Trade Policy in the Shadow of Power
Quantifying Military Coercion in the International System*

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Abstract

In international relations, how does latent military coercion affect governments' policy choices? Because militarily powerful governments can credibly threaten to impose their policy preferences by force, weaker governments may adjust their policy choices to avoid costly conflict. This setting raises an inference problem – do observed policies reflect the preferences of the governments that adopted them or the military constraints of the anarchic international system? Here, I investigate the role of this "shadow of power" in determining trade policy. Specifically, I build a model of trade policy choice under threat that allows me to measure empirically governments' underlying trade policy preferences, the returns to military advantage, and the extent to which power projection capacity degrades across space. I then estimate the parameters of the model using data on governments' observed trade policies in 2011. I find that geographic distance is not an impediment to the projection of force but that there are increasing returns to military advantage in the technology of coercion. Through counterfactual experiments, I quantify the effect of military constraints on the international economy and governments' welfare. These and other exercises shed light on how military power affects international economic exchange, and how expectations about exchange affect governments' military strategies.

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Introduction

Military power holds a central position in international relations (IR) theory. Governments exist in a state of anarchy — there is no world authority tasked with preventing the use of violence in settling policies disputes between them. As a result, powerful governments can employ force against others to secure more favorable policy outcomes. This does not necessarily imply that international relations are uniquely violent, however. Threatened governments can adjust their policy choices to accommodate the interests of the powerful, avoiding costly conflict (Brito and Intrilagator 1985; Fearon 1995). This setting raises an inference problem — do observed policies reflect the preferences of the governments that adopted them, or the military constraints of the anarchic international system?

In this paper, I propose and implement a method to assess the effect of military power on trade policy choices. Trade is a natural issue area in which undertake such an investigation. For a variety of reasons, governments' endeavor to protect their home market to some extent. Governments also seek access to foreign markets (Grossman 2016). These preferences put governments into conflict with one another – each would like to erect some barriers to imports while dismantling barriers to trade abroad. Given dictatorial power, governments would protect their home market and enforce openness elsewhere. Moreover, aggregate policy-induced trade frictions are large (Cooley 2019a) and have large effects on the distribution and level of welfare within and across countries (Autor, Dorn, and Hanson 2013; Costinot and Rodríguez-Clare 2015; Goldberg and Pavcnik 2016). These effects may be particularly salient for politically influential groups (Grossman and Helpman 1994; Osgood et al. 2017). Governments therefore have incentives to use force to shape trade policy abroad to their liking. Historically, they have been willing to fight wars to realize such goals (Findlay and O'Rourke 2007).

Assessing the effect of military power on trade policy requires imagining what policy choices governments would have made in the absence of coercion. In a coercion-free world, policies reflect preferences. If we observe policies, we can learn something about the preferences of the actors that adopted them. When coercion is possible, however, weaker governments must consider the effect of their policy choices on the powerful. If a particular policy choice harms a threatening government enough, it can choose to impose an alternative policy by force. Recognizing this threat, weaker governments adjust their policies to avoid war. In an anarchic world, policies may be determined by both power and preferences.

I proceed in three steps to untangle power and preferences as determinants of trade policies. First, I model a coercive international political economy in which governments propose trade policies, observe others proposals, and choose whether or not to fight wars in bids to modify these. The model's equilibrium depends on a vector of parameters governing governments' preferences for protectionism and the effectiveness of military coercion. I then estimate these parameters by minimizing the distance between the model's predictions and observed policies. Finally, I answer the question posed here: how does military coercion affect trade policy? With estimates for the model's parameters in hand, this question can be answered by a simple counterfactual experiment — eliminate governments' military capacity, and recalculate the model's equilibrium. The difference between counterfactual equilibrium policies and the factual policies represents the net effect of military coercion on trade policy.

Within the coercive international political economy, governments choose trade policies to maximize a country-specific social welfare function. Each government's trade policy is a set of taxes, one for each importing country, imposed on imports. Notably, trade policies can be discriminatory, affecting certain source countries disproportionately. A model of the international economy connects trade policy choices to consumer welfare and trade flows, which determine the magnitude of rents available to governments.[1] Each government is endowed with military capacity which can be employed in wars against other governments. Winning a war allows the victor to choose the trade policy of the defeated government. Counterfactual wars constrain threatened governments and affect their trade policy choices. The effectiveness of coercion, or governments' ability to project power, depends on the geographic distance between potential adversaries.

Governments' ideal policies depend on a country-specific parameter governing the ease with which policy distortions are converted into revenues. Governments' ability to influence the choices of others depends on the effectiveness of power projection over geographic space and the returns to military power preponderance. Preferences and the shadow of power are difficult to measure. However, researchers do observe proxies of governments' total military strength (military spending) and their trade policy choices.[2] The model maps military strength and power and preference parameters to policy choices. With information about total military strength, I show that the model can be inverted to recover parameters that best explain governments' policy choices.

Within-country variation in trade policy identifies the model. Consider the ideal set of trade policies of a government whose preferences are known. The policies that achieve this objective can be readily calculated given knowledge of parameters governing international economic relations. Policies adopted toward imports from countries that pose no military threat will reflect this objective. Conversely, the imports of threatening countries will encounter lower barriers to trade, in order to satisfy the threatener's war constraint. This favoritism is informative about the effectiveness of military threats. The level of barriers toward non-threatening countries is informative about the government's preferences. Differential responses to the same level of threat from different geographic locations identifies parameters governing the effectiveness of power projection across space.

[1] The model of the international economy is a variant of the workhorse model of Eaton and Kortum (2002). Costinot and Rodríguez-Clare (2015) study a broader class of structural gravity models that connect trade frictions (such as trade policy) to trade and welfare outcomes.

[2] I use data on aggregate directed trade policy distoritions from Cooley (2019a), a companion paper to this study. These data are discussed in more detail below.

The identified model enables two classes of counterfactuals. First, it allows me to quantify the "shadow of power" by comparing factual policies to those that would prevail if governments' counterfactually possessed zero military capability. These policies can then be fed into the model of the international economy to calculate the effect on trade flows, prices, and wages around the world. Would different trade blocs emerge in a coercion-free world? Which governments would benefit the most? In the model, consumers benefit from the liberalizing effect of foreign military coercion (Antràs and Padró i Miquel 2011). How large are these benefits? Whose citizens benefit the most from international power politics? How would relative changes to U.S. and Chinese military strength affect the international economy?

The model also allows me to examine how domestic political economic changes (changes to government preferences) affect the salience of military coercion. Governments that value the welfare of consumers prefer to adopt lower barriers to trade. The returns to coercing these governments are smaller, because their ideal policies impose relatively small externalities on potential threatening governments. Military coercion plays a smaller role in influencing trade policy when governments are relatively liberal. Domestic political institutions are believed to effect trade policy preferences (Rodrik 1995; Milner 1999; Milner and Kubota 2005). The model facilitates exploration of how domestic political change affects the quality of international relations and governments' propensity to threaten, display, and use military force against one another.

Estimating the model and conducting the subsequent counterfactual exercises require knowledge of governments' trade policies, disaggregated at the trade partner level. While detailed data on a particular policy instrument (tariffs) are available to researchers, these are but one barrier governments can use to influence the flow of trade. In a companion paper (Cooley 2019a), I show that cross-national prices, trade flows, and freight costs are jointly sufficient statistics for the magnitude of aggregate policy barriers trade, given a structural model of the international economy (Head and Mayer 2014; Costinot and Rodríguez-Clare 2015). I employ these measures of trade policy in this paper and use an identical model of the international economy to connect trade policy changes to international economic outputs.

The method produces a matrix of trade barriers, in which the i, jth entry is the magnitude of policy barriers to trade an importing country i imposes on goods from an exporting country j. In 2011, the estimated barriers were large, equivalent to a 78 percent import tariff on average.[3] They also reveal substantial trade policy discrimination, providing necessary variation to identify the model considered here.

[3] These results and the calibration choices that produce this value are discussed in more detail in Appendix B.

Literature

Conflicts of interest and the specter of coercive diplomacy emerge in the model due to governments' protectionist preferences. Trade theory reserves a role for small trade policy distortions for governments that seek to maximize aggregate societal wealth (Johnson 1953; Broda, Limao, and Weinstein 2008). Empirically, governments implement larger trade distortions than predicted in theory, however. This regularity motivated the study of the political economics of trade policy. While nearly free trade may be good for a society as a whole, owners of specific factors of production may prefer protectionism. If these groups have better access to the policymaking process, trade policy may be more protectionist than is optimal for society (Mayer 1984; Rogowski 1987; Grossman and Helpman 1994). A family of studies uses these theoretical insights to estimate governments' sensitivity to narrow versus diffuse interests (Goldberg and Maggi 1999; Mitra, Thomakos, and Ulubasoglu 2006; Gawande, Krishna, and Olarreaga 2009, 2012, 2015; Ossa 2014). Because these models incorporate no theory of international coercion, these estimates reflect the assumption that policy choices directly reflect preferences. Fiscal pressures might also drive protectionism. Some governments are constrained in their ability to raise revenue through taxes on domestic economic activities. Tariffs and other trade distortions may substitute as a revenue-raising strategy in these cases (Rodrik 2008; Queralt 2015).

I take no stance on the domestic political origins of protectionist preferences. I induce these by varying the ease with which governments can collect revenues from trade distortions. Each government is characterized by a revenue threshold parameter. Trade distoritions above the level of this threshold generate revenue while distortions below this level require subsidies. Governments with higher threshold parameters therefore prefer higher barriers to trade, all else equal. This simple formulation induces heterogeneity in the governments' ideal levels of protectionism and the magnitude of the externalities they would impose on other governments if left to their own devices.

These externalities motivate the lobbying efforts of domestic special interests and structure international negotiations over trade policy. In contemporary political economic accounts, large and productive firms pressure their own governments to secure market access abroad in order to increase profit opportunities (Ossa 2012; Osgood 2016; Kim 2017). By contrast, in my model, lower barriers to trade abroad increase wages at home (helping consumers) and stimulate trade (increasing revenue). Therefore, regardless of their relative preference for consumer welfare versus rents, governments prefer to reduce barriers confronting their exports. Modeling government preferences in this manner captures market access incentives tractably while avoiding ascribing a particular domestic political process to their origin.

Because of these preferences for foreign trade liberalization, governments have incentives to influence others' policy choices. Analyzing governments' foreign policy in the 17th and 18th centuries, Viner (1948) concludes "important sources of national wealth…were available…only to countries with the ability to acquire or retain them by means of the possession and readiness to use military strength." Powerful governments established colonies and threatened independent governments in order to shape policy abroad to their liking (Gallagher and Robinson 1953). While formal empires died quickly after World War II, softer forms of influence remained. Lake (2013) terms the resulting order a "hierarchy" in which weaker countries exchanged sovereignty for international political order, provided by a hegemonic United States. Berger et al. (2013) show that this hierarchy has not always been benevolent — U.S. political influence was used to open markets abroad, a form of "commercial imperialism." An earlier literature ascribed international economic openness to the presence of such a hegemon (Krasner 1976; Gilpin 1981; Kindleberger 1986). In conceptualizing openness as a public good, these theories made stark predictions about the distribution of military power and the international economy. In reality, the benefits of changes to trade policy are quite excludable. The model developed here reflects this reality by allowing governments to adopt discriminatory trade policies. Power can therefore be exercised to secure benefits not shared by other governments. The resulting international economic orders defy characterization as "open" or "closed." In a stylized version of the model developed here, I show that latent regime change threats can be used to open foreign markets. Militarily weak countries adopt lower barriers to trade than their powerful counterparts, all else equal (Cooley 2019b). Antràs and Padró i Miquel (2011) consider a similar model in which governments influence elections abroad. Again, this influence has a liberalizing effect on the foreign government's trade policy.

Nevertheless, debate persists about the efficacy of military power in achieving economic benefits (Mastanduno 2009; Drezner 2013; Bove, Elia, and Sekeris 2014; Stokes and Waterman 2017). These studies all confront the inference problem discussed here — does economic policy reflect governments' underlying preferences or the shadow of foreign military power? When redistribution is an alternative to war and bargaining is frictionless, war is not necessary to achieve coercive effects (Brito and Intrilagator 1985; Fearon 1995; Art 1996). I assume that the effectiveness of military coercion depends on the geographic distance between a threatening and defending country. By examining the responsiveness of policy to foreign threats, I can quantify this relationship, providing estimates of the loss of strength gradient discussed in a body of quantitative studies on war and militarized interstate disputes (Boulding 1962; Bruce Bueno de Mesquita 1980; Diehl 1985; Lemke 1995; Gartzke and Braithwaite 2011).

Several studies have examined trade policy bargaining theoretically and empirically. Grossman and Helpman (1995) extend the protection for sale model to a two-country bargaining setting. Maggi (1999) and Bagwell and Staiger (1999) focus on the effect of the institutional context in which trade policy negotiations take place, relative to an un-institutionalized baseline. Ossa (2014), Bagwell, Staiger, and Yurukoglu (2018b) and Bagwell, Staiger, and Yurukoglu (2018a) quantify these theories in structural models. Of course, the continued functioning of international institutions requires either a) that complying with the rules of the institution be incentive compatible for each member state, given others' strategies or b) that an external authority punish deviations from the institutions' rules sufficiently to induce compliance (Powell 1994). Given the absence of such an external authority and the stark international distributional implications of alternative trade policy regimes, it is natural to consider how the ability to employ military force colors trade policy bargaining.

Trade and trade policy are often theorized as tools governments can leverage to achieve political objectives (Hirschman 1945; Gowa and Mansfield 1993; Martin, Mayer, and Thoenig 2012; Seitz, Tarasov, and Zakharenko 2015). Yet, affecting trade policy and concomitant prices, wages, and trade flows is also a central government objective in international relations. Moreover, the political objectives that ostensibly motivate governments in these "trade as means" models are loosely defined (e.g. "security") and themselves means to achieving other ends. Studying trade policy as a strategic end allows the analyst to leverage a family of empirical methods in international economics to construct counterfactual trade regimes and analyze their welfare implications (Eaton and Kortum 2002; Head and Mayer 2014; Costinot and Rodríguez-Clare 2015; Ossa 2016). Government objectives can be defined flexibly as a function of general equilibrium outputs (prices, wages, revenues).

A handful of other theoretical studies examine how power affects exchange in market environments (Skaperdas 2001; Piccione and Rubinstein 2007; Garfinkel, Skaperdas, and Syropoulos 2011; Carroll 2018). Where property rights are assumed in classical models of the economy, these authors consider exchange and violence as coequal means to acquire goods from others. I instead direct attention to coercive bargaining over endogenous trade frictions (trade policy). These in turn affect the distribution of goods and welfare in the international economy.

Model

There are N governments, indexed $i \in \{1, ..., N\}$. Governments choose trade policies $\boldsymbol{\tau}_i = (\tau_{i1}, ..., \tau_{iN}) \in [1, \bar{\tau}]^N$ which affect their welfare indirectly through changes in the international economy.[4] An entry of the trade policy vector, τ_{ij} is the cost country i imposes on imports from j.[5] The economy, detailed in Appendix A, can be succinctly characterized by a function $h : \boldsymbol{\tau} \to \mathbb{R}^N_{++}$ mapping trade policies to wages in each country, denoted $\boldsymbol{w} = (w_1, ..., w_N)$. These in turn determine trade flows between pairs of countries and price levels around the world.[6]

Throughout, I will use $\boldsymbol{\theta}_m$ to denote the vector of all parameters to be estimated and $\boldsymbol{Z}$ to denote the vector of all data observed by the researcher. $\boldsymbol{\theta}_h$ denotes parameters associated with the economy, h, which will be calibrated. I will explicate the elements of these vectors

[4] $\bar{\tau}$ is an arbitarily large but finite value sufficient to shut down trade between any pair of countries.

[5] Costs enter in an "iceberg" fashion, and I normalize $\tau_{ii} = 1$. Then, if the price of a good in country j is p_{jj}, its cost (less freight) in country i is $\tau_{ij} p_{jj}$. The ad valorem tariff equivalent of the trade policy is $t_{ij} = \tau_{ij} - 1$. I employ structural estimates of these costs from Cooley (2019a) to estimate the model, which are described in more detail in Appendix A.

[6] The economy is a variant of the workhorse model of Eaton and Kortum (2002).

in the proceeding sections and the Appendix.

Government welfare depends on these general equilibrium responses to trade policy choices. Governments value the welfare of a representative consumer that resides within each country. The consumer's welfare in turn depends on net revenues accrued through the government's trade policy distortions, which are redistributed to the consumer. Revenues and induced welfare can be computed given knowledge of the general equilibrium function $h(\boldsymbol{\tau})$. Each government's welfare, is equivalent to the consumer's indirect utility, $V_i\left(h(\boldsymbol{\tau}); v_i\right)$ where v_i is the revenue threshold parameter. This value of this function depends on the consumer's net income and is characterized fully in the Appendix. The consumer's net income can be written as a function of the governments' policy choices

$$\tilde{Y}_i(h_i(\boldsymbol{\tau})) = h_i(\boldsymbol{\tau})L_i + r_i(h(\boldsymbol{\tau}); v_i).$$

L_i is the country's labor endowment, $r_i(h(\boldsymbol{\tau}); v_i)$ is trade policy revenues, and $h_i(\boldsymbol{\tau})$ are equilibrium wages in i. $v_i \in [1, \infty)$ is a structural parameter that modulates the government's ability to extract trade policy rents.

Adjusted revenues are given by

$$r_i(h(\boldsymbol{\tau}), v_i) = \sum_j (\tau_{ij} - v_i) X_{ij}(h(\boldsymbol{\tau})) \tag{1}$$

and $X_{ij}(h(\boldsymbol{\tau}))$ are country i's imports from country j.[7] When v_i is close to one, small policy distortions are sufficient to generate revenue for the government. Conversely when v_i is high, the government must erect large barriers to trade before revenues begin entering government coffers and returning to the pockets of the consumer. Because consumers' consumption possibilities depend on revenue generation, increasing v_i induces governments' to become more protectionist. This formulation provides substantial flexibility in rationalizing various levels of protectionism, while avoiding assuming specific political economic motivations for its genesis. From the perspective of the consumers, rents extracted from imports are valued equally, regardless of their source. Ex ante, governments are not discriminatory in their trade policy preferences. Optimal policies for government i maximize $V_i\left(h(\boldsymbol{\tau}); v_i\right)$.

These optimal policies impose externalities on other governments. By controlling the degree of market access afforded to foreign producers, trade policies affect the wages of foreign workers and the welfare of the governments that represent them. They also partially determine trade flows, which affect other governments' ability to collect rents. In this sense, protectionism is "beggar they neighbor." Governments' joint policy proposals are denoted $\tilde{\boldsymbol{\tau}}$.

[7] This object does not correspond empirically to governments' factual tariff revenues, as τ_{ij} incorporates a larger set of trade policy distortions than tariffs alone. Yet, non-tariff barriers to trade also generate rents that do not accrue directly to the government's accounts (see, for example, Anderson and Neary (1992) for the case of quotas). This revenue function is designed to capture this broader set of rents.

Wars are fought in order to impose more favorable trade policies abroad. After observing policy proposals, governments decide whether or not to launch wars against one another. Wars are offensive and *directed*. If a government decides to launch a war it pays a dyad-specific cost, c_{ji}, and imposes more favorable trade policies on the target. These war costs are modeled as realizations of a random variable from a known family of distributions and are held as private information to the prospective attacker. The shape of these distributions is affected by the governments' relative power resources, denoted $\frac{M_j}{M_i}$, as well as the geographic distance between them, W_{ji}. These costs are distributed with c.d.f. F_{ji} which is described in more detail below. I normalize the cost of defending against aggression to zero.

If i is not attacked by any other government its announced policies are implemented. Otherwise, free trade is imposed, setting $\boldsymbol{\tau}_i = (1, \ldots, 1) = \mathbf{1}_i$. Substituting these policies into j's utility function gives $V_j(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i})$ as j's *conquest value* vis-à-vis i. Note that I prohibit governments from imposing discriminatory policies on conquered states. Substantively, this assumption reflects the difficulty in enforcing sub-optimal policies on prospective client states, relative to reorienting their political institutions to favor free trade. This also ensures that the benefits of regime change wars are public. However, it does not guarantee non-discrimination in times of peace. Governments that pose most credible threat of conquest can extract larger policy concessions from their targets in the form of directed trade liberalization.

Government j therefore prefers not to attack i so long as

$$\begin{aligned} V_j\left(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i}\right) - c_{ji} &\leq V_j\left(\tilde{\boldsymbol{\tau}}\right) \\ c_{ji}^{-1} &\leq \left(V_j\left(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i}\right) - V_j\left(\tilde{\boldsymbol{\tau}}\right)\right)^{-1} \end{aligned}$$

or if the benefits from imposing free trade on i are outweighed by the costs, holding other governments policies fixed. The probability that no government finds it profitable to attack i can then be calculated as

$$H_i\left(\tilde{\boldsymbol{\tau}}; \boldsymbol{Z}, \boldsymbol{\theta}_m\right) = \prod_{j \neq i} F_{ji}\left(\left(V_j\left(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i}\right) - V_j\left(\tilde{\boldsymbol{\tau}}\right)\right)^{-1}\right)$$

I am agnostic as to the process by which the coordination problem is resolved in the case in which multiple prospective attackers find it profitable to attack i. I assume simply that i is attacked with certainty when it is profitable for any government to do so. This event occurs with probability $H_i(\tilde{\boldsymbol{\tau}}; \boldsymbol{Z}, \boldsymbol{\theta}_m)$.

Because of strategic interdependencies between trade policies, optimal policy proposals are difficult to formulate. Governments face a complex problem of forming beliefs over the probabilities that they and each of their counterparts will face attack and the joint policies that will result in each contingency. For simplicity, I assume governments solve the simpler problem of maximizing their own utility, assuming no other government faces attack. I denote this objective function with $G_i(\tilde{\boldsymbol{\tau}})$ which can be written

$$G_i(\tilde{\boldsymbol{\tau}}) = H_i(\tilde{\boldsymbol{\tau}}; \boldsymbol{Z}, \boldsymbol{\theta}_m) V_i(\tilde{\boldsymbol{\tau}}) + (1 - H_i(\tilde{\boldsymbol{\tau}}; \boldsymbol{Z}, \boldsymbol{\theta}_m)) V_i(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i}) \tag{2}$$

where $V_i(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i})$ denotes i's utility when free trade is imposed upon it. This objective function makes clear the tradeoff i faces when making policy proposals. Policies closer to i's ideal point deliver higher utility conditional on peace, but raise the risk of war. Lowering barriers to trade on threatening countries increases $H_i(\tilde{\boldsymbol{\tau}}; \boldsymbol{Z}, \boldsymbol{\theta}_m)$, the probability i avoids war, at the cost of larger deviations from policy optimality.

Policy proposals are made simultaneously. Let $\tilde{\boldsymbol{\tau}}_i^\star(\tilde{\boldsymbol{\tau}}_{-i})$ denote a solution to this problem and $\tilde{\boldsymbol{\tau}}^\star$ a Nash equilibrium of this policy announcement game.

Policy Equilibrium in Changes

The equilibrium of the international economy depends on a vector of structural parameters and constants $\boldsymbol{\theta}_h$ defined in Appendix A. Computing the economic equilibrium $h(\boldsymbol{\tau}; \boldsymbol{\theta}_h)$ requires knowing these values. Researchers have the advantage of observing data related to the equilibrium mapping for one particular $\boldsymbol{\tau}$, the factual trade policies.

The estimation problem can be therefore partially ameliorated by computing the equilibrium in *changes*, relative to a factual baseline. Consider a counterfactual trade policy τ'_{ij} and its factual analogue τ_{ij}. The counterfactual policy can be written in terms of a proportionate change from the factual policy with $\tau'_{ij} = \hat{\tau}_{ij}\tau_{ij}$ where $\hat{\tau}_{ij} = 1$ when $\tau'_{ij} = \tau_{ij}$. By rearranging the equilibrium conditions, I can solve the economy in changes, replacing $h(\boldsymbol{\tau}; \boldsymbol{\theta}_h) = \boldsymbol{w}$ with $\hat{h}(\hat{\boldsymbol{\tau}}; \boldsymbol{\theta}_h) = \hat{\boldsymbol{w}}$. Counterfactual wages can then be computed as $\boldsymbol{w}' = \boldsymbol{w} \odot \hat{\boldsymbol{w}}$.

This method is detailed in Appendix A. Because structural parameters and unobserved constants do not change across equilibria, parameters that enter multiplicatively drop out of the equations that define this "hat" equilibrium. This allows me to avoid estimating these parameters, while enforcing that the estimated equilibrium is consistent with their values. The methodology, introduced by Dekle, Eaton, and Kortum (2007), is explicated further in Costinot and Rodríguez-Clare (2015) and used to study trade policy changes in Ossa (2014) and Ossa (2016).

It is straightforward to extend this methodology to the game studied here. Consider a modification to the policy-setting game described above in which governments propose changes to factual trade policies, denoted $\hat{\tilde{\boldsymbol{\tau}}}$. Note that this modification is entirely cosmetic – the corresponding equilibrium in levels can be computed by multiplying factual policies by the "hat" equilibrium values ($\tau'_{ij} = \hat{\tau}_{ij}\tau_{ij}$). I can then replace the equilibrium conditions above with their analogues in changes.

Let $\hat{V}_j(\hat{\tilde{\boldsymbol{\tau}}})$ denote changes in j's consumer welfare under proposed policy changes. Prospective attackers' peace conditions can be written in changes as

$$\hat{c}_{ji}^{-1} \leq \left(\hat{V}_j \left(\mathbf{1}_i; \hat{\tilde{\boldsymbol{\tau}}}_{-i} \right) - \hat{V}_j \left(\hat{\tilde{\boldsymbol{\tau}}} \right) \right)^{-1}$$

where

$$\hat{c}_{ji} = \frac{c_{ji}}{V_j \left(\boldsymbol{\tau} \right)}$$

measures the share of j's utility lost to wage a war with i. I assume the inverse relative cost of war j incurs when attacking i is distributed Frechét with

$$\Pr \left(\frac{1}{\hat{c}_{ji}} \leq \frac{1}{\hat{c}} \right) = \hat{F}_{ji} \left(\frac{1}{\hat{c}} \right) = \exp \left(-\frac{1}{\hat{C}} \left(\frac{M_j}{M_i} \right)^{\gamma} W_{ji}^{-\alpha} \hat{c}^{\eta} \right).$$

The parameters α and γ govern the extent to which military advantage and geographic proximity are converted into cost advantages. If γ is greater than zero, then military advantage reduces the costs of war. Similarly, if α is greater than zero, then war costs increase with geographic distance, consistent with a loss of strength gradient. $\hat{C}$ and η are global shape parameters that shift the cost distribution for all potential attackers.

Each government's objective function (2) in changes is

$$\hat{G}_i(\hat{\tilde{\boldsymbol{\tau}}}) = \hat{H}_i(\hat{\tilde{\boldsymbol{\tau}}}; \boldsymbol{Z}, \boldsymbol{\theta}_m) \hat{V}_i(\hat{\tilde{\boldsymbol{\tau}}}) + \left(1 - \hat{H}_i(\hat{\tilde{\boldsymbol{\tau}}}; \boldsymbol{Z}, \boldsymbol{\theta}_m) \right) \hat{V}_i(\mathbf{1}_i; \hat{\tilde{\boldsymbol{\tau}}}_{-i}) \tag{3}$$

where

$$\hat{H}_i \left(\hat{\tilde{\boldsymbol{\tau}}}; \boldsymbol{Z}, \boldsymbol{\theta}_m \right) = \prod_{j \neq i} \hat{F}_{ji} \left(\left(\hat{V}_j \left(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i} \right) - \hat{V}_j \left(\hat{\tilde{\boldsymbol{\tau}}} \right) \right)^{-1} \right).$$

With Frechét-distributed relative costs this equation has a closed functional form, with

$$\hat{H}_i \left(\hat{\tilde{\boldsymbol{\tau}}}; \boldsymbol{Z}, \boldsymbol{\theta}_m \right) = \exp \left(- \sum_{j \neq i} -\frac{1}{\hat{C}} \left(\frac{M_j}{M_i} \right)^{\gamma} W_{ji}^{-\alpha} \left(\hat{V}_j \left(\mathbf{1}_i; \tilde{\boldsymbol{\tau}}_{-i} \right) - \hat{V}_j \left(\hat{\tilde{\boldsymbol{\tau}}} \right) \right)^{\eta} \right).$$

Let $\hat{\tilde{\boldsymbol{\tau}}}_i^{\star}(\hat{\tilde{\boldsymbol{\tau}}}_{-i})$ denote a solution to policy change proposal problem and $\hat{\tilde{\boldsymbol{\tau}}}^{\star}$ a Nash equilibrium of this policy change announcement game.

Data and Calibration of Economy

I estimate the model on a set of 9 governments in the year 2011.[8] These governments are listed in Table 1. I aggregate all European Union governments into a single entity and

[8]Focusing on a small set of governments is necessary for computational tractability. However, the largest countries (by GDP) are the most attractive targets for coercion, as changes to their trade policies return the largest welfare gains, regardless of whether the coercer is a rent-maximizer or welfare-maximizer. The estimated model is therefore more useful in understanding "great power politics," rather than smaller political-economic conflicts of interest.

collapse all countries not included in the analysis into a "Rest of World" (ROW) aggregate.[9] Non-ROW countries make up 72 percent of world GDP.

Solving the economy in changes for a set of $\hat{\boldsymbol{\tau}}$ requires values for a vector of economic parameters $\boldsymbol{\theta}_h$ and data on trade flows, policy barriers, and and national accounts. I discuss how I calibrate the economy and the data sources used to do so in Appendix B. There, I also report the magnitude of policy barrier estimates $\tilde{\boldsymbol{\tau}}$ from Cooley (2019a). With $\hat{h}(\hat{\boldsymbol{\tau}}; \boldsymbol{\theta}_h)$ calibrated, $\hat{V}_i(\hat{\boldsymbol{\tau}})$ can be calculated for any set of trade policies and the conquest values can be computed.

With the economy calibrated and policy barrier estimates in hand, I require only a measure of each government's military endowment (M_i) and data on dyadic geography ($\boldsymbol{W}$). I use SIPRI's data on military expenditure to measure governments' military capacity. These values are displayed in Figure 1.

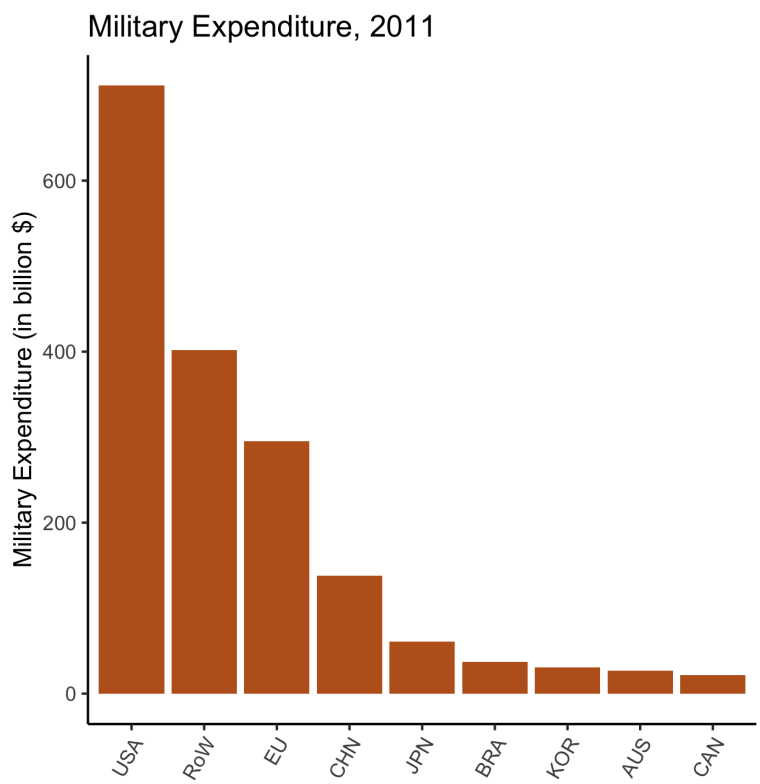


Figure 1: Military expenditure for in-sample governments. Values for ROW and EU are obtained by summing expenditure of all member countries.

[9]Such an aggregation is necessary in order to calculate fully general equilibrium effects of counterfactual trade policies. However, I prohibit other countries from invading ROW and likewise prohibit ROW from invading others. This ensures that estimates of military parameters depend almost entirely on interactions between countries within my sample.

Finally, I use data from Weidmann, Kuse, and Gleditsch (2010) to calculate centroid-centroid geographic distance between all countries in my sample, providing data for W_{ij}

Estimation

The model's equilibrium, $\hat{\tilde{\boldsymbol{\tau}}}^\star$ depends on a vector of parameters $\boldsymbol{\theta}_m = \left(\boldsymbol{v}, \alpha, \gamma, \hat{C}, \eta\right)$. I calibrate the shape parameter, η to be 1. I assume observed policies are generated by the model up to measurement error

$$\tilde{\boldsymbol{\tau}} = \tilde{\boldsymbol{\tau}}^\star(\boldsymbol{\theta}_m) + \boldsymbol{\epsilon}.$$

$\boldsymbol{\epsilon}$ is an $N \times N$ matrix with $\epsilon_{ii} = 0$ for all i and $\mathrm{E}[\epsilon_{ij}] = 0$ for all $i \neq j$. Recall that $\tilde{\boldsymbol{\tau}}^\star$ can be reconstructed from $\hat{\tilde{\boldsymbol{\tau}}}^\star$, the model's equilibrium, by simply multiplying equilibrium policies by factual policies, $\boldsymbol{\tau}$.

Following the assumption that measurement error is mean-zero, I seek an estimator that solves

$$\min_{\boldsymbol{\theta}_m} \sum_i \sum_j \left(\epsilon_{ij}(\boldsymbol{\theta}_m)\right)^2 . \tag{4}$$

Solving this problem presents two computational challenges. First, computing government welfare changes for any given $\hat{\boldsymbol{\tau}}$ requires solving system of equations characterizing the equilibrium of the international economy, $\hat{h}(\hat{\boldsymbol{\tau}})$. These changes must be computed for both the proposed policies and policies imposed under war counterfactuals. Second, computing $\tilde{\boldsymbol{\tau}}^\star(\boldsymbol{\theta}_m)$ requires iteratively solving each government's best response problem until covergence at a Nash equilibrium. I sidestep both of these by recasting the best response problem and estimation problem as mathematical programs with equilibrium constraints (MPECs) (Su and Judd 2012; Ossa 2014, 2016).

To reformulate the best response problem, I consider an equivalent reformulation in which each government chooses trade policies and wages, subject to the additional constraint that chosen wages are consistent with the general equilibrium of the international economy ($\hat{h}(\hat{\tilde{\boldsymbol{\tau}}}) = \hat{w}$). Let $\hat{\boldsymbol{x}}_i = \left(\hat{\tilde{\boldsymbol{\tau}}}_i, \hat{\boldsymbol{w}}\right)$ store i's choice variables in this problem. Then, this problem can be rewritten as follows, noting explicitly dependencies on $\boldsymbol{\theta}_m$

$$\begin{aligned} \max_{\hat{\boldsymbol{x}}_i} \quad & \hat{G}_i(\hat{\boldsymbol{w}}; \boldsymbol{\theta}_m) \\ \text{subject to} \quad & \hat{\boldsymbol{w}} = \hat{h}(\hat{\tilde{\boldsymbol{\tau}}}). \end{aligned} \tag{5}$$

Let $\mathcal{L}_i(\hat{\boldsymbol{x}}_i, \boldsymbol{\lambda}_i)$ denote the associated Lagrangian. This formulation allows me to quickly compute best responses $\hat{\tilde{\boldsymbol{\tau}}}_i(\hat{\tilde{\boldsymbol{\tau}}}_{-i})$ without iteratively solving $h(\hat{\tilde{\boldsymbol{\tau}}})$.

I then reformulate the estimation problem (4) in a similar manner. At an interior Nash equilibrium, the gradient of the Lagrangian is null

$$\nabla_{\hat{\tilde{\boldsymbol{\tau}}}_i} \mathcal{L}_i(\hat{\boldsymbol{x}}_i, \boldsymbol{\lambda}_i; \boldsymbol{\theta}_m) = \mathbf{0}$$

for each government i. In the reformulated estimation problem, seek to choose parameters, trade policies, multipliers, and general equilibrium response variables for the proposed policies and imposed policies in order to minimize measurement error while enforcing these equilibrium constraints, in addition to general equilibrium constraints. Let $\hat{\boldsymbol{x}}_i' = \left(\mathbf{1}_i, \hat{\tilde{\boldsymbol{\tau}}}_{-i}, \hat{\boldsymbol{w}}_i'\right)$ store general equilibrium equilibrium policies and wages when free trade is imposed on i.

Formally, I solve

$$\begin{aligned} \min_{\boldsymbol{\theta}_m, \hat{\tilde{\boldsymbol{\tau}}}, \hat{\boldsymbol{w}}, \hat{\boldsymbol{w}}', \boldsymbol{\lambda}} \quad & \sum_i \sum_j \left(\epsilon_{ij}\right)^2 \\ \text{subject to} \quad & \nabla_{\hat{\tilde{\boldsymbol{\tau}}}_i} \mathcal{L}_i(\hat{\boldsymbol{x}}_i, \boldsymbol{\lambda}_i; \boldsymbol{\theta}_m) = \mathbf{0} \text{ for all } i \\ & \hat{\boldsymbol{w}} = \hat{h}\left(\hat{\tilde{\boldsymbol{\tau}}}\right) \\ & \hat{\boldsymbol{w}}_i' = \hat{h}\left(\mathbf{1}_i, \hat{\tilde{\boldsymbol{\tau}}}_{-i}\right) \end{aligned} \tag{6}$$

The constraints collectively ensure $\hat{\tilde{\boldsymbol{\tau}}} = \tilde{\boldsymbol{\tau}}^\star(\boldsymbol{\theta}_m)$ – or that the policies are consistent with Nash equilibrium in policies, given estimated parameters.

This procedure produces point estimates $\tilde{\boldsymbol{\theta}}_m$. I then construct uncertainty intervals through nonparametric bootstrap, sampling policies from bootstraped estimates in Cooley (2019a) and re-solving (4).

Results

NOTE: Computing uncertainty intervals is computationally expensive and in-progress. I report and discuss point estimates here, with the necessary caution such preliminary discussion requires.

Recall that v_i governs the ease with which governments can extract revenues from trade policy distortions. When v_i is higher government i prefers higher barriers to trade, all else equal. Estimates of these parameters are reported in Table 1.

With estimates of v_i in hand, I can calculate each government's conquest value vis-à-vis all other governments. Recall that governments impose free trade on other governments when they defeat them in wars. Then, j's counterfactual utility in this scenario can be readily calculated given knowledge of its objective function (3). These values are shown in Figure 2. Each cell measures the utility change each row government experiences when successfully conquering each column government, evaluated at estimated v_i. Darker colors correspond to larger changes in utility.

In the model, peace requires that the probabilistic benefits of war do not exceed war's cost for each directed pair of governments. These conquest values assist in the identification of the power projection and war cost parameters in $\boldsymbol{\theta}_m$.

Table 1: Preference Parameter ($\tilde{\boldsymbol{v}}$) Estimates

iso3	Country Name	$\tilde{v}_i$
AUS	Australia	4.52
BRA	Brazil	3.82
CAN	Canada	4.02
CHN	China	1.38
EU	European Union	2.01
JPN	Japan	2.51
KOR	South Korea	2.23
RoW	Rest of World	1.56
USA	United States	1.58

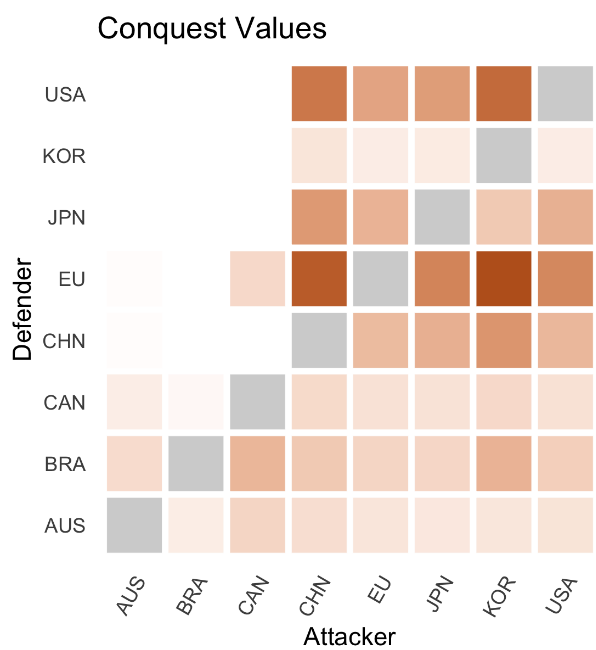


Figure 2: Conquest values evaluated at $\tilde{\boldsymbol{v}}$. Each cell corresponds to the change in utility an attacking country (row) receives for successfully invading the each defending country (column). Darker values correspond to higher utility changes.

Recall that α governs how war costs respond to the distance between prospective adversaries and that γ governs the effectiveness of military advantage in reducing war costs. When these parameters take the value of zero then geography and military advantage have no effect on the war cost distributions. I estimate α to be -0.55, consistent with an inverse effect of distance on power projection capacity. In other words, I find no evidence of a loss of strength gradient. There are, however, substantial returns to military advantage. I estimate γ to be 1.54, consistent with increasing returns to military advantage. In general, however, war is estimated to be quite costly. The scale parameter, $\hat{C}$ is estimated to be 523.1, which renders war prohibitively costly for those that do not enjoy other advantages, such as military strength. In general, governments run very small risks of invasion from other governments. The exception to this rule is threats from the United States, which are estimated to play a significant role in many governments' calculations of optimal policy. This is the result of the United States' substantial military advantages over potential adversaries and the returns these are estimated to bring in the realm of trade policy.

Counterfactual: Coercion-Free World

coming soon

Conclusion

The shadow of power plays a central role in international relations theory, but measuring its effects has proved challenging. It is axiomatic that if governments forgo war, then they must at least weakly prefer the policy status quo to the expected policy outcomes that would result from potential wars. In this paper, I have shown that a flexible model of government preferences over trade outcomes can serve to quantify government welfare under this policy counterfactual. I then leverage the difference between factual government welfare and its conquest values to identify parameters governing the technology of coercion in international relations.

The preliminary estimates of these parameters suggest that military constraints indeed constrain governments' policy choice in international relations. Military spending advantage translates into battlefield advantage. These military constraints serve to contort trade policy toward the interests of the powerful as well as the resolved — those whose benefits from conquest are the largest. Military threats structure interactions in the international economy.

Drawing these conclusions requires taking seriously extant theoretical models of international conflict and international political economy. On the one hand, this limits the credibility and generalizability of the conclusions reached here — if the models are flawed, so too will our inferences about the world. On the other hand, this provides a foundation upon which empirical and theoretical research in these subfields can progress in tandem. Otherwise intractable empirical questions can be answered, leveraging the identifying assumptions embedded in these theories. And theories can be revised to account for anomalous or unreasonable empirical results that rest on these assumptions. Taking the models seriously provides answers to hard empirical questions, along with a transparent edifice upon which those answers rest.

Appendix

A: Economy

The economy is a variant of that of Eaton and Kortum (2002). I present the model here for clarity, but refer interested readers to their paper and Alvarez and Lucas (2007) for derivations and proofs of the existence of a general equilibrium of this economy.

Consumption

Within each country resides a representative consumer which values tradeable goods and nontradable services which are aggregated in Cobb-Douglas utility function, U_i.

Consumer utility is Cobb-Douglas in a tradable goods aggregate Q_i and non-tradable services

$$U_i = Q_i^{\nu_i} S_i^{1-\nu_i} \tag{7}$$

ν_i determines the consumer's relative preference for tradables versus services. Total consumer expenditure is $\tilde{E}_i = E_i^q + E_i^s$ where the Cobb-Douglas preference structure imply $E_i^q = \nu_i \tilde{E}_i$ and $E_i^s = (1 - \nu_i)\tilde{E}_i$.

There is a continuum of tradable varieties indexed $\omega \in [0, 1]$ aggregated into Q_i through a constant elasticity of substitution function

$$Q_i = \left(\int_{[0,1]} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{8}$$

with $\sigma > 0$. With E_i^q fixed by the upper-level preference structure, consumers maximize Q_i subject to their tradable budget constraint

$$\int_{[0,1]} p_i(\omega) q_i(\omega) d\omega \leq E_i^q$$

where $p_i(\omega)$ is the price of variety ω in country i. Let $Q_i^\star$ denote a solution to this problem. The tradable price index P_i^q satisfies $P_i^q Q_i^\star = E_i^q$ with

$$P_i^q = \left(\int_{[0,1]} p_i(\omega)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

Production

Consumers are endowed with labor L_i and earn wage w_i for supplying labor to producers. Services are produced competitively at cost

$$k_i^s = \frac{w_i}{z_i^s}$$

where z_i^s is country i's productivity in services. All countries can produce each tradable variety ω. Production requires labor and a tradable goods bundle of intermediate inputs (Q_i). Producing a unit of variety ω costs

$$k_i(\omega) = \frac{1}{z_i(\omega)} w_i^{1-\beta} \left(P_i^q\right)^\beta$$

with $\beta \in [0, 1]$ controlling the share of labor required in production. Total expenditure on intermediates in country i is E_i^x. $z_i(\omega)$ controls i's productivity in producing variety ω. $z_i(\omega)$ is a Fréchet-distributed random variable. $F_i(z)$ is the probability i's productivity in producing a tradable variety is less than or equal to z. With $F \sim$ Fréchet,

$$F(z) = \exp\left\{-T_i z^{-\theta}\right\}$$

where T_i is a country-specific productivity shifter and $\theta > 1$ is a global parameter that controls the variance of productivity draws around the world. When θ is large, productivity is less stochastic.

Trade Frictions

Let $p_{ij}(\omega)$ denote the price in i of a variety ω produced in j. With competitive markets in production, local prices are equal to local costs of production,

$$p_{ii}(\omega) = k_i(\omega)$$

When shipped from i to j, a variety incurs iceberg freight costs δ_{ji} and policy costs τ_{ji}, meaning

$$p_{ji}(\omega) = \tau_{ji}\delta_{ji}p_{ii}(\omega)$$

Producers and consumers alike search around the world for the cheapest variety ω, inclusive of shipping and policy costs. Equilibrium local prices therefore satisfy

$$p_i^\star(\omega) = \min_{j \in \{1,\ldots,N\}} \{p_{ij}\}$$

The set of varieties i imports from j is

$$\Omega_{ij}^\star = \left\{\omega \in [0, 1] \mid p_{ij}(\omega) \leq \min_{k \neq j} \{p_{ik}\}\right\}$$

Total expenditure in country i on goods from j (inclusive of freight costs and policy costs) is X_{ij}. At the border, the cost, insurance, and freight (c.i.f.) value of these goods is $X_{ij}^{\text{cif}} = \tau_{ij}^{-1} X_{ij}$. Before shipment, their free on board (f.o.b.) value is $X_{ij}^{\text{fob}} = \left(\delta_{ij}\tau_{ij}\right)^{-1} X_{ij}$

Tariff Revenue (Policy Rents)

Governments collect the difference between each variety's final value and its c.i.f. value. Total rents for government i are

$$r_i = \sum_j (\tau_{ij} - 1) X_{ij}^{\text{cif}} \tag{9}$$

This revenue is returned to the consumer, but is valued by the government independent of its effect on the consumer's budget.[10]

Equilibrium

In equilibrium, national accounts balance and international goods markets clear. Total consumer expenditure is equal to the sum of labor income, tariff revenue, and the value of trade deficits D_i

$$\tilde{E}_i = w_i L_i + r_i + D_i$$

Labor income is equal to the labor share of all sales of tradables globally and local services sales

$$w_i L_i = \sum_j (1 - \beta) X_{ji}^{\text{cif}} + X_i^s \tag{10}$$

where

$$X_i^s = E_i^s = (1 - \nu_i)(w_i L_i + r_i)$$

The remainder of consumer expenditure is spent on tradables

$$E_i^q = \nu_i (w_i L_i + r_i) + D_i$$

A β-fraction of producer income is spent on intermediates

$$E_i^x = \sum_j \beta X_{ji}^{\text{cif}}$$

and total tradable expenditure is

$$E_i = E_i^q + E_i^x \tag{11}$$

The share of i's tradable expenditure spent on goods from j is

$$x_{ij}(\boldsymbol{w}) = \frac{1}{E_i} \int_{\Omega_{ij}^{\star}} p_{ij}(\omega) q_i^{\star}\left(p_{ij}(\omega)\right) d\omega = \frac{T_j \left(\tau_{ij} \delta_{ij} w_j^{1-\beta} P_j^{\beta}\right)^{-\theta}}{\frac{1}{C}\left(P_i^q(\boldsymbol{w})\right)^{-\theta}} \tag{12}$$

[10] This formulation requires the "representative consumer" to encompass individuals that have access to rents and those that do not. It avoids "burning" these rents, as would be implied by a model in which the government valued rents but the consumer did not have access to them.

$q_i^\star(p_{ij}(\omega))$ is equilibrium consumption of variety ω from both consumers and producers. C is a constant function of exogenous parameters. The tradable price index is

$$P_i^q(\boldsymbol{w}) = C\left(\sum_j T_j \left(d_{ij} w_j^{1-\beta} P_j^\beta\right)^{-\theta}\right)^{-\frac{1}{\theta}} \tag{13}$$

Finally, I normalize wages to be consistent with world gdp in the data. Denoting world gdp with Y, I enforce

$$Y = \sum_i w_i L_i \tag{14}$$

The equilibrium of the economy depends on policy choices $\boldsymbol{\tau}$, trade deficits $\boldsymbol{D}$, and a vector of structural parameters and constants $\boldsymbol{\theta}_h = \{L_i, T_i, \boldsymbol{\delta}, \sigma, \theta, \beta, \nu_i,\}_{i\in\{1,\dots,N\}}$.

Definition A1: An *international economic equilibrium* is a mapping $h : \{\boldsymbol{\tau}, \boldsymbol{D}, \boldsymbol{\theta}_h\} \to \mathbb{R}_{++}^N$ with $h(\boldsymbol{\tau}, \boldsymbol{D}; \boldsymbol{\theta}_h) = \boldsymbol{w}$ solving the system of equations given by 9, 10, 11, 12, 13, and 14.

Alvarez and Lucas (2007) demonstrate the existence and uniqueness of such an equilibrium, subject to some restrictions on the values of structural parameters and the magnitude of trade costs.

Welfare

With the equilibrium mapping in hand, I can connect trade policies to government welfare given in Equation 2. Consumer indirect utility is

$$V_i(\boldsymbol{w}) = \frac{\tilde{E}_i(\boldsymbol{w})}{P_i(\boldsymbol{w})} \tag{15}$$

where P_i is the aggregate price index in country i and can be written

$$P_i(\boldsymbol{w}) = \left(\frac{P_i^q(\boldsymbol{w})}{\nu_i}\right)^{\nu_i} \left(\frac{P_i^s(\boldsymbol{w})}{1-\nu_i}\right)^{1-\nu_i}$$

P_i^q is given in equation 13 and $P_i^s = \frac{w_i}{A_i}$. Substituting $\boldsymbol{w}$ with its equilibrium value $h(\boldsymbol{\tau}, \boldsymbol{D}; \boldsymbol{\theta}_h)$ returns consumer indirect utility as a function of trade policies. Equilibrium trade flows can be computed as

$$X_{ij}^{\text{cif}}(\boldsymbol{w}) = \tau_{ij}^{-1} x_{ij}(\boldsymbol{w}) E_i(\boldsymbol{w})$$

Substituting these into the revenue equation (9) gives the revenue component of the government's objective function.

Equilibrium in Changes

In "hats," the equilibrium conditions corresponding to 9, 10, 11, 12, 13, and 14 are

$$\hat{r}_i = \frac{1}{r_i} \left(E_i \hat{E}_i(\hat{\boldsymbol{w}}) - \sum_j X_{ij}^{\text{cif}} \hat{X}_{ij}^{\text{cif}}(\hat{\boldsymbol{w}}) \right) \tag{16}$$

$$\hat{w}_i = \frac{1}{\nu_i w_i L_i} \left(\sum_j \left((1-\beta) X_{ji}^{\text{cif}} \hat{X}_{ji}^{\text{cif}}(\hat{\boldsymbol{w}}) \right) + (1-\nu_i) r_i \hat{r}_i(\hat{\boldsymbol{w}}) \right) \tag{17}$$

$$\hat{E}_i(\hat{\boldsymbol{w}}) = \frac{1}{E_i} \left(E_i^q \hat{E}_i^q(\hat{\boldsymbol{w}}) + E_i^x \hat{E}_i^x(\hat{\boldsymbol{w}}) \right) \tag{18}$$

$$\hat{x}_{ij}(\hat{\boldsymbol{w}}) = \left(\hat{\tau}_{ij} \hat{w}_j^{1-\beta} \hat{P}_j(\hat{\boldsymbol{w}})^{\beta} \right)^{-\theta} \hat{P}_i(\hat{\boldsymbol{w}})^{\theta} \tag{19}$$

$$\hat{P}_i(\hat{\boldsymbol{w}}) = \left(\sum_j x_{ij} \left(\hat{\tau}_{ij} \hat{w}_j^{1-\beta} \hat{P}_j(\hat{\boldsymbol{w}})^{\beta} \right)^{-\theta} \right)^{-\frac{1}{\theta}} \tag{20}$$

$$1 = \sum_i y_i \hat{w}_i \tag{21}$$

where

$$y_i = \frac{w_i L_i}{\sum_j w_j L_j}$$

This transformation reduces the vector of parameters to be calibrated to $\boldsymbol{\theta}_h = \{\theta, \beta, \nu_i, \}_{i \in \{1,\dots,N\}}$.

Definition A2: An *international economic equilibrium in changes* is a mapping $\hat{h} : \left\{ \hat{\boldsymbol{\tau}}, \hat{\boldsymbol{D}}, \boldsymbol{\theta}_h \right\} \to \mathbb{R}_{++}^N$ with $\hat{h}(\hat{\boldsymbol{\tau}}, \hat{\boldsymbol{D}}; \boldsymbol{\theta}_h) = \hat{\boldsymbol{w}}$ solving the system of equations given by 16, 17, 18, 19, 20, and 21.

Welfare in Changes

Now changes in consumer welfare can be calculated for any set of trade policy changes $\hat{\boldsymbol{\tau}}$. Manipuating 15, changes in consumer indirect utility are

$$\hat{V}_i(\boldsymbol{w}) = \frac{\hat{\hat{E}}_i(\hat{\boldsymbol{w}})}{\hat{P}_i(\hat{\boldsymbol{w}})} \tag{22}$$

where

$$\hat{P}_i(\hat{\boldsymbol{w}}) = \hat{P}_i^q(\hat{\boldsymbol{w}})^{\nu_i} \hat{P}_i^s(\hat{\boldsymbol{w}})^{\nu_i - 1}$$

and $\hat{P}_i^q(\hat{\boldsymbol{w}})$ is given by equation 20 and $\hat{P}_i^s(\hat{\boldsymbol{w}}) = \hat{w}_i$. Changes in policy rents are given by equation 16.

B: Calibration of Economy

Solving for an international equilibrium in changes (Definition A2) requires data on national accounts (E_i, E_i^q, E_i^x, $w_i L_i$), international trade flows (X_{ij}^{cif}), policy barriers to trade τ_{ij}, and the structural parameters θ, β, and $\boldsymbol{\nu}$. Policy barriers are estimated using the methodology developed in Cooley (2019a). To maintain consistency with the model developed there, I employ the same data on the subset of countries analyzed here. I refer readers to that paper for a deeper discussion of these choices, and briefly summarize the calibration of the economy here.

Data

Trade flows valued pre-shipment (free on board) are available from COMTRADE. I employ cleaned data from CEPII's BACI. To get trade in c.i.f. values, I add estimated freight costs from Cooley (2019a) to these values. Total home expenditure ($X_{ii} + X_i^s$) and aggregate trade imbalances D_i can then be inferred from national accounts data (GDP, gross output, and gross consumption). GDP gives $w_i L_i$ and gross consumption gives $E_i^s + E_i^q + X_i^x$. To isolate expenditure on services, I use data from the World Bank's International Comparison Program, which reports consumer expenditure shares on various good categories. I classify these as tradable and nontradable, and take the sum over expenditure shares on tradables as the empirical analogue to ν_i. Then, expenditure on services is $X_i^s = (1 - \nu_i) w_i L_i$.

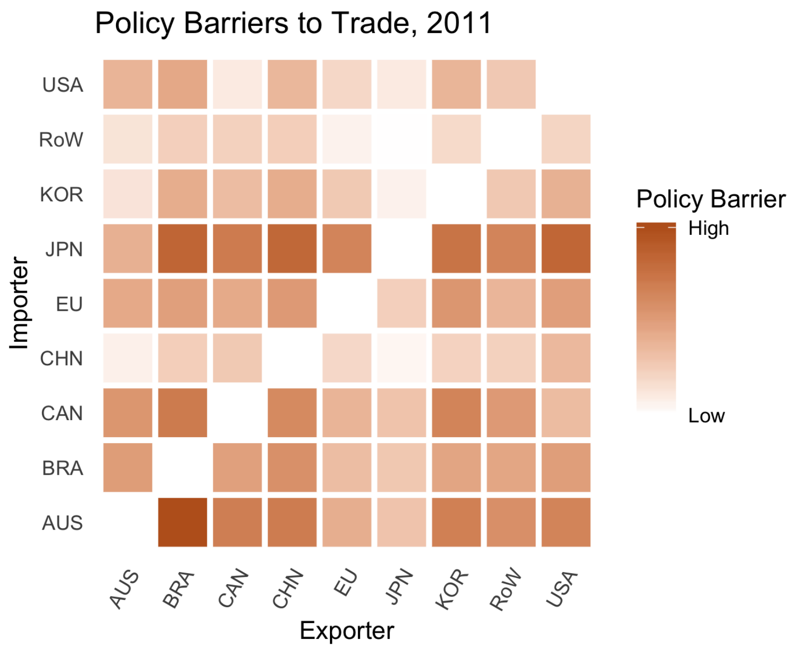
Structural Parameters

I set $\theta = 6$, in line with estimates reported in Head and Mayer (2014) and Simonovska and Waugh (2014). A natural empirical analogue for β is intermediate imports $(E_i - w_i L_i)$ divided by total tradable production. This varies country to country, however, and equilibrium existence requires a common β. I therefore take the average of this quantity as the value for β, which is 0.86 in my data. This means that small changes around the factual equilibrium result in discrete jumps in counterfactual predictions. I therefore first generate counterfactual predictions with this common β, and use these as a baseline for analysis.

Trade Imbalances

As noted by Ossa (2014), the assumption of exogenous and fixed trade imbalances generates implausible counterfactual predictions when trade frictions get large. I therefore first purge aggregate deficits from the data, solving $\hat{h}(\hat{\boldsymbol{\tau}}, \mathbf{0}; \boldsymbol{\theta}_h)$, replicating Dekle, Eaton, and Kortum (2007). This counterfactual, deficit-less economy is then employed as the baseline, where $\hat{h}(\hat{\boldsymbol{\tau}}; \boldsymbol{\theta}_h)$ referring to a counterfactual prediction from this baseline.

Trade Barrier Estimates



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