlinear specification of shared language ties in column 8 seem to strongly reject this possibility. I also note again that the strong significance of NL in column 7 (for services trade without diminishing returns) makes the difference between these variables

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80 I have also experimented with including higher order polynomial terms for SL; the quadratic form seems to be the best fit to the data.
for services trade not as concerning as the corresponding difference seen in column 3.\textsuperscript{81} Building on the discussion laid out in the introduction, it is plausible this stark contrast in results reflects the fundamental differences that exist between trade in manufacturing and trade in services. The argument for diminishing returns relies on the idea that firms are more easily able to do business with foreign partners so long as there exist sufficient bilingual speakers to serve as intermediaries. The nature of services is different, however. For many service industries (e.g. hospitality, air travel, retail, tourism, etc.), the most likely “customers” for service providers are not organized firms with the ability to hire specialized intermediaries, but rather individual consumers of those services. Since individuals are far less likely to employ bilinguals to act on their behalf, it is reasonable to suppose that their purchases of services would be significantly more dependent on their own ability to communicate than on the presence of others who could serve as intermediaries.

To summarize, the PPML results exhibit a reasonable amount of the consistency with the first two of the three main conjectures underlying the argument made in the introduction. The omission of non-native language ties from the estimation of language effects does induce an apparent downward bias in the magnitude of the coefficient for native language ties. I also find that, for manufacturing trade at least, the native language coefficient again moves in sympathy with the $FL$ variable when I explore the possibility of diminishing returns. That these diminishing returns seem to be present only in manufacturing trade, and not in services trade, is again in accordance with the priors that have been set out. Collectively, these results seem to support the general hypothesis that native language ties and non-native language ties affect trade through the same channel.

Stronger confirmation of this interpretation of course also requires a more careful consideration of the last of the three points made in introduction, that estimates of non-native language ties be robust to causal inference methods. As I have discussed, opposing arguments exist for why standard estimates of language effects may exhibit either upward or downward bias due to endogeneity. In the following subsection, I explore the validity of my instruments for causal inference and attempt to characterize the role played by

\textsuperscript{81} A simple reason for why $FL$ might be measured with a larger effect might be due that the Melitz & Toubal method for eliminating double-counting in the construction of $SL$ could be systematically underestimating the “true” value of shared $FL$ ties.
endogeneity bias.

### 2.4.2 IV Estimation

Table 2.3 presents results for the IV-T estimates, using different combinations of the three candidate instruments for both manufacturing and services trade, as well as benchmark estimates using the PPML estimator.\(^{82}\) For both manufacturing and services, I have tried to single out a set of at least two instruments such that the computed \(J\) statistic falls within a tolerable range. For manufacturing, the set of instruments that meets this standard is \(LP\) and \(EW\); for services, I use \(EW\) and \(\hat{FL}\).\(^{83}\) I have also verified that none of the instruments enter significantly in the associated PPML regressions, either jointly or separately. Furthermore, standard “first stage” linear regressions show all three instruments to be strongly associated with \(FL\).\(^{84}\)

Interestingly, the IV-T estimator suggests very different conclusions for the sign of the endogeneity bias for manufacturing trade vs. services trade. By Column 2 of Table 2.3, which shows main IV-T estimates for manufacturing trade, the coefficient on \(FL\) is, if anything, underestimated when treated as an exogenous regressor. Furthermore, I again note that \(NL\) rises in sympathy with \(FL\) as the importance assigned to foreign language ties increases; the coefficient on \(NL\) is now large (1.005) and significant at the 1\% level. This co-movement of the \(NL\) and \(FL\) variables continues to support the interpretation that these variables reflect the value of being able to communicate in a common language. The measured effect of \(FL\) remains larger than \(NL\), however (in fact, the gap seems to have grown slightly.)

In stark contrast, the IV-T estimates for services trade do not find \(FL\) to be significant. At first blush, this finding seems surprising: the PPML estimations for services indicated relatively larger effects for shared languages ties; furthermore, several of the industries categorized under “services” would seem particularly likely to directly benefit from strong two-way communication (such as “Education” and “Post and Telecommuni-
Table 2.3: IV Results for Language Effects (PPML and IV-T)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing trade</th>
<th></th>
<th>Services trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPML (1)</td>
<td>IV-T (2)</td>
<td>PPML (5)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>-0.858***</td>
<td>-1.162***</td>
<td>-0.439***</td>
</tr>
<tr>
<td></td>
<td>(0.053)</td>
<td>(0.055)</td>
<td>(0.061)</td>
</tr>
<tr>
<td></td>
<td>-1.152***</td>
<td>-1.177***</td>
<td>-0.703***</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.055)</td>
<td>(0.064)</td>
</tr>
<tr>
<td></td>
<td>-1.177***</td>
<td>-0.704***</td>
<td>-0.701***</td>
</tr>
<tr>
<td></td>
<td>(0.061)</td>
<td>(0.067)</td>
<td>(0.072)</td>
</tr>
<tr>
<td>Common official language</td>
<td>0.320**</td>
<td>-0.023</td>
<td>0.484***</td>
</tr>
<tr>
<td></td>
<td>(0.154)</td>
<td>(0.202)</td>
<td>(0.050)</td>
</tr>
<tr>
<td></td>
<td>0.023</td>
<td>-0.071</td>
<td>0.050</td>
</tr>
<tr>
<td>Common border</td>
<td>0.357***</td>
<td>0.164</td>
<td>0.118</td>
</tr>
<tr>
<td></td>
<td>(0.120)</td>
<td>(0.109)</td>
<td>(0.156)</td>
</tr>
<tr>
<td></td>
<td>0.320</td>
<td>0.145</td>
<td>0.118</td>
</tr>
<tr>
<td></td>
<td>(0.131)</td>
<td>(0.113)</td>
<td>(0.156)</td>
</tr>
<tr>
<td></td>
<td>0.189*</td>
<td>0.145</td>
<td>0.118</td>
</tr>
<tr>
<td></td>
<td>(0.202)</td>
<td>(0.202)</td>
<td>(0.156)</td>
</tr>
<tr>
<td>Common colonizer</td>
<td>0.883***</td>
<td>0.654**</td>
<td>-1.278***</td>
</tr>
<tr>
<td></td>
<td>(0.235)</td>
<td>(0.307)</td>
<td>0.977*</td>
</tr>
<tr>
<td></td>
<td>0.535</td>
<td>0.332</td>
<td>0.503*</td>
</tr>
<tr>
<td></td>
<td>0.776**</td>
<td>0.345</td>
<td>0.563*</td>
</tr>
<tr>
<td>Ex colonizer/colony</td>
<td>0.211</td>
<td>0.451*</td>
<td>0.704***</td>
</tr>
<tr>
<td></td>
<td>(0.246)</td>
<td>(0.256)</td>
<td>(0.268)</td>
</tr>
<tr>
<td></td>
<td>0.451*</td>
<td>0.202</td>
<td>0.297*</td>
</tr>
<tr>
<td></td>
<td>(0.270)</td>
<td>(0.241)</td>
<td>(0.324)</td>
</tr>
<tr>
<td>Common religion</td>
<td>0.150</td>
<td>0.129</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.105)</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>0.129</td>
<td>0.107</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.176)</td>
<td>(0.103)</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>0.123</td>
<td>0.103</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.103)</td>
<td>0.130</td>
</tr>
<tr>
<td>Common legal system</td>
<td>0.002</td>
<td>0.360***</td>
<td>-0.017</td>
</tr>
<tr>
<td></td>
<td>(0.088)</td>
<td>(0.095)</td>
<td>0.141</td>
</tr>
<tr>
<td></td>
<td>0.311***</td>
<td>(0.101)</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.098)</td>
<td>0.138</td>
</tr>
<tr>
<td></td>
<td>-0.017</td>
<td>-0.141</td>
<td>0.141</td>
</tr>
<tr>
<td></td>
<td>0.129</td>
<td>0.101</td>
<td>0.148</td>
</tr>
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<td></td>
<td>0.145</td>
<td>0.098</td>
<td>0.148</td>
</tr>
<tr>
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<td>0.125</td>
<td>0.086</td>
<td>0.150</td>
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<tr>
<td></td>
<td>0.090</td>
<td>0.138</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.268</td>
<td>0.148</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.269</td>
<td>0.148</td>
<td></td>
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<tr>
<td></td>
<td>-0.267</td>
<td>0.188</td>
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<td></td>
<td>0.145</td>
<td>0.188</td>
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</tr>
<tr>
<td></td>
<td>0.125</td>
<td>0.189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.090</td>
<td>0.189</td>
<td></td>
</tr>
<tr>
<td>Internal trade</td>
<td>1.999***</td>
<td>2.475***</td>
<td>4.872***</td>
</tr>
<tr>
<td></td>
<td>(0.143)</td>
<td>(0.304)</td>
<td>6.145***</td>
</tr>
<tr>
<td></td>
<td>2.442***</td>
<td>(0.313)</td>
<td>6.146***</td>
</tr>
<tr>
<td></td>
<td>2.468***</td>
<td>(0.298)</td>
<td>6.147***</td>
</tr>
<tr>
<td></td>
<td>4.872***</td>
<td>(0.214)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.145***</td>
<td>(0.435)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.146***</td>
<td>(0.436)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.147***</td>
<td>(0.435)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.199)</td>
<td>(0.521)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.175***</td>
<td>2.103***</td>
<td>1.533***</td>
</tr>
<tr>
<td></td>
<td>(0.222)</td>
<td>(0.380)</td>
<td>-0.392</td>
</tr>
<tr>
<td></td>
<td>2.412***</td>
<td>(0.434)</td>
<td>-0.426</td>
</tr>
<tr>
<td></td>
<td>1.737***</td>
<td>(0.400)</td>
<td>-0.356</td>
</tr>
<tr>
<td></td>
<td>1.533***</td>
<td>(0.249)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.392</td>
<td>(0.409)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.426</td>
<td>(0.418)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.356</td>
<td>(0.448)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.864)</td>
<td>(0.864)</td>
<td></td>
</tr>
<tr>
<td>Instrument(s):</td>
<td>-</td>
<td>LP/EW</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>LP</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>EW</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>FL/EW</td>
<td>FL</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>FL</td>
<td>FL</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Underid</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
| Exporter and importer FEs are using to control for \(Y_i/\Omega_i\) and \(E_j/\Phi_j\) (respectively) in (15). Bootstrapped standard errors are reported in parentheses. * \(p < 0.10\), ** \(p < 0.05\), *** \(p < 0.01\).
cations’). Nonetheless, it also seems reasonable to suggest that, on the whole, omitted
cultural affinities may be especially important for understanding services trade. Indeed,
the fact that the IV-T estimates for Services find NL to be significant, but not FL, makes it
difficult to argue otherwise.

The results for both types of trade are backed up (in columns 3-4 and 6-7) by additional
IV-T regressions in which I experiment with using only a single instrument. In all cases,
the results are very close to the original estimates and support their validity.

Table 2.4: IV Results for Language Effects (OLS and 2SLS)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing trade</th>
<th>Services trade</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
<tr>
<td>Log of distance</td>
<td>-1.175***</td>
<td>-1.121***</td>
<td>-1.126***</td>
<td>-1.114***</td>
<td>-0.688***</td>
<td>-0.680***</td>
<td>-0.647***</td>
<td>-0.698***</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.054)</td>
<td>(0.055)</td>
<td>(0.058)</td>
<td>(0.088)</td>
<td>(0.090)</td>
<td>(0.100)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>Common official language</td>
<td>0.188</td>
<td>0.030</td>
<td>0.043</td>
<td>0.010</td>
<td>0.052</td>
<td>0.027</td>
<td>-0.074</td>
<td>0.082</td>
</tr>
<tr>
<td></td>
<td>(0.175)</td>
<td>(0.183)</td>
<td>(0.189)</td>
<td>(0.188)</td>
<td>(0.340)</td>
<td>(0.335)</td>
<td>(0.362)</td>
<td>(0.339)</td>
</tr>
<tr>
<td>Common border</td>
<td>0.301***</td>
<td>0.210*</td>
<td>0.217**</td>
<td>0.198*</td>
<td>0.555***</td>
<td>0.540***</td>
<td>0.479***</td>
<td>0.573***</td>
</tr>
<tr>
<td></td>
<td>(0.103)</td>
<td>(0.108)</td>
<td>(0.110)</td>
<td>(0.114)</td>
<td>(0.162)</td>
<td>(0.169)</td>
<td>(0.162)</td>
<td>(0.185)</td>
</tr>
<tr>
<td>Common colonizer</td>
<td>1.177***</td>
<td>0.942***</td>
<td>0.961***</td>
<td>0.912***</td>
<td>0.440</td>
<td>0.398</td>
<td>0.223</td>
<td>0.492</td>
</tr>
<tr>
<td></td>
<td>(0.358)</td>
<td>(0.310)</td>
<td>(0.323)</td>
<td>(0.309)</td>
<td>(0.815)</td>
<td>(0.795)</td>
<td>(0.778)</td>
<td>(0.827)</td>
</tr>
<tr>
<td>Ex colonizer/colony</td>
<td>0.470</td>
<td>0.262</td>
<td>0.279</td>
<td>0.235</td>
<td>0.963***</td>
<td>0.929***</td>
<td>0.789***</td>
<td>1.004**</td>
</tr>
<tr>
<td></td>
<td>(0.291)</td>
<td>(0.282)</td>
<td>(0.288)</td>
<td>(0.292)</td>
<td>(0.327)</td>
<td>(0.349)</td>
<td>(0.334)</td>
<td>(0.392)</td>
</tr>
<tr>
<td>Common religion</td>
<td>0.024</td>
<td>-0.000</td>
<td>0.002</td>
<td>-0.003</td>
<td>0.474**</td>
<td>0.470**</td>
<td>0.451**</td>
<td>0.480**</td>
</tr>
<tr>
<td></td>
<td>(0.111)</td>
<td>(0.112)</td>
<td>(0.112)</td>
<td>(0.113)</td>
<td>(0.195)</td>
<td>(0.189)</td>
<td>(0.191)</td>
<td>(0.189)</td>
</tr>
<tr>
<td>Common legal system</td>
<td>0.285***</td>
<td>0.379***</td>
<td>0.372***</td>
<td>0.391***</td>
<td>0.410**</td>
<td>0.424**</td>
<td>0.483***</td>
<td>0.393**</td>
</tr>
<tr>
<td></td>
<td>(0.103)</td>
<td>(0.107)</td>
<td>(0.110)</td>
<td>(0.112)</td>
<td>(0.165)</td>
<td>(0.166)</td>
<td>(0.180)</td>
<td>(0.171)</td>
</tr>
<tr>
<td>Years at war</td>
<td>0.056</td>
<td>0.053</td>
<td>0.053</td>
<td>0.053</td>
<td>-0.186</td>
<td>-0.185</td>
<td>-0.182</td>
<td>-0.187</td>
</tr>
<tr>
<td></td>
<td>(0.129)</td>
<td>(0.131)</td>
<td>(0.131)</td>
<td>(0.132)</td>
<td>(0.233)</td>
<td>(0.227)</td>
<td>(0.229)</td>
<td>(0.227)</td>
</tr>
<tr>
<td></td>
<td>(0.361)</td>
<td>(0.358)</td>
<td>(0.355)</td>
<td>(0.364)</td>
<td>(0.617)</td>
<td>(0.591)</td>
<td>(0.596)</td>
<td>(0.591)</td>
</tr>
<tr>
<td>NL</td>
<td>0.224</td>
<td>0.687*</td>
<td>0.649</td>
<td>0.747*</td>
<td>0.533</td>
<td>0.609</td>
<td>0.922</td>
<td>0.440</td>
</tr>
<tr>
<td></td>
<td>(0.319)</td>
<td>(0.371)</td>
<td>(0.402)</td>
<td>(0.384)</td>
<td>(0.636)</td>
<td>(0.709)</td>
<td>(0.667)</td>
<td>(0.807)</td>
</tr>
<tr>
<td>FL</td>
<td>0.655***</td>
<td>1.813***</td>
<td>1.719***</td>
<td>1.962***</td>
<td>0.160</td>
<td>0.344</td>
<td>1.099</td>
<td>-0.064</td>
</tr>
<tr>
<td></td>
<td>(0.214)</td>
<td>(0.431)</td>
<td>(0.523)</td>
<td>(0.593)</td>
<td>(0.367)</td>
<td>(0.712)</td>
<td>(0.934)</td>
<td>(0.995)</td>
</tr>
</tbody>
</table>

Instrument(s):          | -                  | LP/EW          | LP     | EW    | -      | FL/EW  | FL     | EW    |
OverId                  | -                  | 0.730          | -      | -     | -      | 0.408  | -      | -     |
UnderId                 | -                  | 0.000          | 0.000  | 0.000 | -      | 0.000  | 0.000  | 0.000 |

Exporter and importer FEs are using to control for \(Y_i/\Omega_i\) and \(E_j/\Phi_j\) (respectively) in (15).

Bootstrapped standard errors are reported in parentheses. * \(p < 0.10\), ** \(p < .05\), *** \(p < .01\).

For further confirmation, in Table 2.4, I also repeat the specifications shown in 2.3 using OLS and 2SLS as alternate estimators.\(^{85}\) As noted in Section 2, these estimates should

\(^{85}\) Here, I have used the same instruments for both IV-T and 2SLS. As discussed in Mullahy (1997), however, the validity of a given set of instruments under the nonlinear model’s moment condition (\(E[\omega|Z] = 1\)) need not imply validity under the corresponding moment condition for the linear model (\(E[\ln \omega|Z] = 0\)).
be interpreted with caution, because of the special assumptions required for the log transformation of the error term to be valid. Nonetheless, the linear results offer a revealing comparison, for a number of reasons. For one thing, the OLS estimates (columns 1 and 5) differ substantially from the corresponding PPML results in Table 2.3, with OLS generally assigning less importance to shared languages. At the same time, given these initial differences, the 2SLS estimates (columns 2-4 and 6-8) are strikingly similar to their IV-T counterparts. I again observe that using an IV strategy identifies a strong causal effect for FL for manufacturing trade (with NL rising in sympathy) and a lack of an effect for services trade. I also note that the magnitudes of the other non-language covariates are generally much more similar across the two IV estimators than across OLS and PPML. Collectively, these comparisons suggest that omitted variable bias may be a larger issue for obtaining consistent estimates of language effects than the issues commonly associated with log-linearization.

2.5 Total Language Effects

An important, related question—besides “does language communication promote trade?”—is “which language promotes trade the most?” Much other work in this area has raised the question of whether English and/or other European languages might be superior at reducing trading frictions between countries.

Really, though, a more fundamental question is: given that communication through any shared language should serve more or less the same purpose, which language in general can promote the largest overall global trade gains? To answer this question, we must consider how the estimates for language effects obtained above would function within the context of a general equilibrium trade model. It is important to clarify that a reduction in bilateral trade barriers through closer language ties can also have large multilateral effects on trade through effective increases in national incomes as well as reductions in national

---

86. Nonetheless, it is still possible to show that OLS estimates adhere to the same pattern illustrated in Table 2.2, only with smaller magnitudes.

87. For the case of English specifically, see Ku & Zussman (2010). Melitz (2008) and Melitz & Toubal both investigate whether European languages reduce trade barriers more than other languages.
price levels.

To illustrate these linkages, I re-introduce the structural gravity notation described in (14), with some slight alteration. Specifically, let \( \pi_{ij} = \frac{X_{ij}}{E_j} \) denote country \( j \)'s expenditure share on goods shipped from country \( i \). Furthermore, let \( \hat{t}_{ij} = \frac{t'_{ij}}{t_{ij}} \) denote a change in trade barriers from \( t_{ij} \) to \( t'_{ij} \) (due to language acquisition) and, likewise, let \( \hat{p}_i = \frac{p'_i}{p_i} \) denote a corresponding change in the supply price in \( i \) and \( \hat{\pi}_{ij} \) the resulting change in the trade share.\(^{88}\) One can then describe the general equilibrium change in trade flows as

\[
\hat{\pi}_{ij} = \frac{\hat{p}_i \hat{t}_{ij}}{\sum_k \pi_{kj} \hat{p}_k \hat{t}_{kj}}.
\] (23)

In general equilibrium, any increase in a given \( t'_{ij} \) (that is, a decrease in \( t_{ij} \)) not only directly "creates" additional trade between \( i \) and \( j \), but also has the indirect effect of "destroying" some of \( i \) and \( j \)'s trade with outside partners by increasing \( i \)'s seller price (i.e. \( \hat{p}_i > 0 \)) and by decreasing the average buyer price in \( j \) (i.e. \( \sum_k \pi_{kj} \hat{p}_k \hat{t}_{kj} > 0 \)). Intuitively, it is as though sellers in \( i \) experience an increase in world demand for their products while buyers in \( j \) effectively experience an increase in the supply of imports. From an outsider's perspective, however, obtaining goods from \( i \) is now more expensive; likewise, shipping goods to \( j \)'s import market is now more competitive.

Naturally, the more a country is able to increase its overall level of communication with world markets in general, the more trade is created versus destroyed and, in turn, the larger the net effect on trade overall from language acquisition. From this perspective, an obvious hypothesis emerges: English should clearly be the language that promotes global trade the most in general equilibrium, simply because of the number and size of the economies that already possess English as a major spoken language. Indeed, my results will confirm this hypothesis; I will also show, however, that the relative appeal of other world languages turns out to be highly dependent on the present of other, non-language barriers to trade.

To perform the necessary calculations, one can solve directly for price changes in all

\(^{88}\)This "hat algebra" notation, and the related method for solving for changes in equilibrium, is generally credited to Dekle, Eaton, & Kortum (2007).
countries using the following competitive equilibrium condition:

\[ Y_i \hat{p}_i = \sum_j \frac{\pi_{ij} \hat{p}_{ij} \hat{p}_j}{\sum_k \pi_{kj} \hat{p}_{kj} \theta_{ij}} \cdot E_j \hat{p}_j. \]  

(24)

Once changes in seller prices (\( \hat{p}_i \)'s) have been determined, calculating all changes in trade shares is straightforward, using (23).

Lastly, changes in the overall openness of the world to trade due to language acquisition will be measured using a “globalization index”, \( G \), formally defined as

\[ G \equiv \left( \sum_i \sum_j X_{ij} \right) / \left( \sum_i X_{ii} \right). \]

Intuitively, \( G \) indexes the ratio of total world production to total internal trade, such that \( G \) is increasing as countries collectively trade more with each other and less with themselves. The criterion I consider for “Total Language Effects” (TLE) is the change in \( G \) due to language acquisition—or more simply, \( \hat{G} \)—which can be calculated directly, using the fact that \( \hat{X}_{ij} = \hat{\pi}_{ij} \cdot \hat{E}_j = \hat{\pi}_{ij} \cdot \hat{p}_j \).\(^89\)

**Modeling the rest of the world.** To this point, I have ignored the importance of trade flows between the countries that are explicitly included in the trade data and the “Rest of the World” (RoW). Since RoW is actually an important trade partner in the WIOT data, I have tried to incorporate how changing trade costs due to language acquisition will affect trade to and from RoW.

To do this, I proceed in two steps. First, I estimate trade frictions for trade with RoW using a set of additional pair-wise fixed effects for trade with RoW; for example, \( t_{AUS,RoW}^\theta \) can be directly estimated using a fixed effect term that is specific to Australia-RoW trade.\(^90\)

Second, I use Melitz & Toubal’s data to construct measures of aggregate spoken language knowledge for the 20 largest countries not included in the WIOT data. The resulting language knowledge values for this aggregate are: Arabic, .10; Chinese, .02; Dutch, .02;

\(^{89}\)Here, I have followed prevailing approaches to calculating GE trade effects in assuming that \( \hat{t}_{ii} = 1 \), for all \( i \). That is, language acquisition is assumed to affect international trade costs only, and does not reduce barriers to internal trade.

\(^{90}\)Note that this approach does not change the original estimates, since incorporating fixed effects for RoW trade in this way adds exactly one additional degree of freedom for each additional observation.
Simulation exercises. The basic experiment I conduct is the following: let every country in the WIOT sample, including the “Rest of the World” region, experience an increase of 10% in the percentage of its population that speaks language \( l \) (that is, let \( S_i^l \rightarrow \max(S_i^l + 0.1, 1) \), \( \forall i \)). Counterfactual values for \( FL_{ij} \) and \( SL_{ij} \) for all trading pairs can then be calculated using (21), the same formula used to construct the original regressors. I then in turn calculate the resulting change in trade costs, \( \hat{\theta}_{ij}^\theta \), by combining the constructed changes in language covariates with the estimates obtained for \( \delta_{FL} \) (as well as \( \delta_{SL} \), if diminishing returns are assumed). I then simulate the resulting changes in prices and trade shares under the assumption that \( \theta = -4.91 \). Repeating this same exercise for different languages then permits for a general comparison of each language’s TLE impact on overall globalization.

Table 2.5, Panel A shows Total Language Effects based on my PPML estimates for language effects and other trade costs. For completeness, I include calculations for both manufacturing and services.\(^{92}\) I also consider TLEs for manufacturing both with and without the assumption of diminishing returns. The seven major world languages considered are Chinese, English, French, German, Italian, Russian, and Spanish. Unsurprisingly, English is the clearly the language that have the largest GE impact on world trade. The ranking of the other languages depends on the specification and the type of trade. For manufacturing without diminishing returns, Chinese places a relatively distant second, with three of the five continental European languages (Spanish, French, and German) not far behind. For manufacturing with diminishing returns, the results are similar, only with more dispersion. The results for services are more muted, reflecting the relatively large non-language barriers that affect cross-border services trade, with English now inducing roughly double the effect of any other language.

\(^{91}\)Simonovska & Waugh (2014) demonstrate strong evidence in favor of using a trade elasticity of around \(-4\) for manufacturing trade. This value also turns out to be reasonably standard for modeling services trade as well; see Donnelly, Johnson, Tsigas, & Ingersoll (2004).

\(^{92}\)For simplicity’s sake, I model each type of trade as a independent system. In principle, one might also wish to incorporate GE linkages across sectors by explicitly modeling consumer budgeting decisions over manufacturing consumption versus services consumption. The same could be said for allowing for mobile factors of production. I refrain from introducing these additional complexities.
Table 2.5: Total Language Effects (%Δ Total Trade / Internal Trade)

<table>
<thead>
<tr>
<th></th>
<th>Chinese</th>
<th>English</th>
<th>French</th>
<th>German</th>
<th>Italian</th>
<th>Russian</th>
<th>Spanish</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Globalization effects of language shocks based on estimated trade costs (%ΔG)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuf. (w/o d.r.)</td>
<td>1.90</td>
<td>3.21</td>
<td>1.77</td>
<td>1.78</td>
<td>1.59</td>
<td>1.62</td>
<td>1.86</td>
</tr>
<tr>
<td>Manuf. (w/ d.r.)</td>
<td>3.19</td>
<td>4.51</td>
<td>2.84</td>
<td>2.84</td>
<td>2.66</td>
<td>2.74</td>
<td>3.08</td>
</tr>
<tr>
<td>Services</td>
<td>0.37</td>
<td>0.77</td>
<td>0.42</td>
<td>0.42</td>
<td>0.36</td>
<td>0.37</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>B. Globalization effects of language shocks when other trade barriers are removed (%ΔG)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuf. (w/o d.r.)</td>
<td>8.50</td>
<td>11.15</td>
<td>5.68</td>
<td>5.74</td>
<td>5.45</td>
<td>5.47</td>
<td>6.32</td>
</tr>
<tr>
<td>Manuf. (w/ d.r.)</td>
<td>14.52</td>
<td>16.69</td>
<td>9.54</td>
<td>9.57</td>
<td>9.24</td>
<td>9.33</td>
<td>10.51</td>
</tr>
<tr>
<td>Services</td>
<td>5.12</td>
<td>13.41</td>
<td>5.05</td>
<td>4.82</td>
<td>4.71</td>
<td>4.60</td>
<td>5.82</td>
</tr>
</tbody>
</table>

"Total Language Effects" shown here are the %-changes in a globalization index, G, defined as the ratio between total world trade vs. total internal trade, resulting from a 0.1 increase in the number of speakers of a given language in every country.

In Panel B of Table 2.5, I consider an additional experiment where I first remove all non-language trade barriers between countries (that is, I first set all β’s in (22) equal to zero.) In prosaic terms, this exercise is meant to capture the idea of a counterfactual “Pangea”-type world where neither geographical factors (e.g. distance, borders, etc.) nor historical relationships (e.g. colonial ties) have any incidence on trade barriers. Instead, all trade frictions are assumed to be driven by the degree to which two countries share common spoken languages.

Under this alternate scenario, I first note that the changes in G for each language are larger, since language barriers now comprise 100% of all trading frictions. It still holds that English serves as the most valuable language for promoting global trade overall. We also see that English becomes even more dominant at promoting global services trade. Most interestingly, however, the relative appeal of other languages for promoting manufacturing trade is now very different. In particular, Chinese emerges as a reasonably close competitor to English relative to other languages, especially under the assumption of diminishing returns.

This last result is particularly striking since, unlike the European languages, Chinese serves as a major spoken language in only two countries in the sample, China and Taiwan.\(^{93}\) Noting the relatively small size of Taiwan, the obvious reason for this increase in

\(^{93}\)As a point of fact, Chinese is also spoken in several other nations across the Asia Pacific Region, including Singapore, Malaysia, and the Northern Mariana Islands. The broad term “Chinese” can also refer to several different dialects. For simplicity’s sake, I am assuming Mandarin is the common tongue of speakers of different dialects, as is often the case.
the relative appeal of Chinese is increased opportunities for trade with China specifically. Since China is the world’s second largest manufacturing economy in the sample (behind only the U.S.), the exercise of making China less “distant” as a trading partner for the Western hemisphere seems to work heavily in favor of making Chinese more viable as a global language for manufacturing trade. This same effect would not be present for services trade, however, since China’s production of services only makes up only 5% of world output for services, versus 15% for manufacturing.

Notably, the narrowing of the gap between Chinese and English for manufacturing is especially pronounced under the assumption of diminishing returns. Intuitively, as the (large) existing communication linkages between countries that already speak at least some English realize smaller returns, an equivalent increase increase in Chinese, which has not been widely adopted outside of mainland Asia, becomes relatively more valuable.

In sum, if language learning does indeed facilitate trade, it also seems to follow that opportunities for trade may be an important motivation for the language acquisition choices we observe in the world today. It likewise seems highly possible that language education policy could be a potentially important determinant of the path of future globalization. While the immediate future will likely tend towards continued investment in English and other European languages, the longterm outlook may depend on the length of the shadow cast on trade by geography and history.

2.6 Concluding Remarks

Foreign language communication is likely an important omitted variable in gravity estimations of international trade costs. If spoken language ties really do drive increased trade through the facilitation of communication the omission of this variable should lead to underestimation of the importance of communication in general, not just foreign language ties in particular. My PPML and IV estimations both generally confirm this logic: the measured effect of native language ties grow substantially for both manufacturing and services trade, especially for manufacturing trade when the possibility of translation effects (diminishing returns) is taken into account. It similarly follows that, as these more specific ways of
thinking about shared common language effects are introduced, the importance assigned to the traditional “common official language” variable diminishes.

Interestingly, the effect of foreign language ties on services trade behaves very differently than its effect on manufacturing trade, across several different specifications. Trade in services generally does not exhibit diminishing returns with respect to language ties; I also observe some evidence that the measured effect of common language ties on service trade is more likely to reflect the importance of omitted cultural biases for trade—and therefore less likely to reflect the practical importance of communication.

Performing some basic general equilibrium counterfactuals confirms that English is the most effective language for promoting increased global trade, and especially for promoting global services trade. Interestingly, however, removing all estimated non-language barriers to trade reveals that China’s geographical and historical remoteness from the major Western economies has greatly diminished the relative appeal of Chinese as a competing global language for promoting manufacturing trade.

Projecting the future of language acquisition based on these latter results requires weighing competing considerations about the future path of globalization versus the probable development of China as a more services-related economy. In all likelihood, current efforts to liberalize world services trade (a prominent goal of the Trans-Atlantic Trade and Investment Partnership, for example), would, if anything, only re-inforce English’s status as the most desirable language for promoting world trade. On the other hand, as the general incidence of geography and history on trade barriers fades with time, and as China becomes equally prominent as a producer of services as it is a producer of manufactured goods, it does not seem unlikely that Chinese might one day be equally prized as an international language.
Part 3

The Problem of Peace: A Story of Corruption, Destruction, and Rebellion

3.1 Introduction

Every government that faces the prospect of civil war has a fundamental choice to make: push for a peaceful settlement or engage the rebel forces in destructive war. Since the destruction associated with war has devastating economic consequences that could in principle be avoided by settlement, one might expect that the private interests of these actors—governments and rebellion leaders alike—would normally be best served by avoiding war. Yet that is not what we observe. On the contrary, the empirical civil war literature often links the onset of war all too closely with indicators of self-interest, such as the corruption of state finances, the presence of natural resource wealth (and other rent sources), and/or the low incomes of potential rebel recruits (see, for instance, Collier & Hoeffler, 2004; Fjelde, 2009; Besley & Persson, 2011; Dube & Vargas, 2013). The question arises: if civil war is so closely associated with incentives for economic gain, then what are the economic incentives that drive the emergence of civil war itself?

General theories of conflict have been put forward in answer to this question, starting with Fearon’s (1995) argument that the emergence of war reflects an inability to commit to a mutually beneficial peace.95 Recent refinements of Fearon’s “commitment problem” reasoning, beginning with Garfinkel & Skaperdas (2000), have emphasized how victory in war today may be the only way to secure a peace that does not involve continued costly investments in arming in the future. McBride & Skaperdas (2006) and Powell (2013) have each drawn on Garfinkel & Skaperdas’s essential argument as a way of explaining the emergence of civil war in particular. Otherwise, as documented in Blattman & Miguel

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94 With Constantinos Syropoulos.
95 Fearon also formalizes “imperfect information” as an alternative explanation for war. Powell (2006) discusses the advantages and disadvantages of each approach.
(2010), relatively little theoretical work in this area has considered how motivations for civil war may be fundamentally distinct from motivations for other types of war. We, however, isolate an overlooked source of potential inefficiency which draws more narrowly on the specific nature of civil war: the fact that one side is a “government” who may use state fiscal institutions to manipulate (and prey on) its rival’s source of recruits.

Specifically, we explore an otherwise standard model of armed conflict over rents from an insecure resource (e.g. Tullock, 1980) that has three main distinguishing features. First, in order to stake a claim to these rents, both sides must each hire armies from a common pool of labor (as in Garfinkel, Skaperdas, & Syropoulos, 2008). Second, the two players may resolve their competing claims by one of two ways, “conflict” (which destroys resources, including labor) or “settlement” (which preserves them). Settlement is not costless, however. All settlements are conducted in the “shadow of conflict” (see Anbarci, Skaperdas, & Syropoulos, 2002; Esteban & Sákovics, 2007), such that productive resources must be diverted towards arming under both conflict as well as settlement. Third, one of the players (the government) can directly influence the common pool of labor via the use of fiscal instruments: it may either prey on labor’s income using “taxes” or it may supplement it by issuing “subsidies.” Importantly, labor may evade taxation by joining the rebel group. Higher taxes thus reduce both the size of the government’s tax base and its control over rents by swelling the ranks of the rebel group’s forces.

Our main findings regarding conflict and settlement follow directly from this central role given to fiscal policy. The government does not grant subsidies out of benevolence (it has none) nor does it always extract maximal taxes (no one would pay them.) Rather, its desire to amass both rents and tax revenues requires a delicate balancing act. In the case where the value of rents is very large, it prefers to issue generous subsidies in order to dissuade the population from siding with its rival. On the other hand, when rents are less valuable, it would rather ignore them altogether and focus on taxing workers. But subsidizing a large labor force is expensive. And even the smallest presence of rents can

96 These “rents” may stem from either natural resource wealth (e.g. oil, timber) or more generally the privileges of power (e.g. diversion of foreign aid efforts). Recent empirical evidence (respectively, Dube & Vargas, 2013 and Besley & Persson, 2011) supports either interpretation.

97 Our arguments may be generalized to include other policies which directly impact welfare, however, e.g. the production of public goods.
incentivize the recruitment of labor from the government’s tax base towards predatory activities. Perversely, the destruction of productive resources associated with conflict can resolve both of these issues. Allowing citizens to be killed and/or displaced makes buying allegiance from the remainder more affordable. And setting oil fields ablaze may be a useful way to minimize interference with the extraction of tax revenues.

Opportunities for bargained settlements tend to hold the government’s incentives for choosing destruction in check, but not always. Logically, conflict can never be preferred ex post (i.e. once arming is determined) if avoiding destruction creates a positive surplus that can be shared. Nonetheless, the government’s control over fiscal institutions grants it discretionary power over both the size and sign of the eventual surplus. Accordingly, it may intentionally induce a negative surplus, and therefore conflict, by choosing a large enough subsidy such that its savings on subsidizing a reduced labor force outweigh the benefits from preserving non-labor resources. This scenario only arises when the value of contested rents is large enough that the government finds labor destruction to be advantageous; otherwise, settlement always dominates conflict ex post. Preferences for conflict may emerge under more general circumstances, however, if we allow the government to pre-commit to conflict ex ante in order to influence subsequent arming choices. Conflicts that mainly destroy the contested rents themselves can only be preferred ex ante, for example.

Broadly speaking, our explanations for the emergence of conflict are in tune with Fearon’s (1995) rationalization of war as a “commitment problem”, but differ in important ways. In Fearon’s original framework, war emerges because strong players will not find promises of future concessions by weak players to be credible if the balance of power is expected to shift exogenously in later periods. Our reasoning is more compact. In our analysis, the government prefers conflict because conflict itself is a useful tool for shifting the balance of power, whether it is by permitting larger subsidies (when the value of rents is large) or by directly reducing rebel incentives to recruit soldiers (when it is small). To phrase these re-

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98 Even if governments take an active role in violence against the population they still may be successful at obscuring the public record using misinformation, as discussed by Lowi (2005) in the case of Algeria.

99 As we discuss, this particular result requires that the division of the surplus under “settlement” introduces additional incentives for arming, as in the bargaining process proposed by Esteban & Sákovics (2007). The Esteban & Sákovics framework is not sufficient by itself for destruction to become appealing; the role of fiscal policy is still crucial.
sults as a “commitment problem”, war occurs because the rebel leader (the weaker player) cannot commit to restrain his recruitment of labor for a given level of taxation.

Interestingly, the logic of commitment problems can actually work both ways in our setting, since commitments to conflict *ex ante* are not always credible *ex post*. This feature of our model is notable. When conflict arises in Garfinkel & Skaperdas’s (2000) multi-period model, for example, it is always unambiguously preferred both *ex ante* and *ex post*. Other theories which generate preferences for conflict in a static, complete information setting (e.g. Beviá & Corchón, 2010; Chang & Luo, 2013) require that commitments to conflict *ex ante* are credible and irreversible. Our analysis, however, shows that not being able to credibly commit to conflict (as opposed to Fearon’s concept of not being able to commit to peace) can itself be an important commitment problem with its own negative consequences both for private payoffs and for welfare. Giving the government the opportunity to set fiscal policy at the beginning of the game may help resolve this latter commitment problem.

In addition, the fact that we allow for both the balance of power (i.e. the build-up of arms) and the mode of interaction (i.e. conflict vs. settlement) to be endogenously determined allows us to capture the notion of an “armed peace”: just because the two sides avoid war does not mean they cease trying to outmaneuver one another for rents. Our model therefore permits analysis of novel trade-offs between “peace” and (socially wasteful) increases in both arming and taxation. Strikingly, we find that both overall national income and total labor income may be higher under conflict than under settlement.\(^\text{100}\)

Distinguishing in this way between incentives for arming and incentives for conflict, especially in the context of conflict within a small open economy, also grants a unique opportunity to explore how both peace and efficiency respond to external shocks and interventions. We focus specifically on how these incentives respond to changes in the prices of tradable goods. The formation of armed groups in response to trade shocks has been explored previously in Garfinkel, Skaperdas, & Syropoulos (2008) and Dal Bó & Dal Bó (2011), but we add to these perspectives in two important ways. First, we show that shocks

\(^{100}\) The concept of what is best for “welfare” here beyond pure income considerations is beyond our scope, however. We do not intend to deny or minimize the terrible human costs of war. Rather, our intent is to illustrate how a “peace” between corrupt elites may be inherently problematic in its own right.
that favor increases in arming do not necessarily favor conflict (and vice versa). Second, we also consider the implications of allowing players to import weapons as part of their arming technologies. Surprisingly, restricting the supply of these imported weapons can have the indirect effect of making conflict more likely.

In addition, because we place state institutions at the heart of the interactions, the model provides many opportunities to explore how limits on the institutional capacity of the state matter in this context. We focus on two. First, we show that limiting the government’s capacity to tax can tilt the balance towards peace. Intuitively, making the government relatively more dependent on contestable rents eliminates the appeal of destroying them.101 Second (and perhaps more surprisingly), we find that limits on the ability to subsidize the rewards to labor may likewise favor peace. That is to say, restricting the government’s ability to “bribe” its rival’s source of recruits with gifts of land, food, work projects, and other transfers may be an effective way to promote peace, because of how it may use these instruments strategically in combination with conflict.102 Obviously, how state institutions interact with the power dynamics of civil war is a much more complex issue than we depict it here.103 Nonetheless, the powerful incentives we identify in our analysis suggest they may not only be important for understanding the nature of civil war, but for understanding its genesis as well.

The structure of the paper is as follows. Section 3.2 of our paper summarizes the model, starting with the basic conflict game and then introducing the possibility of negotiated settlement. In section 3.3, we establish the main result that situating both players within a common policy environment makes it possible for the player who controls policy to prefer conflict over peace, under several different variations of the model. Section 3.4 then discusses the novel dynamics of peace, arming, and taxation in this framework in response

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101 This perspective resembles that of Acemoglu (2010), who argues that a highly capable predatory state would not hesitate to exploit conflict as a means to gain tighter control over its tax base. It would also seem consistent with the empirical findings of Fjelde (2009), who shows that civil war is closely linked with measures of state corruption (which arguably reflect the state’s capacity for corruption), but only when natural resource wealth is low.

102 For an example of how government forces have obviously and deliberately combined generous fiscal transfers with acts of violence in this way during civil war, see Schirmer’s (1998) account of the “Beans and Bullets” strategy employed by the Guatemalan government during the 1980s. Section 3.3.4 touches on other examples as well.

103 See Acemoglu & Robinson (2001, 2006), Besley & Persson (2011), and De Luca, Sekeris, & Vargas (2011) for other recent perspectives examining this subject.
to external shocks and interventions. Section 2.6 adds concluding remarks.

3.2 Model

In a perfectly competitive general equilibrium model of a small open economy, there are $L$ ordinary individuals—each endowed with one unit of labor—and two key actors/players at center stage: a kleptocratic governing elite, which we personify as “the ruler”, and a self-serving leader of a rebel group. These agents are indexed by 1 and 2, respectively. Actor $i$ securely controls $K_i \geq 0$ units of a resource which, for convenience, we refer to as “capital”. The ruler also possesses $K_0$ additional units of capital; however, its ownership of $K_0$ is contested by the rebel group. Their competing claims can be resolved in one of two ways: through destructive “conflict” or through peaceful “settlement”. Under conflict a fraction $\delta_K \in [0, 1)$ of the contested resource $K_0$ and/or a fraction $\delta_L \in [0, 1)$ of the labor force are “destroyed”, whereas under settlement all endowments are preserved. It would appear then, by preempting destruction, settlement ought to dominate conflict.

As we will show, however, both conflict and settlement are socially costly in this setting because they divert resources away from useful production. Furthermore, we will illustrate that, when power is endogenously determined, conflict may actually enhance the advantages the government derives from controlling the levers of policy.

3.2.1 Overview of the Game

The central innovation in our framework is our assumption that the rival groups differ fundamentally in the following respect: the ruler has the capacity to extract wage taxes from ordinary labor whereas the rebel leader does not. The ruler’s capacity to obtain such revenues is limited, however. First, he can only tax (at a rate $\tau$) workers employed in legal sectors. Furthermore, his capacity is limited by the presence of an institutional ceiling $\tau_{\text{max}}$

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104Even though the rebels may securely “own” a portion $K_2$ of this resource, we can still think of all de facto legal claims to this resource as belonging to the government. $K_2$ then is the amount of appropriation that the ruler is unable to contest.

105The “labor destruction” we are considering here is not so much the killing of soldiers in battle, but rather the death (and/or dislocation) of citizens that occurs in civil wars.

106In general, conflict may also result in the destruction of $K_1$ and/or $K_2$. We focus on the destruction of $K_0$, as in Garfinkel & Skaperdas (2000), in order to preserve comparability with the existing literature.
(i.e., $\tau \leq \tau_{\text{max}}$), as in Besley and Persson (2011), as well as a lower bound $\tau_{\text{min}} < 0$, such that the feasible interval of wage tax/subsidy rates is $T := [\tau_{\text{min}}, \tau_{\text{max}}]$. More figuratively, since a civil war-prone state may not explicitly be able to collect “income taxes” in this way, $\tau$ may alternatively be thought of as the degree to which the government preys on economic activity via corrupt practices. As we will see, the ability to wield such policies is valuable to the ruler not only as a source of payoffs, but also as an instrument for influencing the balance of power.

A second key feature of the game we consider is the build-up of each side’s military capabilities, which we denote by $S_i$ for $i = 1, 2$. It is this measure of military strength that matters for power and the resolution of conflict and settlement. Each player acquires $S_i$ units of strength in order to increase his share $\phi^i$ of the contested “capital” $K_0$ in the event of conflict. We assume $\phi^i$ is given by a standard contest success function (CSF),

$$
\phi^i(S_i, S_j) = \begin{cases} 
\frac{f_i(S_i)}{f_i(S_i) + f_j(S_j)} & \text{if } \sum_{h=1,2} S_h > 0, \\
1 & \text{if } \sum_{h=1,2} S_h = 0 
\end{cases}, \text{ for } i \neq j = 1, 2, \tag{25}
$$

where $f_i(\cdot) \geq 0$, $f_i(0) = 0$, $f_i'(\cdot) > 0$, $\lim_{S_i \to 0} f_i'(S_i) = \infty$, and $f_i''(\cdot) \leq 0$. Thus, by definition, the ruler will control the insecure resource $K_0$ if the rebel group does not contest it. It is easy to verify that $\phi^i$ is increasing in $S_i$ ($\phi^i_{S_i} \equiv \partial \phi^i / \partial S_i > 0$) and decreasing in $S_j$ ($\phi^i_{S_j} \equiv \partial \phi^i / \partial S_j < 0, j \neq i$). A particular functional form for $f_i(\cdot)$ is

$$
f_i(S_i) = \xi_i S_i^m, \ m, \xi_i \in (0, 1], \tag{26}
$$

where $\sum_i \xi_i = 1$, such that $\xi_i$ is the “relative power” of agent $i$, and $m$ captures the return to arming. This functional form is widely employed in the literatures on rent-seeking, tournaments, and conflict. We, too, will make use of it to obtain sharper results.

Naturally, military strength will depend in part on the number of soldiers each side has

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107 Without loss of generality, we could have also described $\tau$ as a tax on production, since the ruler already lays claim to all legal returns to capital and since firms are perfectly competitive. Even $\tau < 0$ may therefore be associated with some degree of “corruption” since the ruler can still draw on the state’s capital wealth for his private consumption.

108 This way of modeling rent competition is attributed to Tullock (1980). For a detailed discussion of this class of models, see Hirshleifer (1989) and Skaperdas (1996).
at its disposal. But workers and soldiers alike must be hired from the same pool of labor. Explicitly speaking, each worker has the following occupational choices: (i) get employed in the production of consumption goods in the legal economy; (ii) serve in the military (controlled by the government); and (iii) join the rebel group (controlled by its leader).\footnote{Conceptually, an individual worker or household could be employed in all three activities simultaneously. The key point here is that the allocation of the labor endowment across these tasks depends on the tax rate.}

The sequence of actions/events is as follows:

1. The government announces a per unit wage tax/subsidy rate $\tau \in T$ in the legal sectors.

2. The government and the rebel leader determine non-cooperatively and simultaneously the size of their respective security forces (i.e., $S_1$ and $S_2$), each taking the actions of its rival as given.

3. Once arming commitments are declared, the contenders announce their respective preferences over “conflict” and “settlement”. If at least one side chooses conflict, a contest ensues in which player $i$ wins a fraction $\phi^i$ of $(1 - \delta_K) K_0$. However, if both sides choose settlement, they go on to negotiate a mutually agreeable and non-destructive division of the relevant surplus (see below).

4. Private production, consumption and trading decisions take place.

In the context of the above game, we wish to identify circumstances under which the ruler (and/or possibly the rebel leader) may prefer conflict over settlement in Stage 3. As we will demonstrate, the emergence of conflict is wholly dependent on how the government’s discretion over tax policy shapes the strategic landscape in which both players make their arming decisions. We will also show, by considering other timing structures, that having the ability to set $\tau$ in advance provides the government with a useful way to credibly commit to conflict “ex ante”, i.e. before arming decisions are made. Such commitments may not be credible otherwise.

A related modeling choice we should underscore here is that we only allow one player (the ruler) to set tax policy. What happens if, by contrast, we were to assume complete
symmetry, such that both players may “tax” the population? We show in the Appendix that our essential results regarding conflict flow through under the timing structure described above. We stick to the case where only one player controls tax policy in our main presentation both because the adherence to symmetry is limiting and because it seems reasonable to assume that controlling the state grants the ruler a significant advantage in the ability to exercise such policies.

Put succinctly, an equilibrium in our model will be summarized by a tax policy ($\tau$), non-cooperatively chosen military strength levels ($S_1, S_2$), and the mode of interaction (“conflict” or “settlement”). Actions by both players will be determined by backwards induction. That is, the government decides taxes in the first stage by internalizing how taxes will shape arming decisions and, ultimately, the mode of interaction. These decisions will be based on the other parameters of the model, most notably the size of the labor force, the size of the insecure resource, international prices, and the degree and incidence of destruction in the event of conflict. We now describe each of the key decision points in detail, starting with the allocation of productive resources.

### 3.2.2 Production and Employment

The production technology for each consumption good $j (= x, z)$ is described by the unit cost function $c^j \equiv c^j(w, r)$, which is increasing, concave and linear homogeneous in factor prices. $c^j_w = \partial c^j / \partial w$ and $c^j_r = \partial c^j / \partial r$ then serve as the conditional demand functions associated with one unit of good $j$. We assume that production technologies can be ranked in terms of factor intensities and factor intensity reversals are absent. Due to competitive pricing in the output markets, we have the following invertible system

$$p_j = c^j(w, r), \text{ for } j = x, z \quad (27)$$

when both goods are produced. In less technical terms, rewards to both labor ($w$) and capital ($r$) in the model are pinned down by international trading prices, which (by our “small open economy” assumption) cannot be affected by changes in domestic production.\textsuperscript{110}

\textsuperscript{110}This price linkage, which is known in the literature as the Stolper-Samuelson theorem (Stolper & Samuelson, 1941), simplifies the analysis of a small open economy considerably. We could relax this assumption by
To examine how incomes and payoffs are determined we must also describe the production of military strength, \( S_i \). We view this strength as a composite good that depends on the size of one’s forces and the degree of armament. More specifically, we suppose \( S_i \) is a linear homogeneous function of the number of troops \( L_i \) and the quantity of guns/weapons \( G_i \) bought internationally \((i = 1, 2)\). Let \( \psi^i \equiv \psi(w_i, q) \) be the cost function associated with the purchase of one unit of military strength by group \( i \), where \( w_i \) and \( q \) capture the costs of hiring one soldier and purchasing one gun respectively.\(^{111}\) The total cost to group \( i \) of securing \( S_i \) units of military force is \( \psi^i S_i \).\(^{112}\)

To keep the analysis compact, we mainly assume a Cobb-Douglas production function for \( S^i \). Furthermore, as labor is an essential input for strength, we define \( \theta_{LS}^i \equiv w_i \psi^i / \psi^i \geq \theta_{LS}^i \in (0, 1] \) as the share of labor (troops) in the cost of producing security. Under the Cobb-Douglas assumption, this share is constant. For more general production functions, the rebel leader’s expenditure share will depend on \( \tau \). Specifically, \( \theta_{2}^\tau > 0 \) if guns and labor are substitutes; \( \theta_{2}^\tau < 0 \) if they are complements.

Recall \( K(\delta_K) \equiv (1 - \delta_K)K_0 + K_1 + K_2 \) and \( L(\delta_L) \equiv (1 - \delta_L)L \) give the effective endowments of capital and labor. Letting \( Q_j \) denote the aggregate output of good \( j (= x, z) \), the conditions for full employment of resources can be written down as

\[
\begin{align*}
\frac{c^x_i}{w_i} Q_x + \frac{c^z_i}{w_i} Q_z + \psi^1_i S_1 + \psi^2_i S_2 &= K(\delta_K) \\
\frac{c^x_w}{w} Q_x + \frac{c^z_w}{w} Q_z + \psi^1_w S_1 + \psi^2_w S_2 &= L(\delta_L),
\end{align*}
\]

where, again, \( \delta_J \in (0, 1) \) under conflict \((J = K, L)\) and \( \delta_J = 0 \) under settlement. To keep the analysis simple and compact we will assume these endowments are sufficiently large considering the possibility of complete specialization in production or by introducing specific factor inputs. These extensions would alter the analysis by restoring the sensitivity of factor prices to factor endowment changes and, therefore, to arming decisions.

\(^{111}\) This cost function for \( S_i \) is unique in its usage of tradable weapons; other work (see, for instance, Garfinkel, Skaperdas, & Syropoulos, 2008) tends to assume instead the contested resource is itself involved in the production of military force. In principle we could likewise allow \( S_i \) to involve capital, without affecting our main results. We could also assume the two players face different costs of acquiring weapons, without loss of generality.

\(^{112}\) For simplicity we assume that both groups face the same technology \( \psi(\cdot) \) but we could amend the analysis to capture the possibility that rebels may have access to an inferior technology. We could also consider cases where the two players face different constraints on their abilities to raise revenues through taxes and/or where \( q_1 \neq q_2 \).
so that the country’s aggregate production of consumption goods remains diversified.\footnote{In principle, if either endowment is sufficiently small, the economy will completely specialize in the production of one of the two goods. In this case, the relative reward to capital, \( r/w \), will no longer be held fixed by world prices, but instead will vary endogenously with the amount of labor employed in legal production as well as the amount of destruction.} A crucial determinant of the endogenous asymmetry that underlies our main results is the allocation of labor. Let \( w \) be the pre-tax wage rate paid by employers (including the state) to employees in formal/legal markets. In the presence of a wage tax \( \tau \), workers in these sectors will obtain the after-tax rate \( (1 - \tau)w \). In contrast, members of the rebel group can evade taxation.\footnote{This assumption is consistent with the observation that in developing nations the state’s ability to tax the informal sector is woefully inadequate (Marcouiller & Young, 1995).} Nonetheless, because occupational choice is based on the reward to productive labor, the effective opportunity cost (to a self-serving rebel leader) of recruiting an additional rebel will be \( w_2 = (1 - \tau)w \). Clearly, the rebel leader’s cost function of building/maintaining a force of \( S_2 \) will be \( \psi((1 - \tau)w, q)S_2 \), where again \( q \) is the price per gun paid to international suppliers of weapons. The ruler’s opportunity cost of arming differs, however. Each soldier he hires not only costs him the compensation owed, \((1 - \tau)w\), but also reduces his tax collection from the productive workforce by an amount \( w\tau \). The cost to the state of securing a force \( S_1 \) will then be \( \psi(w, q)S_1 \); in other words, his cost of hiring soldiers \( w_1 \) is not \((1 - \tau)w\) but rather the full before-tax wage \( w \).\footnote{The analysis could be extended to consider conscription that bestows the state the right to recruit soldiers at below the market wage rates. The state and the rebel leader may also face different prices for guns perhaps because the suppliers of guns in the world market treat them differently. We also may consider cases in which soldiers require additional compensation for disutilities associated with fighting. At any rate, our main results still hold so long as these additional considerations concerning compensation are not related to the government’s tax choice.} His choice of fiscal policy therefore not only serves as an instrument for extracting revenues from his tax base, but also directly affects the balance of power by influencing his opponent’s cost of arming (without affecting his own). We pay special attention to how \( \tau \) shapes the nature of equilibria in our characterization of payoff functions below.

### 3.2.3 Conflict

We are now ready to derive the equilibria that hold in the event of conflict, and in turn serve as “threat points” in the bargaining game. Let all agents’ consumption preferences be identical, homothetic, and risk-neutral. Payoffs for all agents are then given by the...
following indirect utility function

\[ v^i = \mu(p_x, p_z)Y^i, \]

(29)

where \( Y^i \) denotes individual \( i \)'s income, \( p_j \) the price of good \( j \), and \( \mu(\cdot) \) the marginal utility of income. Then, because world relative trading prices are taken as given, \( \mu(\cdot) \) can be treated as a constant, and utility maximization becomes isomorphic to income maximization.

Incorporating these model elements into the indirect utility functions in (29) delivers the following payoff functions for players 1 and 2 and for aggregate welfare under conflict:

**Payoffs under Conflict:**

\[
U^1 = \mu \left[ rK_1 + A\phi^1 - \psi^1S_1 + \tau(w(1 - \delta_L)L - w\psi^2wS_2) \right], \tag{30a}
\]

\[
U^2 = \mu \left[ rK_2 + A\phi^2 - \psi^2S_2 \right], \tag{30b}
\]

\[
U \equiv \mu(1 - \tau)w(1 - \delta_L)L + \sum_i U^i, \tag{30c}
\]

where \( A \equiv r(1 - \delta_K)K_0 \) is the value of the contested rents (the “prize”). Several observations are in order here. First, by virtue of the fact that the ruler has exclusive access to tax revenues, the size of its tax base (the expression inside the parentheses in the third term in (30a) is important to him. Clearly, the larger the tax base the larger his tax revenues. Second, by reducing the price of a recruit in the rebel group relative to the price of guns, higher taxes erode the tax base due to substitution effects. Third, by reducing the rebel leader’s opportunity cost \( \psi^2 \) of building additional military capacity (but not the ruler’s cost \( \psi^1 \)), higher taxes also generate an adverse scale effect that would further erode the tax revenue base. Fourth, as noted above, higher taxes also reduce the ruler’s share of rents in the appropriative contest (\( \phi^1 \)), again via the effect on \( \psi^2 \). Naturally, a self-serving

\[ ^{116} \text{Note that, because prices are fixed, introducing risk aversion would not alter our analysis substantially unless we consider a “winner-take-all”-type contest.} \]

\[ ^{117} \text{Erosion of the tax base may also arise in the presence of labor-leisure choice that gives rise to a Laffer-type curve in revenues. Though our analysis has interesting implications for the shape of the Laffer curve, it differs from standard analyses in that the diversion of labor into distributive conflict further undermines the tax authority’s ability to appropriate resource rents and is, of course, socially wasteful. Clearly, the higher the death rate under conflict the lower the tax base.} \]
kleptocrat will aim to balance these effects at the margin.

In terms of overall welfare, two additional points deserve some emphasis here. First, it is plain from (30c) that aggregate income in the economy decreases when more resources are diverted from production into arming. This relationship has important implications for welfare throughout the paper: to the extent that peace is associated with more extractive tax policy, the resulting increase in arming can mitigate, or even offset, the benefits of avoiding destruction.

Second, however, measuring “welfare” in this way has the disadvantage of ignoring considerations that should be given towards loss of human life in the event of labor destruction ($\delta_L > 0$). We can motivate this simplified perspective by noting that much of the disruption of the labor endowment that occurs during civil wars is via dislocation—rather than death—though we admittedly do not model additional human costs that may be associated with this latter channel either. Nonetheless, we do think it worthwhile to highlight the amount of income that is captured specifically by labor—$(1 - \tau)w(1 - \delta_L)L$—as an alternative welfare criterion to focus on since it is naturally easier to be more sympathetic to the welfare of the “powerless” in this kind of setting.

Keeping in mind that $A \equiv r(1 - \delta_K)K_0$ captures the value of contested rents (the “prize”), the first-order conditions (FOCs) for interior solutions for arming are:

$$U_{iS_i} = A\phi_S - \psi = 0, \text{ for } i = 1, 2. \quad (31)$$

It is straightforward to show that our general assumptions on the nature of the CSF imply the above system of equations has a unique solution.$^{118}$ Moreover, the simplifying functional form (26) (which requires $f_i(S_i) \equiv \xi_i S_i^m, m \leq 1$) allows us to present an analytical solution to (31). Let a tilde “˜” over variables describe their noncooperative equilibrium

$^{118}$As noted above, this solution will qualify as equilibrium only if the associated quantities of factor input demands are sufficiently low (as compared to the economy’s effective factor endowments noted in (28) so that production of consumption goods remains diversified. To avoid unnecessary complications that may cloud the clarity of our arguments, we continue to maintain the assumption of sufficient slack in factor endowments so that the possibility of complete specialization is not a concern. The Appendix touches on some of the complications that may enter otherwise.
values under the contest. One can show that:

\[ \tilde{\phi}^1 = \frac{1}{1 + \gamma}, \quad \tilde{\phi}^2 = \frac{\gamma}{1 + \gamma}, \quad \tilde{S}^i = \frac{\Lambda m \tilde{\phi}^1 \tilde{\phi}^2}{\psi^i} = \frac{\Lambda m \gamma / \psi^i}{(1 + \gamma)^2}, \quad (i = 1, 2). \]  

(32)

where

\[ \xi \equiv \xi_2 / \xi_1, \quad \rho \equiv \psi^2 / \psi^1, \quad \text{and} \quad \gamma \equiv \xi \rho^{-m}. \]  

(33)

Parameters \( \xi \) and \( m \) capture the technology of conflict, whereas \( \rho \) (which is really a function that depends on the wage tax/subsidy rate \( \tau \), the wage rate \( w \), and gun prices \( q_j \)) captures the rebel leader’s relative cost of arming.

Again, what is important to note here is the role of \( \tau \) in determining equilibria via its effect on relative unit costs (\( \rho \)). As Fig. 3.1 illustrates, an increase in \( \tau \) shifts the distribution of power towards the rebel leader by making it cheaper for him (but not the ruler) to hire soldiers. Furthermore, if we assume \( \xi < 1 \) (as in Fig. 3.1), such that the ruler has an inherent military advantage, increases in \( \tau \) also have the effect of increasing the overall level of arming because they make the contest more competitive.

To preface any consideration of how taxes may be used strategically, it is useful first to address the following question: How does an increase in the value of the contested prize
A (which may be due to a fall in the rate of destruction, an increase in $K_0$, or a rise in the rental price of capital $r$) affect agent payoffs and efficiency? Inspection of (32) readily reveals that both agents will expand their military strengths in proportion to $A$ without any resulting change in shares (power). Applying this observation to the rebel leader’s payoff function in (30b) readily implies (after invoking the envelope theorem) that the increase in $A$ proves unambiguously beneficial to him because the direct (and positive) effect of the prize on the payoff dominates the strategic (and negative) effect of its rival’s increased strength. But this is not necessarily the case for the ruler nor for overall welfare. Inspection of (30a), for example, indicates the presence of effects similar to those experienced by the rebel leader. However, there is a new adverse effect here: the resulting increase in the rebel leader’s military capability $\bar{S}_2$ (effected by hiring more troops and purchasing more weapons) reduces the ruler’s tax collections by eroding his tax base. The intensity of this adverse effect varies in proportion with the size of the tax, thus generating the possibility that the ruler’s payoff and overall efficiency may fall if the tax rate is sufficiently high.

For clarity we collect these observations in Proposition 3.1 below.

**Proposition 3.1** For any given wage tax/subsidy rate $\tau$, payoffs under conflict are related to the value of the contested rents $A$ as follows:

(a) There exists a tax rate $\bar{\tau} \in (0, 1)$ such that $d\tilde{U}_1 / dA \geq 0$ if $\tau \lesssim \bar{\tau}$.

(b) The rebel leader’s payoff function is increasing in $A$.

(c) Aggregate welfare may fall as $A$ rises if the tax rate is sufficiently high.

The prediction in part (a) that the ruler’s payoff may fall with the value of the contested rents is interesting. As noted earlier, this relationship is due to the rebel leader’s increased willingness to recruit more soliders when the size of the contested pie increases, thereby eroding the state’s tax base. The fact that this effect dominates when $\tau$ is large suggests the ruler will prefer lower taxes for larger values of $A$.\footnote{In the proof of part (a) in the Appendix we also examine the dependence of $\tau$ on the technologies of conflict and arming.}

Part (b) is due to the fact that the direct (and positive) effect of an increase in $A$ on the rebel leader’s payoff dominates the strategic (and negative) effect of the ruler’s expansion of military capacity. The prediction in part (c), that aggregate welfare may fall
when the value of the contested resources rises is also interesting because it suggests, at least in part, the possibility that negotiation and settlement may help improve efficiency. We will address this issue in subsequent discussion. Still, it is worth noting that we may view this welfare finding as an example of “immiserizing growth” (Bhagwati, 1958) due to internal conflict and suboptimal fiscal policy. Even closer may be its relationship to the more recent literature on the “resource curse” problem—see Sachs & Warner (1995); Ross (2003); Mehlum, Moene, & Torvik (2006); Robinson, Torvik, & Verdier (2006); among others—which identifies a negative link between resource abundance and rates of growth or, more liberally, welfare. While our work resembles the strand that attributes inefficiency to rent-seeking and domestic conflict—see Torvik (2002); Garfinkel, Skaperdas, & Syropoulos (2008)—it differs in that the tax plays a pivotal role here. In particular, if \( \tau = 0 \), an increase in the value of rents benefits both contenders, as would be the case in a standard contest over a fixed prize.\(^{120}\) For clarity and added emphasis we summarize a more general version of this observation in

**Corollary 3.1** If the tax rate on labor is sufficiently low or negative (specifically, if \( \tau < \bar{\tau} \)), then an increase in the value of the contested rents \( A \) is Pareto improving under conflict.

Several questions arise at this juncture. Going to an earlier stage of the game, if the ruler uses fiscal policy to further his own interest what are the salient features of his optimal policy? Does this policy benefit the rebel leader? And, what are its consequences for economic efficiency? Moreover, how does the optimal tax/subsidy, and the payoffs it gives rise to, depend on the value of contested rents? Clearly, the ruler’s discretion over \( \tau \) is a key strategic consideration in this setting and thus we need to examine it in more detail.

### 3.2.4 Optimal Tax Policy under Conflict

To address the above issues let us first derive explicitly the effects of taxes on conflict payoffs. Starting with the ruler, differentiation of his payoff \( \tilde{U}_1 \) with respect to \( \tau \) (while

---

\(^{120}\)Since taxes are still being considered exogenously here, at this point it would be fair to point out that the fall in income comes purely from the change in the government’s payoff. We will see later, however, that under certain conditions ordinary citizens (labor) can also be negatively affected by increases in \( A \) because of associated changes in taxes and/or destruction.
normalizing $\mu = 1$ for simplicity) yields

$$
\bar{U}_1^{\tau} = w \left[ (1 - \delta_L) L - \psi_w^2 S^2 \right] + \tau w^2 \psi_w^2 S^2 + \left( A\phi_{S_2}^1 - \tau w \psi_w^2 \right) S_r^2. \quad (34)
$$

What (34) says is that while taxes have the direct, positive effect of increasing revenues extracted per worker, the ruler must also balance this benefit against several other negative effects at the margin. These effects largely occur because $\bar{S}_r^2 > 0$: making it less expensive for the rebel leader to hire soldiers will not only erode the ruler’s tax base, but also diminish his share of the contested capital (by $A\phi_{S_2}^1 < 0$).\footnote{121} The increase in rebel soldiers can be worsened further by for the ruler by an additional “substitution effect” (captured by $\psi_w^2 < 0$), since when labor becomes cheaper relative to guns, the rebel leader will hire relatively more labor.\footnote{122}

Turning to the rebel leader, differentiation of his payoff $\bar{U}_2$ with respect to the wage/tax subsidy gives

$$
\bar{U}_2^{\tau} = A\phi_{S_1}^2 \bar{S}_r^1 + w \psi_w^2 \bar{S}_r^2. \quad (35)
$$

The direct effect of a marginal increase in the tax rate on the rebel leader’s payoff (the second term in (35)) is positive and it is due to the reduction in the opportunity cost of recruiting rebels. The first term is a strategic effect that is associated with the ruler’s response to the rebel leader’s action when $\tau \uparrow$. This effect is positive or negative depending on whether $\bar{S}_r^1 < 0$ or $\bar{S}_r^1 > 0$. In this case, it is straightforward to show that $\bar{S}_r^1 \leq 0$ if $\gamma \leq 1$. Regardless, however, in Lemma 3.1 below we show that the direct effect dominates; therefore $\bar{U}_r^2 > 0$.

Naturally, higher taxes affect labor adversely because they reduce the after-tax wage rate. Therefore the question that remains is: how do taxes affect overall welfare? Differentiation of (30c) yields

$$
\bar{U}_r = A\phi_{S_1}^2 \bar{S}_r^1 + A\phi_{S_2}^1 \bar{S}_r^2 - \tau w \psi_w^2 \bar{S}_r^2 + \tau w^2 \psi_w^2 \bar{S}_r^2. \quad (36)
$$

\footnote{121}{One can show that, even when $\tau < 0$, $A\phi_{S_1}^1 - \tau w \psi_w^2 < 0$.}

\footnote{122}{This effect is actually positive when $\tau < 0$, however, since a shrinking tax base has the opposite effect in this case.}
All terms in (36) are negative, except perhaps the first. Yet, even that term is negative if the ruler has a sufficient advantage in the contest (i.e., when $\xi$ is sufficiently lower than 1 and $\tau$ is not too high). In short, the overall impact of taxes on welfare is negative; therefore, the optimal policy of a (hypothetical) benevolent leader is a subsidy that hits the institutional bound $\tau_{\text{min}}$. It is easy to verify that this fiscal policy coincides with the policy that minimizes $\psi^1S^1 + \psi^2S^2 + \tau\psi^2\tilde{S}^2$.

With this in mind, let us consider the optimal policy of a kleptocratic ruler. To deepen our understanding of this policy, it is useful to temporarily abstract from fiscal capacity constraints. To this end suppose the admissible tax interval $T$ is sufficiently wide. In addition to summarizing our discussion on the impact of wage taxes/subsidies on payoffs, the following Lemma describes several key features of the optimal tax/subsidy rate under conflict, including its dependence on the value of the contested rents.

**Lemma 3.1** The higher (lower) the wage tax (subsidy) rate the higher the conflict payoff to the rebel leader ($d\tilde{U}^2/d\tau > 0$) and the lower overall welfare ($d\tilde{U}/d\tau < 0$). However, there exists a unique optimal tax/subsidy rate under conflict $\tau^*_c(A) \in T$ that is negatively related to the value of the contested rents (i.e., $d\tau^*_c/A < 0$). Moreover, there exist levels $A^0$ and $\overline{A}$ of the contestable rents such that

(a) $\tau^*_c(A) \leq 0$ if $A \leq A^0$; and
(b) $\tau^*_c(\overline{A}) = \overline{\tau}$.

In the Appendix we prove: (i) $\tilde{U}^1$ is concave in $\tau$ (i.e., $\tilde{U}^1_{\tau\tau} < 0$ which implies uniqueness of $\tau^*_c$), and (ii) a marginal increase in the value of the resource rents $A$ reduces the net marginal benefit of a tax/subsidy increase to the ruler ($\tilde{U}^1_{\tau A} < 0$). This explains why $d\tau^*_c/dA < 0$ in Lemma 3.1. The lesson is clear. The higher the value of resource rents, the lower the ruler’s need (and incentive) to rely on fiscal policy for revenue purposes. Part (a) takes this observation one step further: it establishes that the optimal tax turns negative (i.e., it becomes a subsidy) when the value of resource rents is sufficiently high. This interesting finding suggests that resource abundance may not only temper the ruler’s appetite for tax revenues, but also induce him to subsidize labor! However, this incentive is not based on altruistic motives or a concern for labor’s fortune. Rather, purely a reflection
of the ruler’s calculation that wage subsidies, by raising the opportunity cost of recruiting rebels, curb the rebel leader’s willingness to expand his military capacity.

Part (b) utilizes the monotonicity of the kleptocratic ruler’s optimal fiscal policy in the value of resources to establish that \( \tau^*_C(A) \) will cross \( \tau \) once at some level \( \bar{A} \), as depicted in Fig. 2a. This result proves helpful in our analysis of equilibrium payoffs when taxes are endogenous.\(^{123}\)

Let us index all variables, including agents’ payoffs, with a star “∗” when the tax/subsidy is endogenous. How might resource abundance affect payoffs in this case? First, we address this question under the assumption that the capacity constraints on fiscal policy is not binding. Later, we examine how these constraint matter.

Once again, as in the case of a fixed tax rate, increases in the value of contested rents induce both contenders to expand their military capacities. However, there is a difference: the rebel leader’s incentive to produce more guns is now tempered (but not entirely offset) by a negative effect due to the accompanying fall (rise) in the tax (subsidy) rate. This induced policy effect generates another effect as well: it increases the ruler’s share of the contested resource rents, and thus his power. Proposition 3.2 below summarizes our key findings on the dependence of equilibrium payoffs under conflict on the value of rents \( A \).

**Proposition 3.2** In an unconstrained subgame perfect equilibrium in which the ruler uses fiscal policy optimally, conflict payoffs are related to the value of the contested resource \( A \) as follows:

(a) The ruler’s payoff function is quasi-convex in \( A \) and is minimized at a level \( \bar{A} > 0 \).

(b) The rebel leader’s payoff function and labor’s welfare are increasing in \( A \).

(c) Abundance in resource rents may reduce efficiency if \( A \) is sufficiently small initially.

Part (a) of Proposition 3.2 is an outgrowth of Proposition 3.2(a) and Lemma 3.1(a), and Fig. 3.2 illustrates it. Its key message is that the endogeneity of the tax rate tends to generate a U-shaped relationship between the ruler’s payoff \( U_{1*} \) and contested resource

\(^{123}\) We have expressed the optimal tax/subsidy \( \tau^* \) as a function of \( A \) to highlight the importance of the value of the contested rents in the design of optimal policy. But this policy also depends on the technology of conflict (parameters \( \xi \) and \( m \)), the contenders’ arming technologies (\( \psi^i \)), the prices of guns in the world market (\( q \)), and the bounds of fiscal capacity (the endpoints of \( T \)). The implied relationships between \( \tau^* \) and these parameters can be studied with the help of standards comparative statics methods. The same methods can also be used to study the determinants of \( A^0 \) and \( \bar{A} \).
rents. As shown in Fig 3.2a, the tax policy curve $\tau^*_C$ starts out at the institutional constraint $\tau_{max}$, because the ruler’s tax decision is not disciplined by the threat of rebel arming when $A = 0$. The position of $\tau_{max}$ relative to $\bar{\tau}$ is thus what determines the monotonicity of $U^{1*}$. The lower level of $\tau_{max}$ in Fig. 3.2, for example, which is below $\bar{\tau}$ corresponds to the upward-sloping tangent line in the bottom panel. If $\tau_{max} > \bar{\tau}$ on the other hand, by Proposition 3.1, $U^{1*}$ will be non-monotonic. We will explore this relationship in more detail later when we discuss the role fiscal capacity plays in the emergence of conflict.

Part (b) affirms that increases in resource rents enhance labor’s well-being. The reason for this is the reduction in tax policy that such rent increases give rise to. Similarly, the rebel leader’s payoff also rises because the possibly adverse strategic effect due to the ruler’s response (which is dominated by the favorable direct effect when the tax rate is fixed) is ameliorated by the falling tax rate. (See Fig. 1.)

The validity of part (c) hinges on the reasoning that in societies where resource rents are small initially (and, therefore, where the politically optimal tax $\tau^*_C$ is high), the fall in
the ruler’s payoff may not be offset by the payoff gains of the rebel leader and labor, for reasons similar to those outlined in connection with Proposition 1(c). It should be noted though this possibility is less likely to arise when \( \tau \) is endogenous (because \( \tau_c^* \) falls as \( A \) rises).

The \( U \)-shape of the ruler’s payoff with respect to the value of contested rents is a novel feature of our analysis that is entirely dependent on the endogenous determination of tax policy. In similar settings which lack this added dimension (e.g. Garfinkel & Skaperdas, 2000; Garfinkel, Skaperdas, & Syropoulos, 2008), all agents’ payoffs are always positively related to the value of the contested spoils. This distinction is notable mainly for what it says about the potential strategic utility of destruction in this setting: if the ruler had a choice, he might wish to destroy as much capital as possible in order to maximize his total payoff. Intuitively, for low enough values of \( A \) (specifically, \( A < \bar{A} \)), the presence of insecure capital becomes a detriment to the ruler because he begins to care more about the revenues he extracts from his tax base, \( \tau(w(1 - \delta_L)L - w\psi_2^2 S_2) \), than he does his winnings from the contest. Destroying capital directly diminishes his rival’s incentive to arm in (31), reducing his choice of \( S_2 \) and thereby mitigating the erosion of the ruler’s tax base due to rebel arming. Note, however, that the ruler cannot increase his payoff simply by “giving up” his “rights” to some of the contested capital; he can only benefit if some or all of \( K_0 \) is destroyed. The problem with “consensual” transfers of capital in this context is that they are not credible so long as the transferred rents can still be contested in a later stage.

Similarly, it is also important to observe that labor is not immune to strategically motivated violence in this setting either. This incentive enters specifically when the optimal tax is negative (i.e. a subsidy), since any given \( \tau < 0 \) will be less expensive to the ruler when there is less labor. We formalize the implications for conflict payoffs in the following Proposition:

**Proposition 3.3** In an unconstrained subgame perfect equilibrium in which the ruler uses fiscal policy optimally, the ruler’s conflict payoff is quasi-convex in the size of the labor endowment \( L \) and is minimized at some level \( \bar{L} > 0 \).

For formal explanation, we refer to the ruler’s first order condition for \( \tau \) in (34). De-
stroying a fraction of the labor force reduces the ruler’s optimal tax policy (that is, \( d\tau^*_C / d(-L) < 0 \)) by making positive taxes less valuable and negative taxes (subsidies) less expensive. However, by (30a), this type of violence enhances the ruler’s payoff if and only if the tax is negative; that is, \( dU^{1*} / d(-L) \geq 0 \) if \( \tau^*_C \leq 0 \). In short, \( U^{1*}(L) \) attains a minimum at the (positive) value of \( L \) that solves \( \tau^*_C(L) = 0 \), which we call “\( \overline{L} \)” in the above Proposition.\(^{125}\)

These observations pave the way to the central question we wish to address: Will a “deal” with the rebel leader, conducted in the “shadow of conflict”, always be able to circumvent incentives for destruction of capital and/or labor? To begin answering this question, we turn to describing how payoffs and tax policies differ under settlement.

### 3.2.5 Settlement

Our basic treatment of settlement assumes that, for any given arming and tax choices implemented in earlier stages, the two sides use the Nash bargaining solution to settle their claims over the surplus. More specifically, let \( \beta \) be the share of \( K_0 \) received by agent 1 (which implies agent 2’s share is \( 1 - \beta \)) and let \( V^i \) denote \( i \)'s payoff under settlement. Noting that \( V^i \) depends on \( \beta \), the agents solve the following problem:

\[
\max_{\beta} [V^1(\beta) - U^1]^{\lambda^1} [V^2(1 - \beta) - U^2]^{\lambda^2},
\]

where \( \lambda^i \in (0, 1) \) are the relevant Nash bargaining weights (\( \lambda^1 + \lambda^2 = 1 \)) and \( U^i \) is agent \( i \)'s (disagreement) payoff under conflict. Keeping in mind that, in the presence of trade, the marginal utility of income, \( \mu(\cdot) \), remains the same under conflict and settlement the “surplus” due to settlement, for given military strengths, is defined as \( B \equiv \frac{1}{\mu}(V^1 + V^2 - U^1 - U^2) \). One can show that

\[
B(\tau) \equiv r\delta_k K_0 + \tau w\delta_L L.
\]

\(^{124}\)This result only requires applying the envelope theorem to the ruler’s payoff function: \( dU^{1*}/d(-L) = dU^1/d(-L) = \tau(w(1 - \delta_L)). \)

\(^{125}\)Statements about how destroying labor may affect other agent’s payoffs—in particular the implications for labor’s own “welfare”—are reserved for Section 3.4.
Thus, the value of the surplus to agent $i$ is the market value of the contested rents/resource and the tax revenues that would have been destroyed under conflict (but are not under settlement). Note that if conflict is not destructive (i.e., if $\delta_J = 0$ for $J = K, L$), then $B(\tau) = 0$ and so there is no essential distinction between conflict and settlement. Thus, the conditions for the surplus to be positive are: (i) conflict must destroy a fraction of the contested resource or of labor (i.e., $\delta_K + \delta_L > 0$), and (ii) $\tau > \bar{\tau} \equiv -\frac{r^0_K K_0}{w_0 L}$ if $\delta_L > 0$. This latter requirement points to circumstances in which conflict will clearly dominate settlement. We will take up the importance of this condition when we discuss optimal taxation.

The solution to the above bargaining problem defines the following payoffs and aggregate welfare under settlement:

**Payoff Functions under Settlement:**

\[
V^i = \lambda_i \mu B(\tau) + U^i, \quad i = 1, 2
\]

\[
V \equiv \mu (1 - \tau) w L + \sum_i V^i = \mu B(\tau = 1) + U,
\]

For any given tax rate $\tau > \bar{\tau}$ and a pair of military strengths $(S_1, S_2)$, the surplus $B(\tau)$ will be positive and thus the contenders will prefer settlement over conflict for all $\lambda_i \in (0, 1)$. Similarly, all else equal (i.e., holding taxes fixed), the labor force collectively will also prefer settlement over conflict because settlement involves no destruction. Thus, under the noted circumstances, settlement improves overall efficiency as compared to conflict. This is a standard, unsurprising result: when conflict involves destruction of resources, settlement should always Pareto dominate conflict.

How is it possible then that one side might choose conflict when settlement is clearly more efficient? The key consideration here is the relationship we have noted between $\tau$ and the balance of military power, not just because $\tau$ shapes the threat points for settlement (the $U^i$’s) but also because the incentives for taxation themselves may depend on the expected mode of interaction (i.e., conflict vs. settlement). We formalize how tax policy under Nash bargaining resembles tax policy under conflict in the following Lemma.

**Lemma 3.2** Assuming Nash bargaining, the ruler’s optimal tax policy under settlement (“$\tau^*_S$”)
relates to his optimal tax policy under conflict (“τ∗C”) in the following two main ways:

(a) \( dτ^*_S / dA = dτ^*_C / dA < 0 \)

(b) \( τ^*_S > τ^*_C \).

Intuitively, tax policy under settlement should be decreasing in \( A \) because conflict payoffs still figure directly into bargaining solutions. Explicitly speaking, \( V^1_{τA} / V^1_{ττ} = U^1_{τA} / U^1_{ττ} \) implies part (a). Furthermore, as we observe from the ruler’s objective functions in (30a) and (38), if conflict reduces the size of the labor force (\( δ_L > 0 \)), then we have that \( B’(τ) > 0 \), such that the government has an added incentive to charge higher taxes in the event of settlement in order to increase the value of the eventual surplus. That is, \( τ^*_S > τ^*_C \), as stated in part (b).

The endogeneity of tax policy thus creates an indirect link between the expectation of settlement and the determination the balance of power. Higher taxes under settlement enhance the rebel leader’s ability to build strength—thus reshaping the division of \( A \)—but also in turn introduce problematic welfare effects via the intensification of arming. As we will show in the following section, the cost to the government of the concession of strength associated with settlement may outweigh the benefits of peaceful surplus-sharing under settlement. We also explore the implications of allowing the expectation of settlement to influence arming incentives more directly.

### 3.3 Conflict vs. Settlement

The goal of this section is to illustrate the potential limits of surplus sharing agreements that arise in our setting. Since conflict involves the destruction of productive resources, the natural expectation is that settlement will dominate conflict by creating a positive surplus that can be shared. As we will see, however, allowing state institutions (in our case, fiscal policy) to play a central role may enhance the value of “conflict” in this context. Under the noted assumptions regarding timing and bargaining, for example, we find that the ruler may choose conflict when the value of contested rents is relatively high because the higher taxes associated with settlement hurt his position in the contest over rents. We also find that varying the timing of the game generally does not affect this result, with one
important caveat: Under the original timing, the ruler’s tax policy can serve as a credible mechanism for committing to conflict “ex ante”, i.e. before arming decisions are made. When we explore alternate timing structures, where tax policy is chosen later in the game, there exist cases where the ruler would find it advantageous to commit to conflict even though he does not continue to prefer conflict “ex post”, i.e. after arming decisions.

In each of these cases, conflicts that predominantly destroy capital (as opposed to labor) are always dominated by settlement. This result changes when we allow arming decisions to affect the division of the surplus. In a variation of the model where bargaining weights are endogenously determined, we observe that conflicts that destroy mainly capital become appealing if the value of contested rents is sufficiently low. Again, however, while commitments to conflict in this last case may be optimal ex ante, they are not necessarily credible ex post. We then add further remarks focusing more specifically on the role that constraints on institutional capacity may play in determining the preferences for conflict, both ex ante and ex post.

3.3.1 When does settlement fail?

Consider first a simplified setting without either taxes (i.e., \( \tau = 0 \)) or labor destruction (i.e., \( \delta_L = 0 \)). The surplus in (37) then reduces to a fixed (positive) quantity \( B = r \delta_K K_0 \) and it is obvious the two sides will find a mutually agreeable way to divide it via settlement. This result is standard; see discussion of “The One-Period Model” in Garfinkel & Skaperdas (2000). Generally, settlement always dominates conflict in this setting unless either payoffs in future periods are taken into account (as in Garfinkel & Skaperdas, 2000) or settlement introduces additional incentives for arming (as in Chang & Luo, 2013, where destruction is endogenous).

Introducing tax policy alone does not change this standard result, despite the noted “U-shape” of the ruler’s payoff \( U_1^* \) with respect to the value of contested rents. Even on the downward-sloping portion of \( U_1^* \), the ruler has no reason to turn down the opportunity to share a positive surplus. That is not to say he does not still prefer larger values of capital destruction associated with conflict (i.e. larger values of \( \delta_K \)).\(^{126}\) Rather, the opportunity

\(^{126}\)As shown in Fig. 3.3, the ruler’s payoff under settlement is also U-shaped with respect to \( A \).
for settlement provides him with a way of avoiding destruction that does not incentivize increased arming by his rival, since by assumption each player receives a fixed share \( \lambda' \) of any surplus (we relax this assumption in section 3.3.3.)

When conflict destroys some of the labor force (i.e. \( \delta_L > 0 \)), however, settlements cannot always compensate the ruler completely for the benefits he derives from destruction. As established in Proposition 3.3, under conflict, the ruler prefers a smaller labor force whenever the optimal tax is negative (i.e. a subsidy). A smaller labor force allows the ruler to use larger subsidies, which in turn increase his advantage in the contest over rents. The ruler may then induce conflict in order to retain the opportunity to use larger subsidies, even in cases where a settlement would have resulted in a positive surplus.

When specifically does settlement fail? To answer this question, we first refer to the simple case where conflict emerges even when taxes are held fixed. This is the case where tax policy (in this case, a subsidy) is fixed at a value less than \( \bar{\tau} \equiv -\frac{\delta_L K_0}{\delta_L L} \), the value at which the surplus becomes negative. In Fig. 3.3a, \( \bar{\tau}(A) \) is the dotted line, shown as a function of the (modified) value of rents \( A = r(1 - \delta_K)K_0 \) (such that \( \bar{\tau}(A) \equiv -\frac{\delta_K}{1-\delta_K} \frac{A}{w_L} \)). If the ruler adopted a wage subsidy below this line, the subsidy would be so costly to the ruler that destroying some of the labor endowment would become attractive (as it would reduce the overall bill). This case is not especially interesting, since we are simply noting that conflict would be preferred to settlement when there is no positive surplus to be bargained over. This boundary on the overall appeal of settlement is nonetheless important for explaining what can happen when tax policy is endogenously chosen prior to recruitments. As we now demonstrate, conflict may be preferred even when there would have been positive surplus under settlement.

**Proposition 3.4** Suppose taxes are endogenously determined. If both the relative incidence of labor destruction resulting from conflict (\( \frac{\delta_L}{\delta_K} \)) and the ruler’s capacity to issue subsidies (\( |\tau_{\text{min}}| \)) are sufficiently large, there will exist a range of values of contested rents \( A \in (A_D, \bar{A}_S) \), for which conflict will emerge in equilibrium even though settlement generates a positive surplus. Furthermore, \( A_D > \bar{A} \), such that this range occurs on the upward-sloping portion of the ruler’s conflict payoff \( U^1^* \).
Figs. 3.3a and 3.3b together illustrate the key details behind Proposition 3.4. To explain these results we need to reiterate the salient facts unveiled in Lemma 3.2: (i) $B'(\tau) > 0$, and (ii) $dT_j^f/dA < 0$ for $f = C, S$. Together, these two points explain the behavior of optimal taxes under conflict and under settlement, as shown by the $\tau^*_C(A)$ and $\tau^*_S(A)$ curves (respectively) in Fig. 3.3a.

Existence of the point $A_D$, where the ruler begins to reject surplus sharing, is guaranteed if both $\tau^*_C(A)$ and $\tau^*_S(A)$ cross the zero-surplus line $\check{\tau}(A)$ depicted in Fig 3.3a. For this to occur, we require that $\delta L/\delta K$ is sufficiently large such that the slope of $\check{\tau}(A)$ is not too steep and that $\tau_{min}$ permits the ruler sufficient flexibility to choose levels of $\tau < 0$ (i.e. subsidies). We can then define $(\check{A}_S, \check{\tau}_S)$ as the point where the $\tau^*_S(A)$ curve intersects $\check{\tau}(A)$ in Fig. 3.3b. At $(\check{A}_S, \check{\tau}_S)$, even though the government optimizes its tax policy in anticipation of settlement, both sides will be indifferent between conflict and settlement because $\tau = \check{\tau}_S$ implies the surplus under settlement is zero. But, because $\tau^*_C < \tau^*_S$, $\check{\tau}_S$ is not the

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127Existence may also hold under other conditions, as we explain in the Appendix.
optimal tax the ruler would choose under conflict for $A = \bar{A}_S$. Thus, the government’s payoff under conflict for $\tau = \tau^c_c(\bar{A}_S)$ must then be strictly greater than its payoff under settlement for $\tau = \bar{\tau}_S$ (the best it can do under settlement).

The rebel leader for his part will also prefer conflict for $\tau = \tau^c_c(\bar{A}_S)$, because the surplus under settlement would be negative at that tax rate. More generally, however, he prefers settlement for all values of contested rents up until $\bar{A}_S$ since—unlike the ruler—he always prefers higher taxes and since settlement is associated with a positive surplus for $A < \bar{A}_S$. Both players would then continue to opt for conflict for values of $A > \bar{A}_S$ up until an upper bound $\bar{A}_M$ (shown in Fig. 6), beyond which tax policies are sufficiently constrained by $\tau_{\text{min}}$ to the point where $\tau(A) \leq \tau_{\text{min}}$ and surpluses become positive again.\textsuperscript{128}

Similarly, let $(\bar{A}_C, \bar{\tau}_C)$ be the point at which the $\tau(A)$ and $\tau^c_c(A)$ curves intersect, with $\bar{A}_C < \bar{A}_S$ following directly from $\tau^*_C < \tau^*_S$. Now suppose that at $\bar{A}_C$, the government chooses $\tau_C$ to be its tax rate and the two sides then proceed to considering conflict versus settlement. Obviously since $\tau_C$ lies on the $\tau(A)$ line, both sides will be indifferent between conflict and settlement at that particular tax policy. But the government’s best payoff under settlement will actually be secured when it charges the higher tax policy $\tau^*_S(\bar{A}_C) > \bar{\tau}_C$. Since $\tau_C$ was defined as the government’s optimal tax under conflict for $A = \bar{A}_C$, the government can do better under settlement in this case. Furthermore, since both tax policy functions are greater than $\tau$ to the left of $\bar{A}_C$, the ruler will prefer settlement for all values of $A \in (0, \bar{A}_C)$.

It remains to be shown then there will be a point on the $A$ axis between $\bar{A}_C$ and $\bar{A}_S$ at which the ruler will begin to prefer conflict. But this last piece follows directly from the fact that the ruler’s payoff functions under conflict and settlement are both continuous in $A$. If the ruler strictly prefers conflict for values of $A$ in the neighborhood of $\bar{A}_C$ and strictly prefers settlement for points in the neighborhood of $\bar{A}_S$, then there must be a point in between where his tax policy switches. On Fig. 3.3b, this is point $F$, the point where the $U^{1*}$ curve (the ruler’s payoff under conflict) begins to exceed the $V^{1*}$ curve (his payoffs under settlement). The presence of this switching point (“$A_D$”) to the left of $\bar{A}_S$ is noteworthy.

\textsuperscript{128}To simplify the analysis, we abstract from the possibility that one or both tax policy functions crosses back above $\tau(A)$ before being constrained by $\tau_{\text{min}}$. We discuss these possibilities in the Appendix.
because it means there exist cases where the ruler will prefer conflict even if the surplus under settlement would have been positive. Lastly, note that $F$ must be on the upward sloping portion of $U^*$: $\tilde{\tau}_C < 0 < \tilde{\tau}$ implies that $A_D > \bar{A}$ (by $A_D > \tilde{A}_C > \bar{A}$).

The implications are troubling. Bear in mind that the principal difference between conflict and settlement here, under the stated restrictions on destruction, is that some of the labor force is destroyed. When the government is choosing tax rates that will be in the neighborhood of the $\tilde{\tau}$ line, as occurs when $A \in (\tilde{A}_C, \tilde{A}_S)$, then the $\tau^*_C$ curve will definitely be negative. The role of labor destruction is key here: by reducing the labor force, conflict gives the ruler the budgetary freedom to issue a larger subsidy than would be possible under settlement. The larger subsidy helps subdue rebellion and in turn gives the ruler sufficient advantage in the contest over resources to make conflict viable. In other words, a self-interested government may deliberately allow its population to be decimated in order make controlling the remainder more affordable.

A notable feature of this explanation for the emergence of conflict is that the ruler uses his choice of tax policy ex ante (i.e. before arming decisions are made) to induce a situation where both players prefer conflict ex post (i.e. after arming choices). In other words, tax policy serves as a credible mechanism for the ruler to signal his commitment to conflict to the other player. As we show in the following section, this ability to make credible commitments to conflict should not be taken for granted. In settings where either the timing of the game is changed (such that tax policy is no longer chosen first) or the division of the surplus is endogenously determined (such that settlement itself introduces additional arming incentives), there will exist cases where the ruler would find it advantageous to commit to conflict ex ante, but may not be able to do so credibly.

### 3.3.2 Alternate Timing

Our assumption that the ruler chooses his tax rate before militaries are formed has important consequences for the model because it allows him to anticipate how his tax rate affects

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For simplicity’s sake thus far we have regarded “labor destruction” as being equivalent to the “death” of some of the potential working population, but it could also be thought of as due to dislocation. In the current Syrian conflict, for instance, 100,000 civilians have died but another 2 million have fled to neighboring countries (U.N. Refugee Agency, 2014). Nonetheless, violence against non-combatants is an all-too-common feature of civil wars; see Eck & Hultman (2007).
the formation of military power. In this section, we discuss how varying the timing of the
game may affect the emergence of conflict.

Suppose, for instance, that instead of being chosen first, $\tau$ is chosen simultaneously
with $S_i$'s. To characterize how this timing structure affects our findings, we focus on how
the government's first order condition for $\tau$ changes. First, consider the government's
tax/subsidy choice in the event of conflict under our original timing assumption, charac-
terized in (34).

On the one hand, increases in tax revenues draw higher revenues per worker, a positive
effect. But this positive effect must be balanced against resulting reductions in the tax base,
which occur via two different channels: (i) increased utilization of labor by the rebel leader
for a given $\tilde{S}_2$ (a “substitution” effect, induced by $\psi_{ww} < 0$), and (ii) increased arming in
equilibrium by the rebel leader (i.e. $\tilde{S}_2^\tau > 0$) as the increase in taxes causes a shift in the
balance of power (a “strategic” effect).

The effect of varying the timing of the game such that the ruler cannot anticipate his
rival’s arming response in making his tax decision is equivalent to removing the strategic
effect from (34). Since $w \left[ (1 - \delta_L) L - \psi_{ww} \tilde{S}_2 \right] > 0$ and $w^2 \psi_{ww} \tilde{S}_2 < 0$, $\tau^*_C$ will always be pos-
tive when taxes are decided simultaneously with arming. Obviously, since the potential
optimality of negative taxes plays a key role in the explanation for the emergence of con-
fl i ct described above, this alternate timing assumption has a material effect on our results.
Conflict then will never be preferred to settlement *ex post* under this alternate timing.

Instead, however, we now have the new result that—for sufficiently large values of
$A$—conflict may be preferred *ex ante*, but not *ex post*. The intuition for why this new result
emerges would seem to help justify our original timing assumption. Suppose that before
arming decisions are made, the ruler has the opportunity to declare a binding commitment
to choosing conflict at the end of the game. Furthermore, suppose this commitment is
considered credible; we will discuss potential means for ensuring credibility later. When
the ruler cannot internalize the effect of his tax choice on its rival’s arming decision, he
instead may wish to declare a commitment to conflict *ex ante* in order to convince his rival
he will choose the lower tax rate associated with conflict and thereby cause him to be less
aggressive in his arming. In this case, the opportunity to pre-commit to conflict is directly
analogous to the implicit choice the ruler makes between the $\tau_C^*(A)$ and $\tau_S^*(A)$ curves under the original timing. Only here, instead of using taxes to signal his preferences about conflict, he effectively must use pre-commitment to conflict to signal his preferences about taxes. In either case, his ultimate goal is to use the linkage between taxes and arming to influence the balance of power.

Interestingly, this same result can also hold even when the tax is chosen after arming decisions are made, i.e. even when taxes are decided on jointly as part of any settlement. In this latter case, both sides have every incentive to agree on as high a tax as possible in the event of settlement, which would seem to enhance its appeal. Again, however, that high tax will in turn be anticipated by the rebel leader and he will arm aggressively to take advantage ahead of time. The ruler’s prerogative again may be to prefer to pre-commit to conflict in order to curb his rival’s aggression in the earlier stage.\(^{130}\)

These examples also reveal that even under the original timing, the tax decision itself can serve as a means of committing to conflict. By intentionally inducing a negative surplus the government effectively ensures that conflict will prevail in the later stage. Furthermore, these experiments also reveal the common thread that underlies the emergence of conflict in this setting: the rebel leader cannot credibly commit to restrain his arming for a given level of taxation. If his choice of arms were somehow contractible, he would realize that he and the ruler together could enjoy much larger spoils if neither armed and if labor were taxed up to the maximum amount $\tau_{\text{max}}$. Without perfect contracting, however, the absence of arms is unsustainable: either player would regard the lack of arming by the other as an opportunity to seize the entire pie of rents.

A related alteration to the game tree we should consider is what happens when both players can tax (or subsidize) labor. We show in the Appendix that even when both players are symmetric in every way, including the ability to use tax policy, preferences for conflict still emerge because each player internalizes how his use of taxes will affect labor supply for the other player.\(^{131}\) This finding is important to keep in mind since it reveals that, for the

\(^{130}\)In this latter case, the threat that the rebel leader will substitute some of his guns for more labor is what prevents the government from charging the maximum possible tax in the event of conflict. That is, even though the rebel chooses what level of strength ($S_2$) to finance in the second stage, he still retains discretion over how to allocate that expenditure until the tax is ultimately decided.

\(^{131}\)Intuitively, for large enough $A$, the marginal benefit of using negative taxes to drive up the other player’s
most part, it is not any fundamental asymmetry in the model that generates conflict, but rather the added layer of strategic interdependence provided by the effect of one’s policy choices on a common pool of labor. It is also important to note, however, that a symmetric model can only generate preferences for conflict under the baseline timing and does not generalize to the alternate timing cases we have just described. Furthermore, avoiding the need for symmetry facilitates our discussion of equilibrium dynamics—which we turn to in Section 3.4—and can be justified on the grounds that official state institutions may be significantly less constrained than those of rebel groups.\textsuperscript{132}

\textbf{3.3.3 A Variation on the Model: Endogenous Bargaining Weights}

Thus far, our main result has relied heavily on the idea that conflict eliminates workers who would have provided productive labor in the event of settlement. But what if instead the destruction from conflict is characterized more so by destruction of the contested resource than by destruction of labor? Is it still possible that the endogeneity of the tax rate can cause the government to prefer conflict to settlement in certain cases? The answer is yes. However, we would need to introduce an alternate bargaining framework in which bargaining weights ($\lambda^i$'s) depend endogenously on one’s military strength, as in the “agreements in the shadow of conflict” (ASC) bargaining concept formalized by Esteban & Sákovics (2007).

In the simplest implementation of the Esteban & Sákovics framework, the bargaining weights $\lambda^i$ in Nash’s bargaining model coincide exactly with $\phi^i$, the CSF that determines the division of the prize under conflict (i.e., $\lambda^i = \phi^i$ for $i = 1, 2$). Its general appeal is that it provides an intuitive and yet powerful link between the value of the surplus and arming even in the absence of risk aversion or endogenous destruction.\textsuperscript{133} The key for our purposes is that the need to compete for the negotiation of the surplus under peaceful

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\textsuperscript{132}More general treatments of asymmetry (where each player posseses different levels of institutional capacity) go beyond the scope of this chapter but should not be considered unimportant. Our essential reasoning should still apply directly, however, in cases where one player is constrained in his policy choice and the other is not.

\textsuperscript{133}See Skaperdas & Syropoulos (2002) and Anbarci, Skaperdas, & Syropoulos (2002) for similar approaches that rely on the presence of diminishing returns; also see Chang & Luo (2013) for a model that demonstrates similar frictions when destruction is endogenous.
settlement generates additional arming incentives that are not present under conflict.\textsuperscript{134}

It is important to emphasize at the outset, however, that endogenous bargaining weights by themselves are neither necessary nor sufficient for obtaining conflict in equilibrium.\textsuperscript{135} The main result still depends on the differential effects of tax policy on payoffs, although here the linkage between destruction and the balance of power is more direct. In addition, the mechanism by which conflict is chosen may be different than under fixed bargaining weights (i.e. Nash bargaining). Once again, the emergence of conflict will require that the ruler is able to make a credible promise that it will refuse to settle at the end of the game. Because preserving capital always adds to the size of the eventual surplus, conflicts that destroy mainly capital are still dominated \textit{ex post} as before. From an \textit{ex ante} perspective, however, the opportunity to commit to an outcome where capital is destroyed may be very appealing for the ruler.

For a simple example, take the case where $\tau$ is held fixed at some positive level (as would be the case, for example, if taxes are tightly bound by the capacity constraint $\tau_{\text{max}}$). As the following Corollary formalizes, the anticipation of settlement by the rebel leadership leads to more aggressive arming, which can have further negative consequences for the ruler via the effect on his tax base:

\textbf{Corollary 3.2} Suppose bargaining weights are endogenously determined. Then for a given tax rate $\tau$, the ruler will prefer conflict \textit{ex ante} (but not \textit{ex post}) if $\tau$ is sufficiently large (specifically, if $\tau > \bar{\tau}$, with $\bar{\tau}$ the tax rate that minimizes the ruler’s conflict payoff $\tilde{U}^{1}$). Otherwise he strictly prefers settlement.

The logic behind Corollary 3.2 follows from Proposition 3.1, but requires some further explanation. When bargaining weights are endogenous, one of the effects of “settlement” is to change the relevant value of “$A$” in the first order condition for arming (31) from “$(1 - \delta_K)K_0$” (the value of the undestroyed rents) to simply “$rK_0$” (the full value of rents).

\textsuperscript{134}Even if we stayed within the confines of the Nash bargaining model and treated $\lambda^i$ as constant, the size of the surplus will impact upon arming incentives if the rental rate $r$ in (38) is endogenous (as when either the “small” economy assumption is relaxed or when the economy completely specializes in producing one of the two consumption goods).

\textsuperscript{135}See (for example) the section entitled “A Comparison with the Nash Bargaining Solution” in Esteban & Sákovics (2007) for an example of a model analogous to ours with tax revenues removed from the analysis.
Settlement thus is associated with higher overall arming and, by extension, a reduction in the size of the tax base. For lower taxes, the loss of tax revenues due to this distortion is minimal and settlement will dominate. For high enough taxes, however, the option to commit to conflict \textit{ex ante} becomes an appealing way to restrain incentives for arming. In other words, the ruler prefers to destroy rents when his they are negatively associated with his payoff. By Proposition 3.1, this relationship holds when \( \tau > \overline{\tau} \).

Clearly, however, the role that taxes play here in incentivizing conflict is different from before. Instead of tax policy being used to influence the outcome from conflict, \textit{ex ante} commitment to conflict is being used to enhance the return to tax collection. Furthermore, unlike the cases outlined above, preferences for conflict only materialize when the value of rents is sufficiently low; under fixed bargaining weights, conflict only emerges when the value of rents is sufficiently high. This sharp distinction between how the value of contested rents relates to conflict decisions with variable bargaining weights and fixed taxes versus with fixed bargaining weights and variable taxes begs the question: what happens when both taxes and bargaining weights are allowed to be endogenous? Proposition 3.5 explains.

\textbf{Proposition 3.5} When both taxes and bargaining weights are determined endogenously, conflict can emerge under the following scenarios:

(a) If the incidence of labor destruction (\( \delta_L \)) is sufficiently small, and the ruler’s capacity to tax is sufficiently large (specifically, if \( \tau_{\text{max}} > \overline{\tau} \), the ruler will prefer conflict \textit{ex ante} (but not \textit{ex post}) over settlement for a range of values of contested rents \( A \in [0, A_1] \), with \( A_1 < \overline{A} \) (and \( \overline{A} \) still defined as the value of rents that minimizes the ruler’s conflict payoff \( U^{1*} \))

(b) If both the relative incidence of labor destruction resulting from conflict (\( \frac{\delta_K}{\delta_L} \)) and the ruler’s capacity to issue subsidies (\( |\tau_{\text{min}}| \)) are sufficiently large, then there exists a range of values of contested rents \( A \in (A_D, A_S) \), with \( \overline{A} < A_D < \overline{A_S} \), for which the ruler will prefer conflict (both \textit{ex ante} and \textit{ex post}) even though settlement generates a positive surplus.

The full details of Proposition 3.5 are described in the Appendix. We also defer until
the next section a more focused discussion of the how state capacity constraints (here, $\tau_{\text{max}}$ and $\tau_{\text{min}}$) may limit the appeal of war. The main point to make at this juncture is that the two different conditions specified for the emergence of conflict—on labor destruction ($\delta_L$) in part (a) and on relative destruction ($\delta_L / \delta_K$) in part (b)—are not mutually exclusive. That is, there can be cases where conflict could be preferred solely ex ante (for sufficiently low values of the contested rents) or both ex ante and ex post (for sufficiently high values). Fig. 3.4 illustrates such a case.

Overall, the intuition is straightforward given the relationships we have already discussed. First, consider what happens when the value of contested rents is very small (i.e. when $A = 0$). In this case, there will be virtually no incentive to arm unless there is settlement—in which case a prize of size $w\delta_L L \tau_S^e$ effectively comes into play. Thus (absent constraints on taxation), the government will never choose settlement in this region unless $\delta_L$ is large enough that the damage to its tax base from conflict is too costly to bear. So long as we can identify some point $A_1 > 0$ on the downward-sloping portion of $U^{1*}$ where con-
conflict is preferred, it will always be the case that conflict is preferred everywhere between 0 and \( A_1 \), by the continuity of payoffs. The left-hand side of Fig. 3.4b demonstrates such a case.

The logic behind part \((b)\) unsurprisingly flows from our discussion of Proposition 3.3. As \( A \) increases in size, it can be shown that \( \tau^*_S (A) \) begins to be strictly larger than \( \tau^*_C (A) \), as in the fixed bargaining weights case.\(^{136}\) Then so long as \( \tau^*_S (A) \) and \( \tau^*_C (A) \) each cross the \( \bar{\tau} (A) \) line, which occurs under familiar restrictions on \( \frac{\partial L}{\partial L} \) and \( \tau_{\text{min}} \), the reasoning behind the existence of \( A_D \) is the same as before.

The potentially non-monotonic relationship between contested rents and conflict highlighted this setting illustrates how allowing for an endogenously chosen mode of interaction complicates the analysis of civil war. Much of the empirical literature on rents and civil conflict has looked for straightforward correlations between resource rents and civil war, but our theory suggests rents may affect incentives for peace and incentives for war in different ways. These issues have been touched upon in Le Billon (2003) and Fjelde (2009), but merit further theoretical and empirical investigation.

Finally, one last interesting consideration that arises is the question of how exactly the ruler can credibly “pre-commit” to conflict \( \text{ex ante} \) in situations where settlement is preferred \( \text{ex post} \).\(^{137}\) Even if the government announces ahead of time it will not negotiate for peace, the rebels may not necessarily find these promises to be credible.\(^{138}\) So what can the state in this case do to convince its adversary otherwise? It may, for instance, antagonize its rival by stoking political, ethnic, and/or social divisions. Alternatively, if enforcement of settlement is known to be contingent on the efforts of external powers such as the U.N., the ruler may deliberately sabotage those efforts.\(^{139}\) In sum, even if the exact mechanism for how the ruler might credibly influence the beliefs of its rival is not immediately clear,

\(^{136}\)For proof, see the Appendix.

\(^{137}\)This is a common issue in game scenarios where one player has the opportunity to “pre-commit”. Dixit (1980), for instance, features an analogous situation where an incumbent firm commits to “fight” potential entrants, even though fighting would be suboptimal if entry occurred. Explanations for the emergence of war described in Beviá & Corchón (2010) and Chang & Luo (2013) also require that such pre-commitments are possible.

\(^{138}\)The U.S. government, for instance, which famously “does not negotiate with terrorists”, does in fact negotiate with groups it had previously labeled terrorists on occasion.

\(^{139}\)Walter (1997) presents evidence that external enforcement often plays a crucial role in securing settlements in civil war scenarios.
the model nonetheless indicates that embattled states may have powerful incentives to oppose negotiating for peace.

3.3.4 The Role of State Capacity

Thus far, we have only minimally commented on the operative roles played by institutional capacity constraints ($\tau_{\text{max}}$ and $\tau_{\text{min}}$) in the emergence of conflict. Proposition 3.5 highlights two potential roles in particular worth focusing more on. We take this opportunity now to add some further remarks.

We also wish to place these findings within the context of the wider literature on state institutions and civil war. What, for example, might these conditions on $\tau_{\text{min}}$ and $\tau_{\text{max}}$ allow us to say more generally about how limits on institutional capacity influence war and peace? And how exactly should these parameters be interpreted? The outbreak of civil war is usually found to be negatively correlated with known measures of “fiscal capacity” (Sobek, 2010; Besley & Persson, 2011), contrary to our findings. Some clarification is required.

We start by focusing on $\tau_{\text{max}}$. Fig. 3.5 shows a simplified scenario from our model, drawing on Proposition 3.5b, where bargaining weights are endogenously determined and where only capital is destroyed. We have already described how $\tau_{\text{max}}$ determines the monotonicity of the ruler’s payoff under conflict ($U^{1*}$) in our discussion of Proposition 3.2. Fig. 3.5 now clarifies how this logic carries over to the question of conflict vs. settlement. The dotted and dashed and dashed (tangent) lines illustrate the effects of different levels of $\tau_{\text{max}}$ on the ruler’s payoff curves. Moving from left to right, the two downward-sloping lines depict what occurs when the ruler has sufficient flexibility to vary his tax policy on at least some some values of rents less than the critical value $\Lambda$ (i.e., when $\tau_{\text{max}} > \bar{\tau}$). As in Fig. 3.2b, when the optimal tax policy under conflict ($\tau_{\text{C}}^*$) is allowed to exceed $\bar{\tau}$ the ruler’s conflict payoff ($U^{1*}$) is decreasing in $A$. The new insight here is that the same is also true for his payoff under settlement ($V^{1*}$). In this example, “settlement” resembles “conflict”, only over a larger pie of rents; That is, $V^{1*}(A) = U^{1*}(A/(1-\delta_K))$. It follows that, for $A < A_1$, conflict not only dominates along the unconstrained portions of $U^{1*}$ and $V^{1*}$ (by
Proposition 3.5(a), but the constrained portion as well (by Corollary 3.2).

On the other hand, when constraints on taxation are sufficiently tight (i.e. $\tau_{\text{max}} < \tau$), the ruler lacks the leeway to prey more aggressively on labor when the value of rents would otherwise be too small to be appealing to him (i.e. when $A < \overline{A}$). As shown in Figure 3.5 (by the upward-sloping lines), the effect on payoffs is to eliminate the non-monotonicity in both $U^{1*}$ and $V^{1*}$, such that the payoff to settlement always exceeds the payoff to conflict. This result generalizes further to cases where labor is destroyed (by Corollary 3.2) but this example is sufficient for illustrating the key mechanisms at work.

The idea that limits on institutional capacity to tax promote peace does not attract much support in the literature. Civil wars by far are more prevalent in developing countries with weak formal institutions. Thus we cannot interpret $\tau_{\text{max}}$ literally as signifying the presence of a well-functioning professional revenue collection service, as in Besley & Persson (2011). Instead, we take a broader interpretation. The variable $\tau$ in our model, while it serves to transfer income that otherwise would go to labor, need not be thought of strictly as a “tax”. Rather, it can be thought of in more general terms as “corruption”. Le Billon (2003) observes that corrupt practices contribute to civil war by lowering the opportunity cost of abandoning productive work.\footnote{Le Billon synthesizes prior insights from Mauro (1995, 1998) and Collier (2000).} This argument closely mirrors the role of $\tau$ in our model: to the extent that governments internalize the effect their corruption has on labor’s income...
(and to the extent they themselves can constrain it), varying the degree of corruption may provide an instrument for influencing the supply of labor to their opposition. \( \tau_{\text{max}} \) may then be better thought of reflecting the state’s effectiveness at extracting value from useful production.

Under this broader interpretation of “fiscal institutions”, our model suggests that states who are more effective at corruption, but are not especially wealthy in nonlabor resources, should incur a higher risk of civil war. To the extent that observed corruption in the data reflects high capacity for corruption, empirical evidence does support this prediction; see Fjelde (2009). It remains to be seen, however, if (as our model suggests) conflicts meeting this description involve relatively less violence against the population.

Turning to \( \tau_{\text{min}} \), Fig. 3.6 adds the remaining details (already previewed in Propositions 3.3 and 3.5a) for how limits on subsidy policies affect the appeal of conflict. Specifically, it shows how \( \tau_{\text{min}} \) is associated with a particular value of rents \( \bar{A}_M \), where \( \tau_{\text{min}} \) intersects with \( \bar{\tau}(A) \), the “zero-surplus” line. Conflict then cannot emerge for \( A > \bar{A}_M \) because surpluses will be positive when \( \tau \) is constrained to be greater than \( \bar{\tau}(A) \). The point we want to emphasize for our discussion of \( \tau_{\text{min}} \) is that tighter limits on the ability to subsidize labor’s welfare erode (and eventually eliminate) the appeal of conflict by shifting \( \bar{A}_M \) to the left.

This result too needs to be put in context. In our model, the government uses negative taxes to drive up the rewards to productive labor, in order to restrict the supply of potential recruits to its adversary. We emphasize first that even \( \tau < 0 \) may be associated
with some level of “corruption”, since labor receives no rewards from the state’s nonlabor assets otherwise. But what form do these transfers of nonlabor wealth take? Assuming poor formal institutions, it is again unlikely that the government is able to affect workers’ incomes through direct income subsidies. And general disbursements of wealth or goods to the population may fail to exclude those who join the rebels.

Instead, we suggest $\tau_{\text{min}}$’s interpretation may be expanded to encompass the government’s general capability to (non-coercively) influence the loyalties of a “rational peasantry” (Popkin, 1979). Historically, such gestures have taken a variety of different forms, including the provision of food aid and development projects (as in Guatemala during the 1980s), the reform of property rights and other grievances (as in El Salvador), and/or the use of clientelism and civil service patronage (as in several African conflict-prone nations). The key principle is that a threatened ruling elite may rather fight a smaller rebellion than come to terms with a larger one; thus, it would have a strong incentive to use every tool at its disposal to influence the strength of its opponent.

The role that “public goods”, more narrowly defined, may play in this context is unclear. As argued in Moselle & Polak (2001), the production of “localized” public goods (that benefit only the “loyal” population) are an effective means of restraining the size of an appropriation sector. General improvements in social services and/or infrastructure may not necessarily be “localized”, however, and may therefore be less valuable to the government. Nonetheless, we could also consider extensions to the model where the rebel leadership internalizes the linkage between its own welfare and the government’s provision of public goods. It stands to reason that this linkage may cause them to be less aggressive in interfering the government’s sources of income.

Obviously, there is more that can be said about what other ways “state capacity” may influence incentives for conflict, both within and beyond the context of our framework. Ultimately, the role of the fiscal capacity constraints in our model reflects (and adds to)

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142 Their discussion highlights public celebrations and the building of religious monuments as intuitive examples.
the argument made by Acemoglu (2010): less accountable states will only use stronger institutions (whatever form they may take) to more efficiently pursue the downfall of their rivals.

3.4 Peace and Welfare

Characterizing what “welfare” means in this context requires many caveats. To simply call the total utility enjoyed by all agents in the model a measure of total national well-being glosses over the gross inequities implied by the model, as well as the (unmodeled) human costs associated with violence and destruction. Nonetheless, accounting for the (otherwise overlooked) inefficiencies that may be associated with “peace” is a primary motivation for exploring a model where the mode of interaction is endogenously determined. We begin our discussion of these costs by directly comparing how equilibrium payoffs under conflict would have differed under settlement and vice versa. We then explore how these potential trade-offs weigh on outcomes from external interventions.

3.4.1 The Costs of “Armed Peace”

Our framework highlights two main sources of inefficiency to discuss in this context, arming and taxation. The diversion of productive resources\textsuperscript{143} into arming directly reduces overall production and therefore total national income. Taxation contributes to this inefficiency by incentivizing more arming. “National income” may not be the appropriate welfare criterion to focus on in this context, however, because it includes rents paid to criminals and kleptocrats. If we instead focus strictly on labor’s income to gauge welfare, the negative effects of taxation are obvious.

We have already mentioned in the context of conflict payoffs (in Proposition 3.2, part (c)) that destroying capital may increase “national welfare”. This reasoning in turn extends to the question of conflict vs. settlement, according to the mode of bargaining explored in Section 3.3.3. However, this increase in welfare is solely due to the non-monotonicity of the

\textsuperscript{143}The resources diverted here include not just labor but also rents from (secure) capital used to purchase weapons.
ruler’s payoff with respect to the value of the contested rents. As far as labor is concerned, settlements that preserve primarily capital are (relatively) desirable: destroying capital reduces overall incentives to arm and therefore grants the ruler more freedom to extract higher taxes. The rebel leader is also worse off under conflict (by not having access to as many rents), but the increased channeling of tax revenues to the ruler (reflecting increased overall production) dominates these effects.

When we turn to the case where conflict destroys primarily labor, we observe a more fundamental tension: some labor is destroyed, but the remainder is awarded a higher standard of living. As we show in the Appendix, it is indeed possible that overall labor income will be higher under conflict than under settlement in these cases. Furthermore, our risk-neutrality assumption permits an even more striking statement: there exist cases where all labor will prefer conflict \textit{ex ante}, even though \textit{ex post} a share $\delta_L$ of them will be destroyed. That is to say, labor would “vote” for conflict if they felt the increased subsidy income associated with conflict compensated them for the risk of losing their homes and/or lives.

Clearly, discussing the brutality of conflict in this way abstracts from important considerations that should be discussed in this context. For example, we do not model how citizens who are fortunate enough to avoid destruction may feel about the suffering of those who are not. We also do not model how eliminating some of the population limits an economy’s growth trajectory by affecting productivity and/or and the functioning of formal institutions. Likewise, even though governments have been known to utilize violence for reasons similar to those we describe, it is limiting to assume that agents can perceive with perfect foresight what shares of the population will suffer violence, or that they cannot predict what parts of the population will suffer the most. In short, we identify important incentives that may exist for both violence and war, but do not claim these incentives are justified on the basis of “welfare”.

Instead, what we can say is the unconditional pursuit of “peace” may entail important social costs. The following subsection examines how these confounding trade-offs weigh

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\textsuperscript{144}Our proof of Proposition 3.5 in the Appendix includes this result. 
\textsuperscript{145}We also show, as a corollary, that overall efficiency may be higher in these cases as well. 
\textsuperscript{146}See Valentino, Huth, & Balch-Lindsay (2004); Besley & Persson (2011).
on possible instruments the outside world might use to influence the contest towards settlement.

3.4.2 External Interventions

There are many ways to model how external agents may wish to influence peace and/or welfare in this context. To take advantage of the small open economy structure of the model, we focus on two in particular: general sanctions on imported goods and sanctions on imported weapons specifically.¹⁴⁷ For the sake of brevity, we focus on specific examples rather than try to fully characterize how each of these interventions impacts the different conflict scenarios we have discussed. Generally, we again find that what is best for peace may not be what is best for overall welfare, nor for the welfare of ordinary citizens.

Consider trade sanctions. The small open economy perspective we use provides an intuitive linkage between change in trade prices and incentives for arming via the effect of trade prices on relative factor rewards. To add specificity, assume the capital-intensive sector is the country’s export sector. Also assume the effect of trade sanctions is to lower the domestic price of exports relative to that of imports. It follows that sanctions reduce the reward to capital \((r)\) relative to the reward to labor \((w)\) and thereby (all else equal) mitigate the wasteful diversion of resources towards arming.¹⁴⁸ However, because our framework allows both tax policy and the nature of interaction to be endogenously chosen, the full implications for both conflict and welfare are more complicated. We use the fixed bargaining weights case (Fig. 3.3) for illustration. It is easily seen from Fig. 3.3 that trade sanctions in this case may promote settlement, by lowering the reward to contested capital (embedded in \(A = (1 - \delta_K) rK_0\)). However, as noted in our discussion of conflict payoffs, higher taxes associated lower with lower values of \(A\) themselves generate more intensive diversion of resources away from production. Furthermore, this increase in taxes in response to the reduction in \(A\) is only amplified by the discrete jump in tax policy from \(\tau_C^*\) to \(\tau_S^*\) that occurs under settlement. These negative welfare effects not only come largely at the expense of labor (through the increases in taxes) but may dominate any overall positive effects from

¹⁴⁷ We could also explore, for example, lending technological support to either side’s military.

¹⁴⁸ See Garfinkel, Skaperdas, & Syropoulos (2008) and Dal Bō & Dal Bō (2011) for examples of other work that has studied this linkage.
preserving resources.

We also want to consider how equilibria might respond to external influences on the prices of imported weapons \( (q) \).\(^{149}\) Is it necessarily the case, for instance, that withholding cheap imports of weapons will ward against the risk of conflict in a contested state?

The answer depends on the technology for military strength, \( S_i \): if soldiers and weapons are substitutable in production, then there are two clear channels of effects to discuss. First, higher prices on weapons will make acquiring strength generally more expensive and there will tend to be less overall diversion of resources towards arming. Second, however, higher weapon prices will also make hiring soldiers significantly more attractive. Consequentially, labor markets will only become more sensitive to the ruler’s fiscal policies and he will be more reluctant to use higher taxes. This downward pressure on taxes also tends to reduce overall arming, but what are the implications for conflict?

Actually, sanctions on imported case in this setting would have the (surprising) effect of promoting conflict. The reasoning is as follows. Because the value of \( q \) does not affect \( B'(\tau) = w\delta_L L \) (i.e the marginal effect of taxation on the size of the surplus), the difference between the \( \tau_C^*(A) \) and \( \tau_S^*(A) \) curves in Fig. 3.3 is the same regardless of \( q \). Therefore, the downward pressure on taxes from the increased use of soldiers shifts the critical values \( \tilde{A}_C, \tilde{A}_D, \) and \( \tilde{A}_S \) to the left in Fig. 3.3. In this case where guns and soldiers exhibit substitutability, we thus observe a noteworthy paradox: trade liberalization in weapons may actually reduce the likelihood of conflict.\(^{150}\) We offer this last result as a fitting note to end on. It is only when we separate the means of violence from the use of it that we can better understand the terms of peace against which conflict can be compared.

\(^{149}\)It is also possible to consider separate weapons prices for the two players. The price of imported weapons for the rebel leader is the more interesting of the two in terms of conflict vs. settlement because of how it affects the labor market.

\(^{150}\)Under the assumption that the elasticity of substitution equals 1 (the Cobb-Douglas case), varying \( q \) has no effect on conflict versus settlement. It is straightforward to show increasing \( q \) promotes settlement when this elasticity is less than 1 (when guns and labor are complements) and promotes conflict when it is greater than 1 (when they are substitutes).


3.5 Concluding Remarks

To summarize our main message, accounting for the central presence of state institutions in civil conflict generates novel strategic scenarios that may help explain the emergence of conflict itself. Specifically, the interdependence between the exercise of fiscal policy and the incentive to acquire arms may lead to situations where policy may make violence more effective (and vice versa).

While we show these results within a static political economy model under admittedly stylized assumptions—that both state and rebel groups care exclusively about rents, for instance—the features of our model nonetheless seem to resemble conditions commonly cited as potential causes for the origination and continuation of civil conflicts. We summarize some of the empirically relevant distinctions made possible by our analysis as follows. First, conflict in corrupt states is more likely to occur when the value of “rents” (broadly defined) is either very high or very low. When the value of rents is low, we would expect to see conflicts that are less deadly in nature. When it is high, our model predicts the opposite. Importantly, the outbreak of conflict is conditional on different dimensions of state capacity in either case, which may be difficult to separate in the data. We also do not take a stand on whether or model should be applied empirically to studies of civil war “onset” or “duration”, since we take as given the existence of an armed opposition group.

Another relevant avenue we abstract from here is the intertemporal dimension of civil conflict, as in Besley & Persson (2011). Further work might more explicitly consider civil war as a political competition over future control over the privileges of power. Just like in our static model, the nature of the chosen form of political competition—destructive violence versus political dealmaking—should still depend on the realization of an endogenous tax base. What could prove especially interesting in such a setting might be the state’s potential investments in fiscal capacity. Will the ruling party incur the cost of improving its fiscal institutions knowing that such improvements might reduce its prospects for peaceful deals in the future should it find itself in opposition?

In addition to these questions surrounding civil conflict specifically, this framework more generally raises the issue of how natural interdependencies between players can
generate endogenous shifts in the balance of power which in turn can lead to the emergence of conflict. Our focus here has been on how one side’s discretion over policy affects the dynamics of power within a common economy. Other forms of interdependency that might also be explored in the context of conflict in related work might include trading relationships between countries, complementarities in production, and common external threats.

Appendix

Proof of Proposition 3.1: Once again, we adopt the normalization \( \mu = 1 \). Moreover, to avoid cluttering, we occasionally omit the tilde “\( \tilde{\ } \)" from functions.

Part (a): Differentiating (30a) with respect to \( A \), invoking the envelope theorem and simplifying the resulting expression gives

\[
\tilde{U}_1' = \phi_1 + \left( \phi \frac{s_2 - \tau w \psi^2}{A} \right) \left( A \tilde{S}_A^2 \right) = \phi_1 \left[ 1 - m \phi^2 \left( 1 + \frac{\tau}{1 - \tau} \theta^2_{LS} \right) \right], \tag{A.1}
\]

where, again, \( \theta_{LS} \equiv w_i \psi^i / \psi_i \). Observe that none of the variables on the right-hand side of the above expression depend on \( A \). However, the sign of \( \frac{d\tilde{U}_1^*}{dA} \) does depend on labor taxes. Evaluating the expression at \( \tau \leq 0 \) readily implies \( d\tilde{U}_1^* / dA_{\tau \leq 0} > 0 \). By continuity, the positive sign also arises when \( \tau \) is not too big. Thus, increases in the value of the prize always raise the ruler’s equilibrium payoff when the tax is sufficiently low or negative. Now suppose \( \tau \) is large. The extreme case of \( \tau \to 1 \) helps see that \( \lim_{\tau \to 1} (d\tilde{U}_1^* / dA) < 0 \), provided \( \lim_{\tau \to 1} \theta^2_{LS} > \theta^2_{LS} \), as noted in the text.\(^{151}\) By the continuity of \( \tilde{U}_1^1 \) in \( \tau \), there will exist a \( \tau \in (0, 1) \) such that \( d\tilde{U}_1^1 / dA \geq 0 \) if \( \tau \leq \tau \).

In light of the centrality of \( \tau \) in the subsequent analysis, a couple of comments on its

\(^{151}\)Allowing \( \tau \to 1 \) here is artificial because (i) it may violate the institutional capacity limit \( \tau_{\text{max}} \) or (ii) induce specialization in production. Still, this is a valuable abstraction because it helps identify conditions on parameters that imply \( d\tilde{U}_1^1 / dA < 0 \) at some value of \( \tau \) and, moreover, because it will help us study how (i) and (ii) determine the relationship between \( \tilde{U}_1^1 \) and \( A \) when the tax is optimally determined.
determinants are warranted here. Solving for $\tau$ in (A.1) gives

$$\tau = \frac{1 + (1 - m)\gamma}{1 + (1 - m)\gamma + m\gamma\theta_{LS}^2}.$$ 

The right-hand side of this expression also depends on the tax rate, so $\tau$ is the implicit solution to this equation. Taking this feedback effect of $\tau$ into account, one can prove the following relationships:

$$\frac{\partial \tau}{\partial \xi} < 0, \quad \frac{\partial \tau}{\partial \psi^1} < 0, \quad \frac{\partial \tau}{\partial \psi^2} > 0, \quad \frac{\partial \tau}{\partial \theta_{LS}^2} < 0.$$ (A.2)

In general, the sign of $\frac{\partial \tau}{\partial m}$ is ambiguous.

**Part (b):** Differentiating (30b) with respect to $A$, invoking the envelope theorem, and utilizing the fact that $\phi_{S_i}^i = -m\phi^i(1 - \phi^i)/S_j (i \neq j = 1, 2)$ gives

$$\tilde{U}^2_A = \frac{\partial \tilde{U}^2}{\partial A} = \phi^2 + \phi_{S_1}^2 (A \tilde{S}_A^1) = \phi^2 \left(1 - m\phi^1\right) > 0.$$ (A.3)

**Part (c):** Since, by its definition in (30c), $\tilde{U}_A = \tilde{U}_A^1 + \tilde{U}_A^2$ and, as we have seen in part (a), $\tilde{U}_A^1 \geq 0$ for all $\tau \leq \bar{\tau}$, whereas $\tilde{U}_A^2 > 0$ for all $\tau$, the possibility that $\tilde{U}_A < 0$ may arise if $\tau \in (\bar{\tau}, 1)$. To see this, utilize (A.1) and (A.3) to obtain

$$\tilde{U}_A = 1 + \phi_{S_1}^2 (A \tilde{S}_A^1) + \phi_{S_2}^1 (A \tilde{S}_A^2) - \tau w\psi_2^2 \theta_{LS}^2 = 1 - m\phi^1\phi^2 \left(2 + \frac{\tau}{1 - \tau}\theta_{LS}^2\right),$$

and, once again, let $\tau \to 1$.

**Proof of Corollary 3.1:** Suppose $\tau \leq \bar{\tau}$. Then, by parts (a) and (b) of Proposition 3.1, both the ruler and the rebel leader will benefit from an increase in $A$. Moreover, labor’s welfare does not change because $\tau$ remains fixed.

**Proof of Lemma 3.1:** It remains to be proved that (i) $\tilde{U}_A^{11} < 0$, and (ii) $\tilde{U}_A^{1A} < 0$. For both of these inequalities, we work from the first order condition for tax policy shown in
the text:

\[ \bar{U}_1^1 = w \left[ (1 - \delta_L) L - \psi_\omega^2 \bar{S}^2 \right] + \tau w^2 \psi_\omega^2 \bar{S}^2 + \left( A \phi_{S}^1 - \tau w \psi_\omega^2 \right) \bar{S}^2. \]

The production of military strength requires both labor (soldiers) and imported weapons and is described by a Cobb-Douglas production technology, such that 2’s cost share on labor, \( \theta_{L,S}^2 = \psi_w w (1 - \tau) / \psi^2 = \theta \in (\theta_{L,S}^2, 1), \) can be treated as a parameter. Note also that, by 2’s first order condition for arming, and by \( \bar{\phi}_1^1 = -\bar{\phi}_S^2, \) we have that \( A \bar{\phi}_1^1 = -A \bar{\phi}_S^2 = -\psi^2. \) The above then simplifies to

\[
\bar{U}_1^1 = w (1 - \delta_L) L + \left( -\psi^2 - \frac{\tau \psi^2}{1 - \tau} \right) \bar{S}^2 + \left( -\frac{\theta}{(1 - \tau)^2} \psi^2 + \frac{\theta^2 \tau}{(1 - \tau)^2 \psi^2} \right) \bar{S}^2
= w (1 - \delta_L) L - \frac{1 - (1 - \theta) \tau}{1 - \tau} \psi^2 \bar{S}^2 - \frac{1 - \theta \tau}{(1 - \tau)^2} \theta \psi^2 \bar{S}^2.
\]

It follows immediately that

\[
\bar{U}_1^1 = -\frac{1 - (1 - \theta) \tau}{1 - \tau} \psi^2 \bar{S}^2 + \frac{1 - \theta \tau}{(1 - \tau)^2} \theta \psi^2 \bar{S}^2.
\]

Noting that \( \bar{S}^2_A > 0 \) and \( \bar{S}^2_{\tau A} > 0, \) we then have that \( \bar{U}_1^1_A < 0. \) Showing that \( \bar{U}_1^1_{\tau A} < 0 \) requires a little more work, however.

Explicitly, \( \bar{U}_1^1_{\tau A} \) can be written as

\[
\bar{U}_1^1_{\tau A} = -\frac{1 - (1 - \theta) \tau}{1 - \tau} \psi^2 \bar{S}^2_{\tau A} - \frac{1 - \theta \tau}{(1 - \tau)^2} \theta \psi^2 \bar{S}^2_A.
\]

One can show that the coefficient on \( \psi^2 \bar{S}^2_{\tau A} \), \( -\frac{\theta + (1 - 2 \theta \tau)}{(1 - \tau)^2} \), is strictly less than zero for all values of \( \theta \) between 0 and 1 (noting that \( \tau \leq \tau_{\text{max}} < 1 \)). By inspection, the coefficients on \( \psi^2 \bar{S}^2_{\tau A} \) and \( \psi^2 \bar{S}^2 \) are likewise negative. We have already noted that \( \bar{S}^2_{\tau} > 0; \) all that remains to be explored is the sign of \( \bar{S}^2_{\tau A}, \) the second derivative of the rebel leader’s arming choice with respect to taxation.

\[^{152}\text{As previously noted, assuming that } \lim_{\tau \to 1} \theta_{L,S}^2 > \theta_{L,S}^2 \text{ is meant to ensure the existence of } \tau < 1.\]
Recall from the text that
\[ \tilde{S}^2 = \frac{Am\gamma/\psi^2}{(1 + \gamma)^2}. \]

Using the definitions of \( \gamma \) and \( \psi \), we can re-write \( \tilde{S}^2 \) to suit our current purposes as
\[ \tilde{S}^2 = \kappa \cdot \frac{(1 - \tau)^{-\theta(m+1)}}{[1 + \xi (1 - \tau)^{-m\theta}]^3}, \]

where \( \kappa \) is a combined parameter which incorporates elements which do not vary with \( \tau \) (explicitly, \( A, m, \xi, q, \theta, \) and \( w \)). Differentiating with respect to \( \tau \), we obtain
\[ \tilde{S}^2_{\tau\tau} = \kappa \cdot \theta \cdot \frac{[1 + \xi (1 - \tau)^{-m\theta}]^3 (m + 1) (1 - \tau)^{-m\theta - \theta - 1} - 2\xi m (1 - \tau)^{-2m\theta - \theta - 1}}{[1 + \xi (1 - \tau)^{-m\theta}]^3} \]
\[ \quad > 0. \]

To characterize \( \tilde{S}^2_{\tau\tau} \), note that \( \tilde{S}^2_{\tau\tau} / \tilde{S}^2_{\tau} = d \ln \tilde{S}^2_{\tau} / d\tau \). Noting that \( \tilde{S}^2_{\tau} > 0 \), it follows then that \( \tilde{S}^2_{\tau\tau} > 0 \) iff \( d \ln \tilde{S}^2_{\tau} / d\tau > 0 \). This condition can be written out as
\[ \frac{(m\theta + \theta + 1) (1 - \tau)^{-1} + \xi \frac{1-m}{m+1} (2m\theta + \theta + 1) (1 - \tau)^{-m\theta - 1} - 3\xi m\theta (1 - \tau)^{-m\theta - 1}}{1 + \xi \frac{1-m}{m+1} (1 - \tau)^{-m\theta}} > 0. \]

(A.4)

Cross-multiplying, one can re-write this condition as a quadratic function in terms of \( x \equiv (1 - \tau)^{-m\theta} \).

Explicitly, \( \tilde{S}^2_{\tau\tau} > 0 \) iff
\[ \xi^2 \frac{1-m}{1+m} (\theta + 1 - m\theta) x^2 + \xi \frac{1-m}{1+m} (2\theta + 2 - 4m^2\theta) x + (1 + \theta + m\theta) > 0. \]

Using the fact that \( 0 < m \leq 1 \) and \( 0 < \theta \leq 1 \), it follows that this quadratic function is strictly positive for \( x > 0 \). In other words, \( \tilde{S}^2_{\tau\tau} > 0 \) for all \( \tau < 1 \). This completes the proof.
Comments on Proposition 3.4: As noted, we take as given that the ratio $\frac{\delta L}{\delta K}$ is large enough that it is possible for both optimal tax curves to intersect the zero surplus line $\tilde{\tau}(A) \equiv -\frac{r_K K_0}{w L}$, and furthermore that $\tau_{\min}$ is sufficiently less than zero. For added simplicity, we also assume that once each tax policy curve crosses below $\tilde{\tau}$ it does not cross back above it until it is constrained by $\tau_{\min}$. These conditions are sufficient for proving existence of equilibria where the ruler chooses conflict even though settlement would have resulted in a positive surplus. They should not be considered necessary, however, and we discuss more general cases below.

First, consider what happens when neither $\tau^*_S$ nor $\tau^*_C$ intersect $\tilde{\tau}$ in Fig. 3.4, either because $\frac{\delta L}{\delta K}$ is too small or the $\tau_{\min}$ constraint is too tight. Because $\tau^*_C > \tilde{\tau}$ always in this case, $\tilde{A}_C$ is effectively infinite. Therefore, settlement is always preferred to conflict, for all values of $A$.

However, if only the $\tau^*_C$ curve, and not the $\tau^*_S$ curve, intersects $\tilde{\tau}$, $\tilde{A}_C$ is clearly finite, but $\tilde{A}_S$ is not. While there still may be a “switching point” such as $A_D$ in this case we cannot guarantee its existence. If such a point does exist, then it follows that there may also be a second switching point $\tilde{A}_M > A'_D > A_D$ where the government prefers conflict for $A \in (A_D, A'_D)$ but prefers settlement for all $A > A'_D$.

In addition, because tax policy functions are non-linear in $A$, whereas $\tilde{\tau}$ is linear, it may be the case that $\tau^*_S$ climbs back above $\tilde{\tau}$ before it reaches the $\tau_{\min}$ constraint. Call the point where this occurs $\tilde{A}'_S$, noting that $\tilde{A}'_S > \tilde{A}_S$. Once again, it would seem possible for there to be an additional switching point $A'_D > \tilde{A}'_S$ where the ruler’s preferences switch from conflict back to settlement. For $A \in (\tilde{A}_S, \tilde{A}'_S)$ both players prefer conflict as before, but for $A \in (\tilde{A}'_S, A'_D)$ the rebel leader will change his preference to settlement, while the ruler maintains his preference for conflict. One can envision further such “switching points” deriving from more elaborate non-linearities in the tax policy functions.

Lastly, yet another possibility that may come into play as $A$ increases in size is that the residual tax base (net of arming) shrinks to the point where the economy completely specializes in the production of the capital-intensive good. In this case, because the relative reward to capital, $r/w$, becomes endogenous, the relationships between $A$, $\tau^*_C$, $\tau^*_S$, and $\tilde{\tau}$ would be harder to pin down. There are two straightforward reasons why complete
specialization would tend to work in favor of settlement, however. First, \( r/w \) should fall as \( K_0 \) increases beyond the point of complete specialization, thereby increasing incentives for taxation and curbing incentives for conflict. Second, the destruction of labor associated with conflict would tend to reduce \( r/w \) even further. As we have noted in the text, however, it is relatively straightforward to choose parameters such that we can focus on cases where production remains diversified.

**Proof of Corollary 3.2:** When bargaining weights are endogenous, it is useful to express the ruler’s payoff function under settlement as follows:

\[
\tilde{V}^1(A, \tau) = \tilde{U}^1(A + B(A, \tau), \tau),
\]

where \( \tilde{U}^1(A, \tau) \) is the payoff function under conflict, with \( \tilde{U}_{A}^1 < 0, \tilde{U}_{\tau}^1 < 0, \) and \( \tilde{U}_{AA}^1 = 0, \) and \( B(A, \tau) \) is the (linear) surplus function with \( B_A > 0, B_\tau > 0. \)

The proof follows directly from the definition of \( \tau \) in Proposition 1: \( \tilde{U}_A^1 \gtrless 0 \) if \( \tau \gtrless \overline{\tau}. \) When \( \tau > \overline{\tau} \) the fact that \( A + B(A, \tau) > A, \) together with \( \tilde{U}_A^1 < 0, \) implies \( \tilde{V}^1(A, \tau) = \tilde{U}^1(A + B(A, \tau), \tau) < \tilde{U}^1(A, \tau). \) Note, however, that \( \tilde{U}^1(A, \tau) \) is the ruler’s “ex ante” payoff from conflict—it is only achievable if he is able to convince his rival before arming decisions are made that there will be conflict in the last stage of the game. *Ex post*, however—i.e. once arming decisions are made—settlement is always a dominant strategy for fixed \( \tau > \overline{\tau}, \) since \( \tau > \overline{\tau} > 0 > \underline{\tau} \) implies the surplus from avoiding conflict \( B(A, \tau) \) will always be positive. The *ex post* payoff under conflict in such cases is \( \tilde{U}^1(A + B(A, \tau), \tau) - \phi^1B(A, \tau) < \tilde{V}^1(A, \tau). \)

**Proof of Proposition 3.5, part (a):** For the proof for part (a), it is first necessary to note that conflict and settlement are always equivalent in the neighborhood of \( A = 0 \) in the special case where \( \delta_L = 0. \) Because there is virtually nothing to fight over under conflict, and likewise no surplus created when there is settlement, \( U^{1\ast} \) and \( V^{1\ast} \) should both simply be given by \( wL\tau_{\text{max}}^\ast, \) the maximum tax revenue 1 can extract when he is unopposed and when the labor force stays whole. It is clear in this limiting case that conflict is weakly preferred to settlement.
Generalizing to allow for $\delta_L > 0$ requires that we answer several questions about the nature of preferences for conflict over the region $A \in [0, \overline{A})$. First, how do payoffs for both conflict and settlement in the neighborhood of $A = 0$ change when we introduce small, positive values for $\delta_L$? Second, what is the optimal tax policy associated with settlement under this alternative bargaining protocol? Third, what can we say about preferences for conflict in the neighborhood of $A = 0$? Lastly, what do preferences for conflict look like in this region when $\delta_L$ becomes large and/or when $\tau_{\text{max}}$ becomes small? We address these outstanding questions using a series of additional lemmas.

**Lemma A.1** When $A = 0$, the ruler will prefer conflict to settlement for sufficiently small values of $\delta_L$ if $\tau_{\text{max}} \geq \overline{\tau}$.

**Proof:** Since we already have that conflict is weakly preferred in the neighborhood of $A = 0$ when $\delta_L = 0$, we can say that conflict will generally be ex ante preferred to settlement in the neighborhood of $A = 0$ for at least some small values of $\delta_L$ if we have that $\frac{dV^1}{d\delta_L} = 0, \delta_L = 0 \leq \frac{dU^1}{d\delta_L} = 0, \delta_L = 0$. Note that this comparison is made easier by the fact that $\tau^*_S = \tau^*_C = \tau_{\text{max}}$ for $A = 0$ and $\delta_L = 0$ as noted above. This observation, together with the envelope theorem, allows us to write the following:

$$
\frac{dV^1}{d\delta_L} = \frac{dV^1(0, \tau_{\text{max}})}{d\delta_L} = \frac{d\tilde{U}^1(0, \tau_{\text{max}})}{d\delta_L} + \tilde{U}^1_A \frac{\partial B(0, \tau_{\text{max}})}{\partial \delta_L} \bigg|_{\delta_L = 0}
$$

where again we specify the relationship between the ruler’s payoff functions as $\tilde{V}^1(A, \tau) = \tilde{U}^1(A + B(A, \tau), \tau)$, with $\tilde{U}^1(A, \tau)$ again denoting the ruler’s (ex ante) conflict payoff for a given $(A, \tau)$.

By $\frac{\partial B}{\partial \delta_L} > 0$, it follows that $\frac{dV^1}{d\delta_L} = \frac{dU^1}{d\delta_L} = 0, \delta_L = 0 \leq \frac{dU^1}{d\delta_L} = 0, \delta_L = 0$ if $\tilde{U}^1_A \leq 0$. By Proposition 3.1, $\tilde{U}^1_A(0, \tau_{\text{max}}) \leq 0$ iff $\tau_{\text{max}} \geq \overline{\tau}$.

**Lemma A.2** When bargaining weights are endogenous, the ruler’s optimal tax policy under settlement $\tau^*_S(A)$ is still unique for any value of $A$ and is still strictly decreasing as the value of
contested rents decreases (i.e. \(d\tau^*_S/A < 0\)).

Proof: Again let the relationship between the ruler’s payoff functions be expressed as
\[\tilde{V}^1(A, \tau) = \tilde{U}^1(A + B(A, \tau), \tau),\]
with \(\tilde{U}^1(A, \tau)\) denoting the ruler’s (ex ante) payoff under conflict for a given \((A, \tau)\), with \(\tilde{U}^1_{\tau\tau} < 0, \tilde{U}^1_{\tau A} < 0\), and \(\tilde{U}^1_{AA} = 0\).

We need to show: (i) \(\tilde{V}^1_{\tau\tau} < 0\), and (ii) \(\tilde{V}^1_{\tau A} < 0\). The first inequality follows from \(B_\tau > 0, B_{\tau\tau} = 0\), such that \(\tilde{V}^1_{\tau\tau} = \tilde{U}^1_{\tau\tau} + \tilde{U}^1_{\tau A} B_\tau + \tilde{U}^1_{A\tau} B_\tau < \tilde{U}^1_{\tau\tau} < 0\). Likewise, \(\tilde{V}^1_{\tau A} = U^1_{\tau A} + U^1_{AA} B_\tau = U^1_{\tau A} < 0\). The uniqueness of \(\tau^*_S(A)\) follows from \(\tilde{V}^1_{\tau\tau} < 0\), with \(d\tau^*_S/\tau < 0\).

Lemma A.3 Settlement is always preferred to conflict at \(A = \overline{A}\), for any value of \(\delta_L\).

Proof: We know by Lemma 3.1 that \(\tau^*_C(\overline{A}) = \tau\), such that \(\tilde{U}^1(\overline{A}, \tau) = 0\) and therefore \(U^1(\overline{A}, \tau) = 0\). We also have, as a corollary of Proposition 3.4, that \(V^1(\overline{A}, \tau) = U^1(\overline{A}, \tau)\). All that remains to be shown is that \(\tau^*_S(\overline{A}) \neq \tau\), such that \(V^1(\overline{A}, \tau) = V^1(\overline{A}, \tau^*_S(\overline{A})) > V^1(\overline{A}, \tau) = \tilde{U}^1(\overline{A}, \tau) = U^1(\overline{A}, \tau)\).

\(\tilde{V}^1(\overline{A}, \tau) < 0\) then follows from the the fact that \(\tilde{U}^1_{\tau\tau} < 0\), again using the definition of \(\tau\). Specifically,
\[
\tilde{V}^1(\overline{A}, \tau) = \tilde{U}^1(\overline{A} + B(\overline{A}, \tau), \tau) + \tilde{U}^1_{\tau A}(\overline{A} + B(\overline{A}, \tau), \tau) \cdot B_\tau < 0,
\]
by \(\tilde{U}^1_{\tau A}(\cdot, \tau) = 0, \tilde{U}^1(\overline{A}, \tau) = 0\), and \(\tilde{U}^1_{\tau\tau} < 0\). We already have that \(\tilde{V}^1_{\tau\tau} < 0\) from the above Lemma, so there must be a unique \(\tau^*_S(\overline{A}) < \tau\) that maximizes the ruler’s payoff under settlement. The ruler’s payoff under settlement at \(\overline{A}\) is therefore strictly greater than his payoff under conflict.

Furthermore, it must be the case that, because payoff functions are continuous, conflict can only be ex ante preferred to settlement for values of \(A\) up to some value \(A_1\), with \(A_1\) strictly less than \(\overline{A}\) as stated in the original Proposition.

Lemma A.4 Settlement may be preferred to conflict in the neighborhood of \(A = 0\) for large enough values of \(\delta_L\) and will be preferred to conflict with certainty in this region if \(\tau_{\max} < \bar{\tau}\).
Proof: Again we invoke the fact that settlement will be preferred in the neighborhood of $A = \bar{A}$. In this case, what is important to know is that $\bar{\tau} = \frac{1+(1-m)\gamma}{1+(1-m)\gamma + m\eta_{LS}}$ is not affected by changes in $\delta_L$. On the other hand, the tax policy under conflict $\tau^*_C(A)$ does depend on $\delta_L$. To see this, we first repeat the expression for $\tilde{U}_1^{\tau C}(A)$ given in the discussion of optimal tax policies

$$\tilde{U}_1 = w \left[ (1 - \delta_L) L - \psi^*_w S^2 \right] + \tau w^2 \psi^*_w S^2 + \left( A \phi^*_S - \tau w \psi^*_w \right) S^2.$$ 

Note that $\tilde{U}_1^{\tau C}$ is strictly less than zero. At the same time, however, $\tilde{U}_1^{\tau A}$ and $\tilde{U}_1^{\tau}$ are unaffected by varying $\delta_L$. Thus, while $\delta_L$ is negatively associated with the level of the tax policy function $\tau^*_C(A)$, it does not affect its slope with respect to $A$ ($d\tau^*_C/dA$). Furthermore, if the level of $\tau^*_C(A)$ falls such that $\tau^*_C(A)$ is unconstrained by $\tau_{max}$ in the neighborhood of $A = 0$, the fact that $\lim_{A \to 0} \tilde{U}_1^{\tau C}(A) = 0$ (and $\lim_{A \to 0} \tilde{U}_1^{\tau A}(A) < 0$) implies that $\lim_{A \to 0} d\tau^*_C/dA = -\infty$.

Because $\tau^*_C(A)$ shifts downwards with $\delta_L$, and because $\bar{\tau}$ does not depend on $\delta_L$, we can say that increases in $\delta_L$ also cause $\bar{A}$ to move to the left. We can also say that it is possible that $\bar{A} \to 0$ as $\delta_L$ gets sufficiently large, since the slope of $\tau^*_C(A)$ can become vertical near $A = 0$. Since, by Lemma A.3, we know $V^1(A) > U^1(A)$ always, the movement of $\bar{A}$ closer to the origin makes it more likely that settlement will be preferred to conflict in the neighborhood of $A = 0$.

If on the other hand $\tau_{max}$ is sufficiently small such that $\tau_{max} < \bar{\tau}$, we have that $V^1_{A=0} = \bar{V}^1(0, \tau_{max}) \geq V^1(0, \tau_{max}) = \bar{U}^1(B(0, \tau_{max}), \tau_{max}) > \bar{U}^1(0, \tau_{max})$, from the definition of $\bar{\tau}$ and the fact that $\tau_{max}$ constrains tax policy under conflict with certainty at $A = 0$, but may or may not constrain tax policy under settlement.

Thus, we have that conflict will be ex ante preferred to settlement in the region $A \in [0, A_1)$, with $0 < A_1 < \bar{A}$, for at least some sufficiently small positive values of $\delta_L$ so long as $\tau_{max} \geq \bar{\tau}$ (and will be strictly preferred if $\tau_{max} > \bar{\tau}$). On the other hand, settlement will always be preferred in the neighborhood of $A = 0$ if $\tau_{max} < \bar{\tau}$ and may also be preferred in this region if labor destruction is sufficiently large.

Proof of Proposition 3.5, part (b): The proof here is unsurprisingly very similar to
the reasoning behind Proposition 3.3. Again we take as given that $\delta_L/\delta_K$ is sufficiently large and $\tau_{min}$ sufficiently negative such that it is possible for both tax policy functions $(\tau^c_\delta(A) \text{ and } \tau^c_\zeta(A))$ to intersect the zero-surplus line $\bar{\tau}(A)$. Furthermore we require that both curves only cross $\bar{\tau}(A)$ once before they become constrained by $\tau_{min}$.

We first need to show that $\tau^{x}_\delta(\tilde{A}_C) > \tau^{x}_c(\tilde{A}_C) = \bar{\tau}_C$, with $(\tilde{A}_C, \bar{\tau}_C)$ defined as in the discussion of Proposition 3.3 as the intersection between $\tau^{x}_c(A)$ and $\bar{\tau}(A)$ in Fig. 3.3a and 3.4a. The fact that the point $(\bar{A}_C, \bar{\tau}_C)$ generates zero surplus implies that $\bar{V}^1(\bar{A}_C, \bar{\tau}_C) = \bar{U}^1(\bar{A}_C + B(\bar{A}_C, \bar{\tau}_C), \bar{\tau}_C) = \bar{U}^1(\bar{A}_C, \bar{\tau}_C)$. It also follows from $\tau^{x}_c(\bar{A}_C) = \bar{\tau}_C$ that $\bar{U}^1(\bar{A}_C, \bar{\tau}_C) = 0$. To prove $\tau^{x}_\delta(\tilde{A}_C) > \tau^{x}_c(\tilde{A}_C)$ it is then only necessary to show that $\bar{V}^1(\bar{A}_C, \bar{\tau}_C) > 0$. This follows from $\bar{V}^1(\bar{A}_C, \bar{\tau}_C) = \bar{U}^1_A(\bar{A}_C + B(\bar{A}_C, \bar{\tau}_C), \bar{\tau}_C) \cdot B_\tau(\bar{A}_C, \bar{\tau}_C)$. This last expression is positive by the fact that $\bar{\tau}_C < 0 < \bar{\tau} \implies \bar{U}^1_A(\cdot, \bar{\tau}_C) > 0$ and by $B_\tau > 0$.

To complete the proof, we note that $B(A, \tau^{x}_S(A)) > 0$ and $\tau^{x}_S(A) < \bar{\tau}$ everywhere between $\bar{A}$ and $\tilde{A}_C$. Thus, settlement should be preferred to conflict, both ex post and ex ante everywhere between $A_1$ and $\tilde{A}_C$, provided that both $A_1$ and $\tilde{A}_C$ exist. If $A_1$ does not exist (perhaps because $\delta_L$ is too large), then settlement is preferred for $A \in [0, \tilde{A}_C)$. The remainder follows the same “continuity of payoffs” argument we have noted in the text: there again must be some point $A_D \in (\tilde{A}_C, \tilde{A}_S)$ such that the ruler’s preferences switch from “settlement” to “conflict” at the point $A_D$, with $\tilde{A}_S$ defined by $\tau^{x}_\zeta(\tilde{A}_S) = \bar{\tau}(\tilde{A}_S) > \tau^{x}_c(\tilde{A}_S)$. The role of $\tau_{min}$ in this context is the same as before.

**Both players can tax labor**

For the sake of precision, we want to make it clear what it is about this environment that limits the appeal of surplus sharing. It is not necessarily the inherent asymmetric nature of the game (i.e. that the ruler has an additional strategic instrument) that generates incentives for conflict. Rather it is the fact that the two players are interdependent via the effects of fiscal policy. We show here that even, if players are symmetric in every single way—including the ability to tax the labor force—preferences for conflict still emerge, because each player will internalize how his use of taxes will affect labor supply for the other player.
This particular extension—where both players collect taxes—is also appealing to study since rebel groups themselves have been known to prey on economic activity to finance their operations (Wennmann, 2007). How does it change things? Assume the players are completely symmetric, such that each player $i$ extracts an (endogenous) share $\tau_i$ of the economy’s total wage bill $(1 - \delta_L)wL$. The key insights are familiar. Player $i$’s cost of arming $\psi^i$ will be given by $\psi^i = \psi(q, w_i)$. The crucial point here is that $w_i = w(1 - \tau_{-i})$, such that $i$ will internalize the fact that increasing his own tax will make arming less expensive for the other player, but not for himself. This follows since, for every soldier he himself hires—at a cost $w(1 - \sum \tau_i)$—he misses out on the tax revenue that soldier would have produced for him had he been employed in production.

Payoffs under conflict for each player are given by

$$U^i = \mu \left[ rK_i + A\phi^i - \psi^iS_i + \tau_i(w(1 - \delta_L)L - w\psi^{-i}_wS_{-i}) \right]$$

This expression is no different than the ruler’s payoff function from before and needs no further interpretation. Consider then the incentives for taxation:

$$\tilde{U}^i_{\tau_i} = w \left[ (1 - \delta_L)L - \psi^{-i}_wS^{-i} \right] + \tau_iw^2\psi^{-i}_wS^{-i} + \left( A\phi^i_{S^{-i}} - \tau_iw\psi^{-i}_w \right) S^{-i}_{S^{-i}}.$$

Again, the analysis is effectively the same as what we’ve seen. Without loss of generality, we can re-use our proof from before that $d\tau^*_i / dA < 0$, by $\tilde{U}^i_{\tau_i} < 0$ and $\tilde{U}^i_{\tau_iA} < 0$ (since $\tilde{S}''$'s dependence on both $\tau_i$ and $A$ is also effectively the same as before, holding $\tau_{-i}$ constant). Furthermore, as $A$ gets sufficiently large, each player $i$ will find it optimal to use negative values of $\tau_i$. And, crucially, both players will still have an incentive to use higher taxes under settlement than under conflict (for $\delta_L > 0$), since (again) taxes enter the surplus that is created by avoiding destruction.

What is interesting to note then is that, even though both players will earn the exact same share of $A$ under both conflict and settlement (by the symmetry of the model), there will still be cases where conflict emerges despite the possibility for negotiating a settlement over a positive surplus. That is to say, the marginal benefit of driving up the other player’s
cost of arming using negative taxes becomes so large (as \( A \) becomes sufficiently valuable) that the two players each find it beneficial to destroy some of the labor force in order to make negative taxes less expensive, even though this tactic does not actually allow either player to gain any ground on the other in equilibrium.\(^{153}\)

It is also possible to show that a similar result to Proposition 3.5\((a)\) also holds under symmetry in the case where predominantly capital is destroyed and bargaining weights are endogenous. Thus, we conclude that it is the additional layer of strategic interdependence created by the effects of policy choices on a common pool of labor which serves as the main source of bargaining frictions in this setting, rather than any fundamental asymmetry.

When does asymmetry make an important difference? Consider again the cases discussed above where tax policies are decided either at the same time as arming decisions or afterwards. In the asymmetric game, we found that the ruler might find it optimal to commit to conflict \((\text{ex ante})\) in such cases because such a commitment would signal to the other player that he will be choosing the lower tax rate associated with conflict and would thereby curb rebel arming. Note, however, that his preference for this option derives from the belief that the lower tax under conflict will grant him a larger share of the contested rents in equilibrium. That cannot be the case under symmetry!

We maintain nonetheless that placing our focus on the case of asymmetric instruments is worthwhile because the adherence to symmetry is limiting in this context. After all, it seems reasonable to assume that having the institutional capacity of the state on his side grants the ruler a significant advantage in this area. This analysis by virtue of comparison then helps clarify the key channels at work in our results.

**Labor benefits from conflict**

Overall income for labor increases from conflict whenever a decrease in taxes associated with conflict (from \( \tau^C \) to \( \tau^S \)) exceeds the share of labor that would be destroyed in conflict.\(^{153}\) More precisely, \( \tilde{\rho}^i = \frac{1}{1+\psi^i/\psi^C} \). The marginal benefit of increasing \( \psi^i \) (by decreasing \( \tau^C \)) is increasing as \( \psi^i \) increases (i.e. as \( \tau^C \) itself decreases). \( \psi^i = \psi^{-i} \) in equilibrium, therefore \( \tilde{\rho}^i = 1/2 \) always.
($\delta_L$). That is to say, labor prefers conflict \textit{ex ante} if

$$(1 - \delta_L) (1 - \tau^*_C) > (1 - \tau^*_S)$$

We show this can occur for small enough values of $\delta_L$ (and relative destruction $\delta_K/\delta_L$) using a stylized example.

Assume the following: (i) no capital is destroyed ($\delta_K = 0$); (ii) only an arbitrarily small share ($\varepsilon > 0$) of labor is destroyed ($\delta_L = \varepsilon$); (iii) producing $S_i$ uses only labor, such that $\psi^i = w^i$; (iv) $A$ is in the neighborhood of $A_0$, which is defined in Lemma 3.1 as the value of rents at which $\tau^*_C$ crosses 0; (v) the ruler’s “bargaining weight” $\lambda^1$ is given by $\lambda^1 = 1$, such that he claims the entirety of any surplus. This scenario guarantees, other other things, that $\check{\tau}(A) = 0$. We also note that the surplus here, $\delta_L w L \tau^*_S$, is arbitrarily small as well. It follows that $\tau^*_C$ and $\tau^*_S$ are each arbitrarily close to zero. When we introduce some labor destruction at this point, we will see that (i) conflict becomes preferred to settlement at $A = A_0$; (ii) labor may prefer conflict; (iii) overall “welfare” (as we have defined it) may be higher under conflict. In this stylized example, (ii) will always turn out to be true. For (iii), we will require that the labor endowment, $L$, is sufficiently large.

Outcomes under conflict and settlement are arbitrarily similar for $\delta_L = 0$. For $\delta_L = \varepsilon$, overall labor income is higher under conflict if

$$-(1 - \tau^*_C) - (1 - \delta_L) \frac{d \tau^*_C}{d \delta_L} > - \frac{d \tau^*_S}{d \delta_L},$$

which simplifies down to

$$-(\frac{d \tau^*_C}{d \delta_L} - \frac{d \tau^*_S}{d \delta_L}) > 1,$$

using the arbitrary smallness of $\delta_L$. Note that $\check{V}^1_{\tau \tau} = \check{U}^1_{\tau \tau} < 0$ (suppressing the “$1$” superscript usually denoting the ruler). Then, applying Roy’s identity twice, the above inequal-
ity holds if

\[
\frac{\tilde{U}_{1\delta} - \tilde{V}_{1\delta}}{\tilde{U}_{1\tau}} > 1.
\]

Considering the ruler’s first order conditions for \( \tau \) under conflict (34), we have that \( \tilde{U}_{1\tau} = -wL \). Usefully, the assumption that \( \lambda^1 = 1 \) implies that \( \tilde{V}_{1\tau} = 0 \). We also note that in the neighborhood of \( \tau = 0 \), and with only labor used in production of arms, \( \tilde{U}_{1\tau} \) is given by:

\[
\tilde{U}_{1\tau} = -wS^2_{\tau} - wS^2_{\tau\tau}.
\]

We then need to verify if \( L < S^2_{\tau} + S^2_{\tau\tau} \). Note, however, that—given \( \tau \)—\( S^2_{\tau\tau} \) is not otherwise a function of \( L \). Note also that—under the examination of the point \( A = A_0 \)—it must be the case that \( L = S^2 + S^2_{\tau} \) (in order for the ruler to optimally choose \( \tau = 0 \)). The inequality is satisfied then whenever \( S^2_{\tau\tau} > S^2 \) for \( A = A_0 \). It can be shown directly that this latter inequality, in turn, is automatically satisfied in the neighborhood of \( A = A_0 \). Specifically, \( S^2_{\tau\tau} > S^2 \) for \( \tau = 0 \) if

\[
(m + 1)(m + 2) + 4\xi (1 - m^2) + \xi^2 (1 - m) (2 - m) > (1 + \xi)^2.
\]

Since \( m \) and \( \xi \) both \( \in (0, 1] \), this inequality always holds.

It follows then that, for arbitrarily small \( \delta_L \), and in the absence of capital destruction,

\[
\tau^*_S (A_0) = \bar{\tau} (A_0)
\]

\[
\tau^*_C (A_0) < \bar{\tau} (A_0)
\]

As we know from our discussion of Fig. 3.3, the value of rents where \( \tau^*_S (A) \) and \( \bar{\tau} (A) \) intersect is the point \( \bar{A}_S \). Conflict is strictly preferred at \( \bar{A}_S \) if \( \tau^*_C (\bar{A}_S) < \tau^*_S (\bar{A}_S) \). In this case, \( \bar{A}_S = A_0 \) implies conflict will be preferred at \( A_0 \). Furthermore, in this case, labor will be better off under conflict.

It remains to be seen what will happen for total welfare. The ruler’s payoff, too, is clearly higher under conflict (otherwise, he would not have chosen it.) The question then
is whether the increase in labor’s payoff plus the ruler’s payoff offsets the decrease in the rebel leader’s payoff.

Another way of examining the same issue is to ask whether the total amount of arming decreases by more than the amount of labor destruction. Capital is not destroyed, therefore total income in the economy is \( rK_0 \) (unaffected) plus \( w \) times the amount of labor used in production. We verify if:

\[
- \left( \tilde{S}_1 + \tilde{S}_2 \right) \frac{d\tau}{dL} > 1
\]

where we have already shown (by assumption) that \( \frac{d\tau}{dL} < -1 \). The inequality is ensured if \( \tilde{S}_1 + \tilde{S}_2 > 1 \). Again we are free to make assumptions. In the neighborhood of \( A = A_0 \), it can be shown that \( \tilde{S}_1 + \tilde{S}_2 > 1 \) is guaranteed so long as the labor endowment, \( L \), is sufficiently large. This result occurs because the critical point \( A_0 \) is itself increasing in \( L \), by our discussion of Proposition 3.3.
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