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Abstract
This article applies recent advances in network analysis to highlight a central tension faced by policymakers – balancing the benefits of engaging with the international system and the associated domestic policy costs. International trade rewards certain domestic practices, such as respect for human rights. Enforcing such practices, however, is politically costly and sometimes prohibitive to state leaders who rely on political repression to stay in power. In such cases, domestic elites often resort to an alternative strategy of securing the benefits of international trade – setting up indirect trade channels through intermediary states. These competing incentives are modeled within a single framework using a formal network game in which states form trade-links (direct or indirect) with other states, while simultaneously choosing their optimal level of domestic human rights protections. The model suggests that there may be an inverse relationship between a state's embeddedness within a network of indirect trade and respect for human rights: indirect trade channels serve as loopholes that allow domestically troubled states to enjoy the benefits of trade without pressure for domestic improvement. The predictions are supported by the results of the empirical analyses of the international trade and repression data (1987–2000), conducted using a coevolutionary actor-oriented longitudinal-network model – a statistical estimator that closely mimics the theoretical model.

Keywords
human rights, indirect trade, network analysis, network game, repression

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Dangerous Liaisons:

An Endogenous Model of International Trade and Human Rights

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Abstract

The paper applies recent advances in network analysis to highlight a central tension faced by policy-makers—balancing the benefits of engaging with the international system and the associated domestic policy costs. International trade rewards certain domestic practices, such as respect for domestic human rights. Enforcing such practices, however, is politically costly, and sometimes prohibitive, to state leaders who rely on political repression to stay in power. In such cases, domestic elites often resort to an alternative strategy of securing the benefits of international trade—setting up indirect channels through intermediary states. Counter-intuitively, the theoretical model predicts an inverse relationship between indirect trade and respect for human rights: rather than an incentive for strengthening domestic human rights protections, indirect trade is a loophole that allows domestically troubled states to enjoy the benefits of trade without pressure for domestic improvement. I find support for my predictions by testing them on international trade and repression data (1987-2000) and employing a coevolutionary actor-oriented longitudinal-network model.

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Introduction

This paper builds on recent advances in network analysis to explore the relationship between international trade and domestic respect for human rights. Through its tight link to international finance, international trade creates a powerful incentive for leaders to protect domestic human rights. Repression and arbitrary law enforcement undermine the business marketplace by creating uncertainty. Even if businesses are not the direct target of repressive actions, arbitrary arrests, disappearances, and instances of torture within a country undermine the confidence of financial institutions, raising insurance premiums and interest rates on obtaining credit and, thus, stifling trade. At the same time, many governments rely on repressive tactics in order to maintain power. While a government may want the economic benefits that come from trade, improving the domestic conditions that facilitate trade may reduce their ability to extract rents or control dissent. Finding the balance between the benefits accrued from international trade and the level of domestic repression is, therefore, one of the central tasks faced by state leaders. The network perspective adopted in this paper recasts this task as more than a binary trade-off between the amount of trade and repression, by highlighting an additional option of relying on *indirect trade*—trade relationships in which an intermediary state earns a risk premium by channeling goods to/from high-risk states.

One drawback to arrangements utilizing such middlemen, of course, is that indirect trade is less efficient than direct trade, as each intermediary takes a "cut" from the profits as the cost of assuming risk. Despite its inefficiency, examples of indirect trade are ubiquitous and can be found in many industrial sectors ranging from diamonds and weapons to automobiles and soft drinks. Hong Kong, for example, has long served as such a bridge between the human-rights conscious world and China (The Economist 2014). On a more intricate level, Iranian entrepreneur Babak Zanjani was able to earn $17.5 billion by channeling millions of barrels of oil through a web of indirect trade routes that included 64 companies in Dubai, Turkey and Malaysia (Erdbrink 2013).

The goal of this paper is to explore the relationship between states' reliance on indirect trade and protections of human rights. I capture this complex relationship with a multi-player non-cooperative formal game, in which actors simultaneously choose their own type (level of respect for human rights) and the set of direct trade relationships with other actors. Counter-intuitively, the model predicts that, under some reasonable conditions, there is an inverse relationship between an actor's number of indirect links and its incentive to protect human rights: indirect trade creates a loophole that allows domestically-troubled states to enjoy the benefits of trade without pressure for domestic improvement. I find support for the theoretical predictions by testing them on international trade and human rights data between 1987-2000. The simultaneity of network formation and effect is modeled using a a co-evolutionary actor-oriented longitudinal-network model, RSiena, with two dependent variables (Ripley, Snijders and Preciado 2012).

The paper makes two important theoretical and empirical contributions. First, it demonstrates that, under some reasonable assumptions, some states may have an incentive to channel some or even most of their trade through indirect links, despite the inefficiencies associated with relying on intermediaries. Second, the model explains why some states may rationally choose to ignore the economic incentives to enhance their domestic business environments, created by the international trade network.

This paper advances our knowledge of international organization by problematizing the origin of international networks within a unified theoretical framework that treats network formation and its unit-level effects as part of a single strategic process. Unlike most of the previous literature that takes the existing international organization as given, the theory developed here provides an account of network formation being endogenous to its effect. In doing so, this paper also makes an important contribution to the growing networks literature, making a move away from descriptive analysis towards explicit theoretical models of network formation and effects on their members.

International Trade and Domestic Repression

Recent human rights research has shifted away from the traditionalist view on the relationship between international commerce and respect for human rights, which treated the interests of international firms to be in natural alignment with those of the repressive regimes (i.e., both benefit from using repression to keep down the costs of labor and production).[1] While this perspective

[1] Within each state, there exists some firms that engage in and benefit from engaging in international trade, known as internationally trading (exporting and importing) firms, or just *trading firms* (Bernard et al. 2007). Although the interests of trading firms are neither in perfect harmony with one another nor with that of the government, the small number, large size, productivity and lobbying budgets, and access to political elites provide internationally trading firms with an important say in their country's international economic policies. For example, only 4 percent of the 5.5 million US firms in 2000 engaged in exports, with the top 10 percent accounting for 96 percent of total US exports

found some support during earlier time periods (Cardoso and Faletto 1979; Maxfield 1998), more recent empirical research suggests that such relationship may no longer hold (Blanton and Blanton 2007; Hafner-Burton 2009; Richards, Gelleny and Sacko 2001). There are three explanations for this change: spotlight effects, a changing labor market, and the financial risk, or *operations cost*, mechanism developed in this paper.

As noted by recent studies, the issue of human rights has come up with increased frequency during economic negotiations, especially those involving the US or Western European states (Hafner-Burton 2005, 2009). The 2004 US-Singapore free trade agreement, for example, stipulates that both parties "strive to ensure" a number of collective bargaining, labor, and minimum wage rights, and establishes a number of joint committees and procedures to oversee compliance with these terms (Hafner-Burton 2009, 7). Similar clauses are found in large number of agreements involving the US or European states. Increased attention to human rights practices has been drawn by the so-called "spotlight effect," associated with the human rights advocates' use of media to shame multi-national corporations (MNCs) into improving human rights conditions in their international locations (Murdie and Davis 2012). Such shaming, more recently accompanied with legal and economic sanctions against the violating firms, has been rather effective, forcing a number of MNCs, most notably Nike, Reebok, Starbucks Coffee, and The Gap, to make substantial revisions to their oveseas practices or even pull their business out of states with repressive regimes altogether.

The second explanation posited by the literature emphasizes a shift of international business interests from natural resource procurement to consumer products, manufacturing, information, and service sectors (Blanton and Blanton 2007; Kozlow, Rutter and Walker 1978). According to this explanation, changes in labor markets triggered a corresponding shift from the demands for cheap labor to the focus on skilled and qualified workforce (Mody, Dasgupta and Sinha 1999; Moran 2002). By damaging human capital (decreasing productivity, discouraging the pursuit of certain professions), repression prevents the workforce from reaching its full potential in terms of competitiveness on the world market (Blanton and Blanton 2007, 146). While respect for human rights is not a necessary condition for achieving high skills and productivity, talent and creativity

(Bernard et al. 2007, 2). The most famous example of a "national firm" perhaps the 1953 testimony by General Motors (GM) chairman Charles Wilson at his Senate Armed Services Committee confirmation hearing to become US defense secretary, stating that keeping his current position at GM poses no conflict of interest, because "what is good for the country is good for General Motors, and vice versa" (Fogel, Morck and Yeung 2008).

are more likely to thrive in favorable human rights conditions.

While the spotlight effect and the labor market explanations help account for improvements in labor rights, neither of them speaks directly to the central relationship of interest in this paper—that between international trade and domestic repression. In this paper, I draw on the economics literature to develop a third explanation for the relationship between international trade and domestic repression, one that highlights the economic risks of business operation, or *operations costs*, associated with repressive regimes.

I argue that domestic repression imposes several economic costs on trading firms, as well as their international partners. First, international trade is impossible without the support of international financial institutions, who insure the transactions between the buyers and sellers, grant credit, and collect payments (Van der Veer forthcoming). Even if businesses are not the target of repressive actions *per se*, arbitrary arrests, disappearances, and instances of torture within a country undermine the confidence of financial institutions, which respond by increasing insurance premiums and interest rates on obtaining credit (Jensen 2008). The Ukrainian government's repression against protesters in Maidan in winter of 2013-2014, for example, was met with two reductions in their Standard & Poor credit rating just in the month of February (World Business Press 2014). China's crackdown on 2014 protests in Hong Kong had similar detrimental effects for Hong Kong's economic role as a business intermediary between China and the world (The Economist 2014).

In summary, repression increases the risk of working within a country by disrupting the flow of capital, goods, and information, which leads to higher costs of insurance and interest rates, which cuts into business profits. All these factors decrease the efficiency of business operations, making repressive regimes less attractive venues for international firms.

Deflecting the Economic Costs of Repression

Broadly speaking, any government's survival in power hinges on its successful use of three strategies: distributing economic rents (private goods), offering policy concessions (public goods), and repressing opposition (Acemoglu and Robinson 2012; Conrad and DeMeritt 2013; Ritter 2013). The use of repression, however, is neither costless nor most preferred, as it destroys the loyalty of the population—a necessary condition for the successful use of the other two tools (Gandhi 2008;

Wintrobe 1998). Governments, therefore, are most likely to rely on repression as a last resort, when distribution of benefits or policy concessions do not constitute viable alternatives, i.e. in countries that lack both rich resources necessary to distribute rents and political institutions that would allow for making credible policy concessions (Gandhi 2008; Conrad and DeMeritt 2013; Wintrobe 1998).

In other words, once it starts relying on repression, a government risks being caught in a "vicious cycle" of not being able to give it up. In order to give up repression, it must shift to another tool of maintaining its hold on power. Distribution of rents, however, is dependent on the availability of rich natural resources, which are usually exogenous. The ability to provide public goods in the form of policy concessions, in the meantime, is predicated on the capacity to build viable political institutions and re-building the lost trust of the population—both lengthy and gradual processes.

As a result, elites within repressive regimes are unlikely to give up repression. Repression's negative effects on international trade, in the meantime, can be moderated by setting up international economic transactions through indirect channels. Reliance on intermediaries allows elites from repressive states to benefit from economic deals with less- or non-repressive states, who would be unable or reluctant to deal with them directly. Unable to do direct business with the American companies, such as Coca-Cola, for example, North Korea is known to import Coke from intermediary countries like Taiwan or Singapore (New Zealand Herald 2012; Williams 2013). In a similar manner, Antwerp, Belgium has become the smuggling hub for conflict diamonds from the Congo region (Farah 2001). In each case, the illicit trade is channeled through chains of intermediaries, with the goal of either obfuscating its final destination (e.g., Coke and North Korea) or the original source (e.g., diamonds and the Congo). In summary, unwilling to give up repression as a tool to maintain their authority, elites may deflect some of the associated economic costs by paying a risk premium to intermediaries, who help channel their international trade.

The Networks Game

In this section, I recast the theoretical mechanisms described above in more formal terms.

Players

Let $N = \{1, ..., n\}$ represent the states in the international system. Network relationships among these states are formally represented by a network graph (g) whose nodes are identified with the states and whose arcs capture their pairwise relations. Let ij denote the subset of N containing i and j and refer to it as the relationship between actors i and j. The interpretation is that if $ij \in g$ (alternatively written as $ij = 1$), then nodes i and j are directly connected, while if $ij \notin g$, then nodes i and j are not directly connected.

For example, if the network graph g represents the network of international trade relationships, the ij^{th} cell entry of this graph would equal to 1 if there existed a positive flow of goods between state i and state j. If states i and j have no good exchange, then the ij^{th} cell would be coded as 0.

Actions

Each actor has to make two simultaneous decisions: (1) what trade links to form, if any, and (2) whether to adopt a *Low Type* or pay a fixed cost σ to become a *High Type*. The rules for making each of these decisions are described below.

Decision 1: Choosing Trade Links

This decision involves each state simultaneously announcing the set of states to which it wishes to form trade links. The links that are formed are those in which both of the states involved in the link named each other. More formally, for the first decision made in the game, the action space of player i is a vector $S_i = [s_{i1}, \ldots, s_{in}]$, where $s_{ij} = 1$ if i chooses to form a link with j, and $s_{ij} = 0$ otherwise. If $S = S_1 \times \ldots \times S_n$ is the profile of actions played, then link ij forms if and only if both $\{s_{ij} = 1\} \in S_i$ and $\{s_{ji} = 1\} \in S_j$. The network that forms is

$$g(S) = \{ij | s_{ji} = 1 \text{ and } s_{ij} = 1\}.$$

Decision 2: Choosing Domestic Type

In this part of the game, each state chooses its type: *High* (action "1") or *Low* (action "0"). An actor's type captures the factors that improve its trade benefits and attractiveness as a trade partner, which may be thought of as its domestic economic risks or the risk of conducting economic transactions with that state. Although not explicitly formalized, the idea that a government chooses a state's domestic type that either facilitates or impedes the formation of international economic relationships is not new to the interdependence literature. In the words of Souva, Smith and Rowan (2008, 385), for example:

> [...I]t is important to clarify the role of politics in promoting trade. The policies governments choose make it more or less difficult for trade to occur. Facing any government is a menu of choices. If a certain set of policies are chosen, the political barriers to trade will be nonexistent, and trade can occur in the frictionless environment found in economics texts. However, if another set of policies are chosen, trade will be choked off. Government chooses first, and then firms must make choices within the policy environment that has been determined by the government.

The action space of player i for the type decision is

$$D_i = \{0, 1\}.$$

Payoffs

Decision 1: Choosing Trade Links

States derive trade benefits from their direct trade links, such as the ability to sell goods on their markets and access to their goods (Dreher 2006; Ricardo [1817] 2004; Wolf 2005). States also derive benefits from the indirect links connecting them to the trade partners of their trade partners. As previously discussed, indirect links allow for movement of goods that are unavailable through direct trade for political or other reasons. Indirect trade may also allow for movement of substitute goods. For example, Russian weapons are purchased as substitutes for superior, yet prohibited US-manufactured weapons, in the face of US-imposed trade restrictions on human rights abusing states (Yanik 2006).

The trade benefits that state A obtains from trade with state C, however, are diminishing with the number of links through which goods have to travel. Transporting goods through numerous intermediaries results in efficiency loss. To capture this, I denote the benefits that state A would derive from a direct trade relationship with state B by δ, such that $0 < \delta < 1$. If the two states are not directly connected, but instead trade through at least one intermediary, then indirect trade benefits are calculated by raising δ to the power that is equal to the number of states on the shortest path between them. For example, for the trade network depicted in Figure 1, A's indirect trade benefit from trade with C would be calculated by raising δ to the second power, as A is trading with C through one intermediary B (the shortest path between A and C consists of two links: AB and BC). Note that restricting δ between 0 and 1 ensures that trade benefits decline with the number of intermediaries, as raising δ to higher powers results in lower values.

International trade also involves certain costs. Apart from transportation and communication costs associated with moving goods across borders, international trade requires legal expertise to successfully draft contracts, pay foreign taxes, etc. The literature also shows, for example, that trade may hurt domestic producers by lowering the prices for their goods (Hiscox 2002; Mukherjee, Smith and Li 2009; Rogowski 1989). The costs of forming direct trade relationships with each state are captured in the model by a homogeneous parameter $c > 0$.

In summary, let $u_i(g)$ denote the "net value" that state i derives from trade with j, and c denote the cost to i of maintaining the link ij. The utility of each player i from graph g is then a function of the number of i's direct trade partners k_i, or i's *degree*, multiplied by the cost of forming a link c, and the sum of i's benefits from each direct and indirect trade link that it is involved in, $\delta^{t_{ij}}$, where t_{ij} is the number of links in the shortest path between i and j. The shortest path from i to j is defined as the path involving the lowest number of links that connects i and j.[2] More formally:

$$u_i(g) = f\left(\sum_{j \neq i} \delta^{t_{ij}}, ck_i\right). \tag{1}$$

Note that t_{ij} is set to ∞ if there is no path between i and j.

Finally, the value of $u_i(g)$ depends on the action the players take in the second part of the game.

Decision 2: Choosing Domestic Type

The second decision involves each state's choice of its domestic type: *High* or *Low*. *High Type* states pay a fixed cost $\sigma > 0$ to establish more favorable business environments than *Low Type* states by engaging in stronger protection of domestic human rights. The cost of playing *High Type*, σ,

[2]If there are two or more shortest paths of equal lengths, I assume that i selects the one with the greatest number of links of *High Type*. In case of a tie, i randomly decides to use one of the paths with the same length.

however, may be compensated by the increases in trade benefits, associated with a more favorable domestic business climate.

To distinguish the costs of business operations in a given country from the transaction costs associated with moving goods through indirect channels, I refer to the former as *Operations Costs* and to the latter as *Transaction Costs*. *Operations Costs*, therefore, capture domestic impediments to conducting business operations. The state's type (*High* or *Low*) is determined depending on the government's choice of the level of *Operations Costs* that it is going to enforce.[3]

To model *Operations Costs* and their effect on international trade relationships, suppose α represents the benefit that state i gains from trade or i's attractiveness as a trade partner, where $0 < \alpha \leq 1$. This benefit α may vary depending on a set of exogenous factors, such as domestic market size or resource endowment, or endogenous factors, such as the level of domestic enforcement of human rights protections—the focus of this paper.[4] As a result, states with higher values of α (e.g., strong protections of human rights) both make more attractive trade partners and derive greater benefit from international trade. Indirect trade through states with stronger human rights protections (high α) provides more benefits than indirect trade through states with weaker human rights protections (low α).

Thus, α enters i's utility function in three ways: (1) as α_i or i's own operations costs given i's human rights protections, (2) as α_j or a weighting parameter on i's benefit from trading with j, given j's operations cost (j's human rights protections), and (3) as α_l or a weight on i's benefit from indirect trade, which captures the level of human rights protections in the intermediary states on the shortest path from i to j. Assume that α takes on the value of 1 if state i is a *High Type* ($d_i = 1$). For all states i, $0 \leq \alpha \leq 1$, and $\alpha_i \in \{\alpha, 1\} \, \forall i$. With this in mind, u_i's utility function takes the following form:

$$u_i \left(g | d_i, d_1, ..., d_n\right) = \alpha_i \sum_{j=1}^{n} \prod_{l \in P} \alpha_{ij_l} \delta - \sigma d_i - k_i c, \tag{2}$$

where $P = \{l_1, \ldots, l_j\}$ is the shortest path between i and j, or the set of links that make up the

[3] Although exploring every single domestic issue that may translate into *Operations Costs* is beyond the scope of this paper, it is worth mentioning that one can extend the logic of *Operations Costs* to such factors as domestic rule of law, fiscal capacity, capital tax rates, constraints on the chief executive, etc.

[4] Note that more broadly, both exogenous and endogenous factors that make i a more attractive trade partner can be thought of in terms of operations costs. For example, large markets decrease operations costs by allowing for economies of scale.

path with the lowest number of links between i and j. So α_{ij_l} is the type of each state l, which is a link on the shortest path from i to j.

Figure 2 provides an illustration. Let the white and blue nodes represent *High* and *Low Type* states, accordingly. Then Figure 2.a presents a network made up of *High Type* states or states that chose to pay a fixed cost for enforcing domestic human rights protections. The utility to state A from this network consists of $\delta - c$, its net benefit from a direct trade link with state B, plus four times δ^2 for four indirect links through B to C, D, E, and F. Finally, we must subtract σ, the fixed cost of *High Type*. More formally, state A's utility can be written as:

$$u_A\left(g|d_A = 1, d_B = 1, d_C = 1, d_D = 1, d_E = 1, d_F = 1\right) = \delta + 4\delta^2 - c - \sigma \tag{3}$$

The corresponding utility to state A in the network presented in Figure 2.b consists of $\alpha^2\delta - c$, its net benefit from a direct trade link with state B, plus four times $\alpha^3\delta^2$ for four indirect links through B to C, D, E, and F or:

$$u_A\left(g|d_A = 1, d_B = 1, d_C = 1, d_D = 1, d_E = 1, d_F = 1\right) = \alpha^2\delta + 4\alpha^3\delta^2 - c \tag{4}$$

Note that the two networks depicted in Figure 2 differ only in the types of states that make them up. Comparing Equations 3 and 4, we see that this difference results in two trade-offs in the payoff function: (1) *High Types* must pay σ, while *Low Types* have no cost, and (2) *Low Types*' utilities are discounted by α. Importantly, the value lost due to this discounting increases with the number of both direct and indirect links in the network.

Empirical Predictions

The solution to the game provides several important insights regarding the relationship between international trade and domestic human rights.[5] First, despite the efficiency loss associated with trading through intermediaries, the model identifies the conditions, under which some or even most of international states will rationally choose to channel their trade indirectly. Second, while international trade favors human rights "respecters" over "abusers," the model helps identify some reasonable conditions, under which some or even the majority or international states will not protect

[5] The full solution to the game is available in the Appendix.

domestic human rights. In particular, these two relationships hold within a class of equilibria, to which I refer as *heterogeneous equilibria*—that exist when the net cost-benefit from a direct trade link, while positive, is less than that from an indirect (second degree) trade link. Such link costs, in other words, favor indirect, or intermediated, trade and lead to equilibria, in which some states "separate" into two groups: some act as intermediaries, while others act as "indirect traders" and use these intermediaries to channel their trade.

By combining distance-based discounting (i.e., mutual trade benefits are inversely related to the length of the shortest path between actors) and type-specific discounting parameters (i.e., the benefits from trading with "low types" have a steeper distance-based decline), the utility function creates a strong preference for "high type" intermediaries. As a shift from trading directly to trading indirectly would result in a greater net loss for "respecters" than for "abusers," states will maximize their benefits by minimizing their total shortest paths to human rights "respecters." As a result, "respecters" will be more likely to serve in the roles of trade intermediaries and form more direct trade relationships than "abusers." Replacing the dichotomous "respecter"/"abuser" language of the game with a more continuous conceptualization of the level of human rights protections, this prediction can be re-stated as Hypothesis 1 (derived from Proposition 3).

Hypothesis 1. *There is a positive relationship between the level of human rights protections and the probability of forming direct trade links.*

Since the relationship between trade and human rights is endogenous, one must also explore the other part of this relationship—that between a state's trade position and the incentive to protect human rights. Depending on their trade roles ("intermediaries" and "indirect traders"), states face different incentives to protect domestic human rights.[6] In particular, the incentive to protect domestic human rights is inversely related to a state's reliance on indirect vs. direct trade relationships. This relationship is a result of a distance-based discounting function associated with the net benefit of protecting human rights, i.e. each additional direct link creates a larger benefit that can be gained by protecting human rights than each additional indirect link (removed by a

[6] Although not the focus here, the two groups also obtain unequal *payoffs* from the international network: since there is a greater net benefit from each indirect link, intermediaries, who by definition have a larger number of direct than indirect links, obtain lower total payoffs than indirect traders. Note that unequal payoffs are common in formal games, and do not prevent players from playing equilibrium strategies. The equilibrium in the Game of Chicken, for example, is for one player to "swerves" and obtain a lower payoff than the other player, who "does not swerve."

shortest path of one or more intermediaries). States protect human rights when the additional trade benefits to be gained from this improvement in transaction costs outweigh the fixed cost of implementing it (e.g., forgoing repression and investing in the necessary administrative capacity). If we think of the total trade benefit necessary to compensate for the cost of implementing human rights protections as in terms of a threshold value, each additional direct link brings a state closer to this threshold at a faster pace than each indirect link.

This logic shows that intermediary states, or states a larger number of direct trade links than the indirect traders, will have a greater incentive to protect domestic human rights than indirect traders, and vice versa: indirect traders will have a lower incentive to protect domestic human rights than intermediaries. This prediction generalizes across all equilibria: rather than dichotomizing states into "intermediaries" and "indirect traders," we can rank them in terms of their relative dependence on indirect links (in relation to its total number of direct and indirect links).[7] Then, states with a greater reliance on indirect links will have a weaker incentive to protect domestic human rights (this hypothesis is derived from Proposition 4).

Hypothesis 2. *A state's reliance on indirect trade links is inversely related to a state's respect human rights.*

In more substantive terms, this prediction highlights that, all else equal, repressive states whose firms channel a large portion of their trade indirectly find themselves in such a position for a reason: they *choose* to rely on indirect trade, in order to avoid the international pressure for domestic improvement. Given the high level of connectedness within the contemporary trade network, each indirect link is a manifestation of the absence of a (more profitable) direct link, rather than an additional trade channel. States resort to indirect links out of necessity rather than economic preference, opting for indirect trade in exchange to more leeway in their domestic politics.

Importantly, poor human rights practices are only one of the reasons for a state to rely on indirect rather than direct trade. States may also engage in indirect trade as a result of other

[7]In all non-empty equilibrium networks, all states will be connected to all other states, either directly or indirectly (see Proposition 1 of Appendix). This effectively means that an increase in indirect links can only come at the expense of a decrease in direct links, and vice versa: a state's number of direct and indirect trade partners are not independent, as long as there is a fixed total number of players. Although the empirical trade relationships are more complex (e.g., not all states are connected to all other states, directly or indirectly), the same general pattern will hold: the total numbers of a state's direct and indirect trade partners will be inversely related. Reliance on indirect trade, therefore, is best captured with a ratio of the number of indirect links and the total number of links.

factors (captured in the model by the cost of forming a direct trade relationship or *link cost* parameter), such as political disagreements (e.g., China and Taiwan, North and South Korea), poor administrative capacity (e.g., Somalia), geographical isolation (e.g., island states), or to take advantage of the economies of scale (e.g., many European states channel large amounts of goods through the Netherlands or Belgium). Regardless of the reason, greater reliance on indirect trade is associated with lower international constraints on domestic policy-making. The lack of economic dependence on direct trade relieves the government of pressure from the international community and financial institutions. Thus, indirect trade "frees up" the domestic government to engage in repression, if it so chooses.

Research Design

The theoretical model is best statistically mimicked by a *coevolutionary actor-oriented longitudinal-network model*, also known as Siena or RSiena, with two simultaneously determined dependent variables: the network links formed by the actors and actor-specific outcomes.[8]

Siena was originally developed by Snijders, Steglich and Schweinberger (2007), and expanded upon by Steglich, Snijders and Pearson (2010) for the purposes of modeling and separating the over-time effects of *co-evolution*, *homophily*, and *mutual influence* in social networks.[9] The model

[8] The type of non-independence among observations, posited by the theoretical model, may also be statistically modeled using a regression with spatially lagged independent or dependent variables (SAR) (Beck, Gleditsch and Beardsley 2006; Franzese, Hays and Kachi 2012), or an exponential random graph model (ERGM) (Cranmer and Desmarais 2011). Franzese, Hays and Kachi (2012, 186) provide a rather comprehensive comparison of Siena and SAR and conclude that Siena is "essentially unbiased in lower-T samples," with both Siena and SAR producing comparable estimates.

Both SAR and ERGMs, however, have issues deeming them inappropriate for the current application. The SAR approach, for instance, does not allow for a separation between the effects of direct and indirect ties—a separation central to the paper's main argument, as SAR rests on an implicit assumption of complementarity between direct and indirect spatial ties: each unit's score is assumed to be affected by the average score of its spatially contiguous neighbors. Since unit A's neighbors are affected by their own neighbors average scores, this means that unit A's score is also indirectly affected by the scores of it's neighbors' neighbors. These effects are complementary by construction: SAR estimates a single parameter, *rho*, for each of the specified connectivity matrices. In order to test the theoretical predictions of this paper, an estimator must be able to isolate the effects for (1) the neighbor's effect on unit A, and (2) the neighbors' of A's neighbors effect on unit A, which SAR is not intended to do. While the ERGM approach allows for a separation between the effects of direct and indirect ties (through inclusion of separate covariates), existing ERGM estimators do not allow for modeling of a second important dynamic, posited by the theoretical model—the simultaneity between network formation and effect. While one could model such simultaneity using a two-stage estimation technique, the properties of simultaneous estimation using either SARs or ERGMs are currently unexplored. I employ a number of additional robustness checks, with results virtually unchanged (available upon request).

[9] For a detailed overview of the model, see Snijders, Steglich and Schweinberger (2007), Steglich, Snijders and Pearson (2010), and Ripley, Snijders and Preciado (2012).

has two simultaneously determined outcome variables that are observed in each time period: the network and the actor behavior. The central premise of the model is that the actors are a part to the *nxn* network $\mathbf{g}$ and have control over their direct outgoing ties, i.e. actors can observe, evaluate, and change who they link with from one time period to the next. $\mathbf{g}_{ij}(\mathbf{t})$ denotes the value of the relationship between actors i and j at time t. In this paper, the network ties represent trade links among international states. For tractability purposes, this model assumes that $\mathbf{g}$ is *dichotomous*, i.e., that $\mathbf{g}_{ij} = 1$ represents a presence of a tie, and $\mathbf{g}_{ij} = 0$ represents a tie's absence. Finally, consistent with the logic of Markov-chain processes, actors make the decisions to change ties in the period $t + 1$ after observing the network in the current period t, without any memory of the network states in periods $t - 1$ or earlier.[10]

At the same time, in every period each player chooses a level of behavior (i.e. the level of human rights protection)—measured on an ordinal scale and denoted as $\mathbf{d}$, where $\mathbf{d}_i(\mathbf{t})$ refers to actor i's behavior at time t. To be more precise, the simultaneity between the choice of ties and behavior is approximated by randomization of choices (reviewing ties or behavior) under the assumption of continuous decision-making. In other words, although the data is gathered on a discrete level (yearly), the estimator assumes that the actual changes in the network ties and behavior happen in continuous time: hence, each temporal unit of observation (here, year) is decomposed into into a series of small steps or *micro-steps* (Holland and Leinhardt 1977; Steglich, Snijders and Pearson 2010). The continuous time assumption effectively means that no two decisions by the same actor or by two different actors can occur at the exact same moment in time, forbidding such arrangements as a binding contract of the kind "when you improve your human rights, I will trade with you."[11] From a modeling perspective, continuous-time modeling significantly simplifies the estimation by relieving us from explicitly modeling simultaneous changes. Instead, at each micro-step, whose length is determined by a randomly drawn parameter r, an actor is randomly chosen to either review its direct ties (where it has the options on keeping the existing ties, adding, or deleting one tie at a time) or its behavior (where it has the options of maintaining the current level, increasing or decreasing it by one unit).

The model may be used to estimate the effects of actor-level, as well as dyadic-level, exogenous

[10]For a detailed overview of continuous Markov-chain models, see Gill (2006).

[11]Given the known commitment problems associated with states' international interactions (e.g., Powell 2006), an assumption that states cannot credibly commit to such an arrangement seems reasonable.

covariates, which are denoted $\mathbf{v}$ and $\mathbf{w}$, respectively, where $\mathbf{v}_i^{(x)}$ represents actor i's score on actor-level covariate $\mathbf{x}$, and $\mathbf{w}_{ij}^{(x)}$ stands for the dyadic covariate $\mathbf{x}$ measured for the pair ij. In the context of this paper, an actor-level covariate is, for example, state *GDP per capita* or *population*, while an example of a dyadic-level covariate is the *geographical distance* between two states.

The first observations of network ties $\mathbf{g(t_1)}$ and behavior $\mathbf{d(t_1)}$ serve as the starting values of the Markov process, i.e., these values are not modeled themselves but used to condition the subsequent changes in network and behavior. The estimations begins with a draw of the network and behavior *micro-step lengths* from two independent exponential distributions, and the time unit $\mathbf{t}$ being incremented by each of the drawn values. If the drawn values do not exceed the end time of the observed period, then the estimator randomly determines whether the next change is a network change or a behavioral change and what actor is making the change. Finally, the estimator calculates the change to be made using a multinomial logit shape:

$$\frac{e^{\left(f_i^{net}(g',d)\right)}}{\sum\limits_{g''} e^{\left(f_i^{net}(g'',d)\right)}}, \tag{5}$$

or

$$\frac{e^{\left(f_i^{beh}(g,d')\right)}}{\sum\limits_{d''} e^{\left(f_i^{beh}(g,d'')\right)}}, \tag{6}$$

where $\left(f_i^{net}\right)$ is the function of changes in actor ties, $\left(f_i^{beh}\right)$ is the function of changes is actor behavior, $\mathbf{g}'$ is the current network, $\mathbf{g}''$ is a set of possible networks that can be formed in the next micro-step. Analogously, d' refers to the current level of behavior and d'' denotes a set of possible behaviors in the next micro-step. This process is repeated until the end of the period is reached and for each of the subsequent time periods.

Dependent Variables

The theoretical model highlights non-independence between network formation and effect: recognizing repression's adverse effects on international trade, leaders consciously balance between optimizing their economic profits and political power. The empirical model captures this relationship with a simultaneous estimation of two dependent variables. The first dependent variable is a the trade network, measured at the system-level. The dependent variable in the second equation is the monadic (or state-level) respect for human rights.

The first dependent variable—trade network—is measured as a directed nxn matrix $\mathbf{g}$ whose $\mathbf{g}_{ij}(\mathbf{t})$ cells are coded as 1 if state i exported any goods to j in time period t ($\text{export}_{ij} > 0$), else the cell entry is coded as 0.[12] Export data are obtained from the Correlates of War Trade Data (Barbieri, Keshk and Pollins 2009).

The second dependent variable—a state's level of respect for human rights—is measured using the *Physical Integrity* variable from the CIRI Human Rights Data Project (Cingranelli and Richards 2010). The *Physical Integrity* variable is an index that consists of additive five additive component variables (Torture, Extrajudicial Killing, Political, Imprisonment, and Disappearance), each ranging from 0 (the worst outcome) to 2 (the best outcome) (Cingranelli and Richards 2010). As a result, the *Human Rights* variable is measured on a 9-point ordinal scale ranging from 0 (no respect for human rights) to 8 (full respect for human rights). Although the CIRI dataset includes information for 195 countries between 1981-2009, the estimation sample is limited to 126 countries between 1987-2000, due to the data availability on other variables, primarily the *Rule of Law* measure and *Trade*.

Independent Variables

In accordance with Hypothesis 1, which predicts a positive relationship between human rights protections and direct trade, the dependent variable from the *Human Rights* equation—*Human Rights*—also serves as the two primary independent variables (*Human Rights A* and *Human Rights*

[12]There are some trade-offs with using such a binary export link measure, as the computational advantage comes at the price of information loss. However, a binary measure of exports also has advantages over a continuous one, as scholars have long struggled with the proper standardization of the continuous measure. Some advocate standardizing exports by GDP (e.g., Maoz et al. 2006), while others argue for using the raw amount (e.g., Keshk, Pollins and Reuveny 2004). Each of these approaches comes with their own biases, as the export to GDP ratio measure will underestimate and the raw measure will overestimate the importance of trade for states with large GDP. The binary measure adopted here, while less precise, has the advantage of bypassing this issue: it treats all trade links as equally important rather than forcing the analyzer to arbitrarily favor a standardization approach. Even more importantly, the binary trade link measure seems more appropriate, as the theory's predictions concern trade link formation rather than the amount of trade between two states.

The statistical results are robust to employing imports instead, or varying the thresholds, e.g., $\text{export}_{ij} > 1\%$ or 5% of i's total trade. While the primary estimator used here requires a binary network measure, the results are robust to using a continuous measure, as a naïve OLS or a three-stage least squares models produce similar results. These additional models are available upon request.

B) in the *Trade Network Formation* equation.

The *Trade* equation also includes a set of standard control variables, which are summarized in Table 1. Finally, this equation contains a network-specific endogenous variable: *Degree Density*, which is estimated as the average number of outgoing ties across all actors. The *Degree Density* parameter can be thought of as the actor's overall tendency to form ties. If all other parameters are zero, an insignificant *Degree Density* parameter indicates that each tie in the network is formed at random or with probability of 0.5. In the long run, such a network would have a density of 0.5, with actors forming 50% of all possible ties. Social networks, however, are typically characterized by much lower densities (Steglich, Snijders and Pearson 2010, 360). The *Degree Density* parameter accounts for this effect (Ripley, Snijders and Preciado 2012).[13]

The *Human Rights* equation includes the primary independent variables—*Indirect Degree Ratio*, as well as its constitutive terms *Indirect Degree* and *Total Degree*—necessary for testing Hypothesis 2.

As described in Empirical Predictions section, *Indirect Degree Ratio* conceptualizes a state's relative reliance on indirect vs. direct trade and is thus an interaction between *Indirect Degree* and 1 over *Total Degree*. *Indirect Degree* is calculated as the total number of unique "second degree" trade partners (partners that can be indirectly reached through one intermediary), excluding i's indirect links to states with whom it already has a direct trade link. Cases in which a pair of states engage in a mix of direct and indirect trade relationships, such as North and South Korea, are excluded by the measure of indirect degree adopted here. Just like in the theoretical model, the measure of *Indirect Degree* captures the *opportunity* available to the states to channel goods indirectly, rather than the presence of actual trade flows. In accordance with the theoretical model, it is the *opportunity* to channel goods through indirect trade and, thus avoid domestic and international pressures to protect human rights, that enables governments to rely on repression, if they so choose.[14] *Total Degree* is a sum of *Indirect Degree* and *Direct Trade Degree*, which is the total number of state's direct trade partners.

[13]I do not include *Transitive Triads* nor *Reciprocity* because they are not theoretically relevant and each is highly correlated with *Degree Density* in dense networks, such as the international trade network.

[14]Data on actual indirect trade flows is difficult, and often impossible, to gather: for example, sanction-busters are unlikely to reveal the information about their illegal sales. In the absence of such data, the measure of indirect links, adopted here, suffers from some imprecision. The possible bias resulting from such measurement inefficiency, however, would be conservative in nature, providing for a more difficult test of the model.

The *Human Rights* equation also includes a number of standard control variables, which are summarized in Table 1. The model accounts for temporal dependence by including a linear and a quadratic shape effects, which capture the basic drive towards higher values on the dependent variable over time. Finally, to facilitate interpretation, all independent variables are mean-centered.

Empirical Results

The results of the empirical analysis are presented in Table 2. I focus my discussion on the results associated with the theoretically relevant variables, since all control variables act in their expected direction.

In the *Trade Network* equation, the primary parameters of interest are *Human Rights A* and *Human Rights B*. Consistent with Hypothesis 1, both of these variables are positive and statistically significant. This indicates that states with greater respect for domestic human rights are both more likely to engage in trade themselves, as well as being more attractive trade partners to other states. This result is important, as it yields credence to the model's central assumption which posits that repression creates unfavorable business environment.

The effect of trade network on human rights protections is explored in the second equation of Table 2. The central variables of interest here are the interactive term, *Indirect Degree Ratio*, which conceptualizes a state's relative reliance on indirect trade, as well as two constitutive terms that make it up, *Indirect Degree* and *Total Degree*. The coefficient on the interaction tells us the effect of *Indirect Degree Ratio* when the constitutive terms are *held at their mean*, as all covariates are mean-centered. Since the coefficient on *Indirect Degree Ratio* is negative and statistically significant, it suggests a negative relationship between reliance on indirect links and human rights protections. This provides support for Hypothesis 2, indicating that states with a greater reliance on indirect trade tend to have lower respect for human rights. This result suggests that repressive states find themselves in "vicious cycles:" by starting on the path of repression, they are also forced to rely on indirect trade, which in turn, lowers their future incentives for improving human rights protections.

Together with the theoretical model, the empirical results suggest some policy insights, identifying some reasons for the failure of several solutions attempted by the international community, such as economic sanctions or humanitarian military intervention (Li and Drury 2004; Peksen 2012).

Both of these options impose or demand a change in domestic type (e.g., from weak to high level of human rights protections), without providing any compensation for the cost of such a change or even creating additional costs by destroying infrastructure and destabilizing the economy. Bilateral sanctions merely force the target to re-direct its trade flows through indirect trade links, hurting only the sender (Lektzian and Biglaiser 2012).

Multi-lateral sanctions also fail to induce an improvement in human rights, as, in the game, states engage in human rights protections when the potential trade benefits from the network outweigh the costs. In other words, states fail to protect human rights, when the cost of building functioning human rights institutions is greater than the potential gains from becoming a more efficient and attractive trader. By isolating human rights abusers from the rest of the trade network, multilateral economic sanctions decrease rather than enhance their incentive to engage in human rights protections. If the benefits of the pre-sanctions network were insufficient to outweigh the cost of domestic improvements, then the even lower benefits from a sparser post-sanctions network will not do so either. A state with no direct trade partners, in other words, has no incentive to start protecting human rights, as it has no positive benefits from the network to outweigh the cost of doing so. A state with an infinite number of direct trade relationships links, on the other hand, will have the greatest incentive to refrain from repressive behavior, but whether this incentive is sufficient is ultimately determined by the cost of enforcing human rights protections.

Similarly, humanitarian intervention fails to deal with the underlying reasons for poor human rights practices. Simply removing the regime does not change the existing equilibrium, as the new regime will face the same incentives and costs as the previous one. A forced regime change by itself neither creates additional network benefits (e.g., additional direct links) to outweigh the cost of building human rights institutions, nor decreases the cost of building human rights institutions. The model implies, however, that the success of a humanitarian intervention may be enhanced (but not guaranteed) when it is accompanied by administrative and reconstruction aid, as such aid may sufficiently decrease the cost of building human rights institutions.

Instead, the game suggests two solutions. First, the equilibria are, in part, determined by the cost of forming trade relationships, conceptualized as the costs of transportation, as well as the costs of negotiating tax treaties and acquiring the legal expertise necessitated with operating within a different state. As these costs decrease and all else holds constant, the network slowly moves towards a complete network equilibrium, in which each state has a direct connection to each other state, providing additional incentives for improving domestic practices. Such improvement, however, implies a long-term process, associated with over-time improvements in transportation, information technology, legal training and treaty negotiation. Second, equilibria are separated based on the cost of building human rights institutions and forgoing repression as a tool for extracting economic benefits. Lowering this cost may be made possible through a more active involvement of the international community, such as negotiating "golden parachutes" with the current political elites (Mansfield and Snyder 2007).

Finally, a third way to change the equilibrium involves changing the game or playing an out-of-equilibrium strategy to induce an out-of-equilibrium response. If there emerged a player, such as a state, an IO, or an NGO, whose payoff would incorporate changing the behavior of human rights abusers by providing them with side-payments that would either lower their trading costs or the cost of building domestic human rights institutions. If the European Union, for example, was interested in causing change in Ukraine's human rights practices, it could choose to pay the cost of admitting Ukraine into the Union without requiring domestic change, for the sake of providing Ukraine with additional economic incentives to improve its domestic practices on its own.[15]

Conclusion

The argument of this paper is that human rights abuses impose a number of important economic costs on the repressive states. Domestic economic elites within such states have two strategies for avoiding these costs. The first strategy lies in the lobbying or otherwise pressuring their government to improve its human rights practices. When the first strategy is unavailable or too costly, the domestic groups can instead rely on conducting their economic transactions through international intermediary states—states that are willing to trade with repressive states, yet have high enough respect for human rights, so that they can also maintain trade relationships with states that avoid direct trade with human rights abusers. The theoretical model predicts an endogenous relationship between domestic respect for human rights and the number of direct trade partners. Namely, the relationship works both ways: states with strong respect for human rights attract more direct trade

[15] For similar solutions to collective action problems, see Conybeare (1980) and Hardin (1982).

partners, and states with a larger number of direct trade partners have higher respect for human rights. Second, there is an inverse relationship between a state's number of indirect trade partners and its respect for human rights.

More broadly, this paper emphasizes the non-random processes behind network formation, or the endogeneity between network formation and effect. Whether it is a network of professional associates, legislative co-sponsorships, campaign contributions, or international conflict, membership is associated with a particular selection and/or self-selection processes. This means that the task of evaluating the effects of such networks—e.g., their centrality, polarity, or shortest path measures—is inseparable from modeling their formation—a step rarely undertaken by existing networks research. In contrast, treating such network measures as exogenous imposes a rather strict and often unrealistic assumption, which may bias the resulting inferences.

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Figure 1: Direct vs. Indirect Links: An Illustration

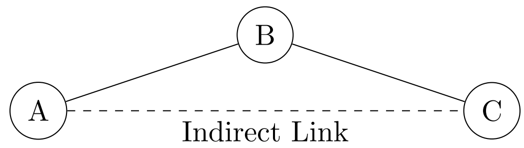
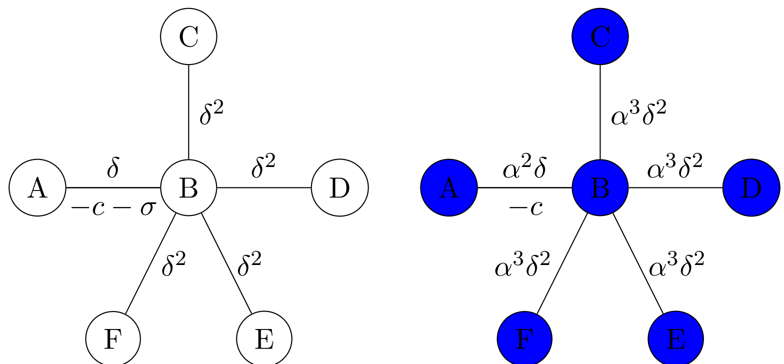


Figure 2: Calculating Players' Utilities: An Illustration



(a) High Type Network (b) Low Type Network

Table 1: Control Variables

Name	Effect	Argument	Data Source
		Trade Equation	
Rule of Law	+	States with market protecting institutions make more favorable business environments (Souva, Smith and Rowan 2008)	ICRG Data
Ongoing MID	—	Military conflict undermines trade by increasing transaction costs (Keshk, Pollins and Reuveny 2004).	Ghosn and Bennett (2003)
Peace Years	+	Military conflict undermines trade by increasing transaction costs (Keshk, Pollins and Reuveny 2004).	Ghosn and Bennett (2003)
GDP/capita	+	States with larger economies engage in more trade (Hegre, Oneal and Russett 2010)	Gleditsch (2002)
Population	+	States with larger economies engage in more trade (Hegre, Oneal and Russett 2010)	Gleditsch (2002)
Distance	—	States are more likely to trade with more proximate states, as transportation costs increase with distance.	Hegre, Oneal and Russett (2010)
Joint preferential trade agreement (PTA)	+	PTAs facilitate trade by providing clear legal guidelines (Goldstein, Rivers and Tomz 2007).	Goldstein, Rivers and Tomz (2007)
Alliance Portfolio Similarity	+	States with similar policy preferences will be more likely to also have trade relationships (Keshk, Pollins and Reuveny 2004).	Signorino and Ritter (1999); Hage (2011)
		Human Rights Equation	
Civil War	—	Domestically-troubled states are more likely to engage in repression (Poe and Tate 1994).	Correlates of War (Sarkees and Wayman 2010)
International War	—	States engaged in international disputes may have a lower capacity to protect the rights of their citizens (Poe and Tate 1994).	Correlates of War Sarkees and Wayman (2010)
GDP/capita	+	Human rights abuses stems from resource competition, which is less adverse in affluent societies (Fearon and Laitin 2003)	Gleditsch (2002)
Population	-	Human rights abuses stems from resource competition, which is more adverse in countries with larger populations (Fearon and Laitin 2003)	Gleditsch (2002)
Polity	+	More democratic states have greater respect for human rights (Poe, Tate and Keith 1999)	Marshall and Jaggers (2008)
Durability	+	Human rights abuses are likely to spike during the periods of regime transitions (Hafner-Burton 2005)	(Marshall and Jaggers (2008)
British Colony	+	Human rights practices may stem from colonial legacies (Poe and Tate 1994)	Wimmer and Min (2006)
Oil	+	Resource-rich states are less likely to repress, as they maintain power through resource redistribution (Gandhi 2008).	Ross (2001)

Table 2: Trade Network Formation and Domestic Human Rights (RSiena)

Equation 1: Trade Network Formation (Dyadic Level)		
	Exports	
Human Rights A	0.113**	(0.006)
Human Rights B	0.113**	(0.006)
Rule of Law A	0.063**	(0.009)
Rule of Law B	0.018**	(0.008)
Ongoing MID	−0.965**	(0.151)
Distance	−0.087**	(0.006)
GDP/cap A	0.435**	(0.012)
GDP/cap B	0.328**	(0.010)
Population A	−0.027*	(0.014)
Population B	−0.020*	(0.012)
PTA	0.630**	(0.029)
Alliance Similarity	0.507**	(0.036)
Peace Years AB	0.002**	(0.001)
Degree Density	0.985**	(0.010)
Equation 2: Human Rights (Monadic Level)		
Ind Deg Ratio	−1.169**	(0.226)
Ind Deg	2.077	(3.724)
Total Deg (Dir+Ind)	−0.003	(0.001)
Civil War	−0.358**	(0.064)
Intl War	−6.404**	(2.910)
GDP/cap	0.002	(0.031)
Population	−0.170**	(0.029)
Polity	0.016**	(0.003)
Durability	0.004**	(0.001)
British Colony	0.005	(0.047)
Oil	−0.002	(0.011)
Linear Shape	0.075**	(0.021)
Quadratic Shape	−0.064**	(0.008)
N(t)	126 countries (13 years)	

Note: Two-tailed: **p< 0.01, *p< 0.05. Time parameters are suppressed. All convergence parameters are less than 0.1.

Appendix A Stable Networks and Their Shapes

Equilibria Concepts: Strong Pairwise Nash Stability

The game's equilibria consist of two parts, which correspond to the two decisions made by actors: (1) the set of links that they would like to make, and (2) the choice of own type (high or low) $D = \{0, 1\}$. Since forming a link requires the consent of both players, we have to move beyond the Nash equilibrium concept (and its standard refinements) to consider coordinated actions on the part of coalitions (at least pairs) of players (Jackson and Wolinsky 1996; Jackson 2008). Jackson and Wolinsky (1996) address this by proposing the concept of *pairwise Nash stability.* Pairwise stability involves two rules about a network: (1) no player can raise her payoff by deleting a link that she is directly involved in and (2) no two agents can both benefit (at least one strictly) by adding a link between themselves. More formally, the graph g is pairwise stable if:

1. $\forall ij \in g, u_i(g) \geq u_i(g - ij)$ and $u_j(g) \geq u_j(g - ij)$
   and

2. $\forall ij \notin g$, if $u_i(g) < u_i(g + ij)$ then $u_j(g) > u_j(g + ij)$.

We say that g is *defeated* by g' if $g' = g - ij$ and (1) is violated for ij, or if $g' = g + ij$ and (2) is violated for ij. Condition (2) embodies the assumption that, if i strictly prefers to form the link ij and j is just indifferent, then the link ij will be formed. A network is *pairwise Nash stable* if it is both Nash stable and pairwise stable.

Type Stability

The second part of the equilibria for this game concerns actors' binary choice of type $D = \{0, 1\}$. Here, I use the standard Nash equilibrium concept: an action profile $d_i^* \in D$ is a Nash equilibrium if no unilateral deviation in strategy by any single player is profitable for that player, that is:

$$d_i \in D_i, d_i \neq d_i^* : u_i\left(d_i^*, d_{-i}^*\right) \geq u_i\left(d_i, d_{-i}^*\right). \tag{7}$$

In order to solve the game, I combined the equilibria concepts described above into a new equilibrium concept—*strong pairwise Nash stability.* A network is defined to be strongly Nash stable if it is both pairwise Nash stable and type stable.

Pairwise Stable Network Shapes

The shape of the equilibrium networks will depend on the relationship between link cost c, trade benefits δ, and trade partner attractiveness (operations' costs) α. In terms of domestic operations' costs, there will be three types of equilibria, separated by two threshold cost σ_1^* and σ_2^*, so that all states choose the low costs type ($d = 1$) when $\sigma < \sigma_1^*$, some states choose the low cost ($d = 1$), while others choose the high cost ($d = 0$) when $\sigma_1^* < \sigma < \sigma_2^*$, and all states play the high cost type ($d = 0$) when $\sigma > \sigma_2^*$.

The model has a large number of equilibria. I begin with three types of *symmetrical* equilibria, and then extend the discussion to the relevant features of *asymmetrical* equilibria. The model is solved in two stages: first, I identify the most common *symmetrical* shapes that trade networks take on at different cost ranges, then I identify the Nash stable type choices for each possible network position. The first stage of the analysis reveals three common *symmetrical* shapes that trade networks can take on depending on the cost of links: *complete* networks or *cliques*, *stars*, and *circles* or *rings* (see Figure 3).[16]

A *complete* network or a *clique* is a network in which each player has a link to each other player: $g \in g^N$ is a complete network if $\forall i \in g, j \in g : ij = 1$. An empirical example of a complete trade network is a trade union, such as the European Union (EU) or the North Atlantic Free Trade Agreement (NAFTA).

A *star-shaped* or a *hub–and–spokes* network is a network in which all players are linked to one central player—*the hub*—and there are no other links: $g \in g^N$ is a star if $g \neq \emptyset$ and there exists $i \in N$ such that if $jk \in g$, then either $j = i$ or $k = i$. Individual i is the center of the star. Empirical examples of star-shaped networks include colonial trade networks with the colonizer as the center of the star and the colonies as the *vertices* or *spokes*(the British or French Empires and their colonies, etc.).

Finally, a *circle* or a *ring* is a network in which each player has direct links with exactly two other players. The most prominent example comes from nuclear proliferation literature, which commonly refers to the "rings" of non-nuclear developing countries with varying technical capabilities trading knowledge in attempts to enhance each other's nuclear potential.

Since making/maintaining direct links is costly, as the cost c increases, states form networks with fewer direct links. When the cost of forming/maintaining links is low, states form complete networks, as the cost increases, states forgo direct links for the indirect ones—as the indirect links allow for deriving the network benefits without paying the costs. Finally, when the cost of links is high, states choose to form networks with the minimal number of direct links, maximizing their reliance on the indirect links. This relationship between the cost of links and network shapes is formally stated in Proposition 1.

Proposition 1 (stated on p. 46, an extension of Jackson and Wolinsky (1996)). In the symmetric connections model:

i For $c + \sigma < \alpha_i \alpha_j \left(\delta - \alpha_{ijl}\delta^2\right)$, the unique pairwise stable network is the complete graph, g^N.

ii. For $\alpha_i \alpha_j \left(\delta - \alpha_{ijl}\delta^2\right) < c + \sigma < \alpha_i \alpha_j \delta$, a star encompassing all players is pairwise stable, but not necessarily the unique pairwise stable graph.

iii. For $\alpha_i \alpha_j \delta < c + \sigma$, any pairwise stable network which is non-empty is such that each player has at least two links.

Proof of Proposition 1. i. In this cost range, any players who are not directly connected will benefit from forming a link. Equation (3) can be rearranged in the following way, so that the costs of forming a link are on the left side and the benefits are on the right ride of the equation:

$$\alpha_i \sum_{j=1}^{n} \prod_{l \in P} \alpha_l \delta - \sigma - k_i c_{ij} = 0 \tag{8}$$

$$\sigma + k_i c_{ij} = \alpha_i \sum_{j=1}^{n} \prod_{l \in P} \alpha_l \delta \tag{9}$$

The sufficient condition for the actors to always prefer a direct link over an indirect one is that the difference between the benefit from a direct link and the benefit from an indirect link is at least as high as the cost of a direct link. Based on equation (4), this difference can be expressed as:

$$\alpha_i \alpha_j \delta - \alpha_i \alpha_j \alpha_{ijl} \delta^2, \tag{10}$$

[16]Of course, the existing trade networks rarely fall neatly into these three shape categories. Therefore, the three shapes identified here are best thought of as the ideal types.

where α_{ijl} represents the domestic type (high or low cost) of the intermediate link between i and j. Equation (5) simplifies in the following way:

$$\alpha_i \alpha_j \delta - \alpha_i \alpha_j \alpha_{ijl} \delta^2 = \alpha_i \alpha_j \delta \left(1 - \alpha_{ijl} \delta\right). \tag{11}$$

ii. In this cost range, the benefit of turning indirect links into direct ones do not justify the costs. Each connected player will have at least one direct link and derive additional benefit from indirect links without paying the costs of turning them into direct ones.

iii. In this range, pairwise stability precludes "loose ends", so every connected player will have at least two links.

□

The Center of Star-Shaped Networks

We can obtain an interesting extension of Proposition 1.iii by examining the conditions under which the star network's center takes the costly action $d = 1$ to improve its type. It can be shown algebraically that states will form a star network with a low cost state at the center when $c < \alpha_i \alpha_j \left(\delta - \delta^2\right)$, while the necessary condition for a network with a high cost state at the center is $c < \alpha_i \alpha_j \alpha_l \left(\delta - \delta^2\right)$ or simply $c < \alpha_i \alpha_j \alpha \left(\delta - \delta^2\right)$, since $\alpha_l = \alpha$ for this case. Since $\alpha < 1$, it follows that $\alpha_i \alpha_j \left(\delta - \delta^2\right) > \alpha_i \alpha_j \alpha \left(\delta - \delta^2\right)$. This means that when $\alpha_i \alpha_j \alpha \left(\delta - \delta^2\right) < c < \alpha_i \alpha_j \left(\delta - \delta^2\right)$, we will observe star networks with low cost centers, but not star networks with high cost centers. This can be restated as Lemma 1.

Lemma 1. *When $\alpha_i \alpha_j \alpha \left(\delta - \delta^2\right) < c < \alpha_i \alpha_j \left(\delta - \delta^2\right)$, we will observe star networks with low cost centers, but not star networks with high cost centers.*

Complete Networks

Lemma 2. *i. A necessary condition for an equilibrium consisting of a complete network of low cost states is $\sigma < (n-1)(1-\alpha)\delta$.*

ii. A necessary condition for a complete network of high cost states equilibrium is $\sigma > (n-1)(1-\alpha)\delta$.

Proof of Lemma 2.

i. In a complete networks of low cost types, no state can benefit by unilaterally playing $d = 0$ when:

$$U_i(1) - U_i(0) > 0; \tag{12}$$

$$U_i(1) = (n-1)\delta - (n-1)c - \sigma; \tag{13}$$

$$U_i(0) = (n-1)\alpha\delta - (n-1)c. \tag{14}$$

Substituting (13) and (14) into the left-hand side of (12), we obtain:

$$U_i(1) - U_i(0) = (n-1)(1-\alpha)\delta - \sigma.$$

Equation (12) holds when:

$$(n-1)(1-\alpha)\delta - \sigma > 0$$

or

$$\sigma < (n-1)(1-\alpha)\,\delta.$$

ii. In a complete network of high cost states, no state can improve its utility by unilaterally deviating to playing $d = 1$ when

$$U_i(d=1) - U_i(d=0) < 0; \tag{15}$$

$$U_i(d=1) = (n-1)\,\alpha\delta - (n-1)\,c - \sigma; \tag{16}$$

$$U_i(d=0) = (n-1)\,\alpha^{\delta} - (n-1)\,c. \tag{17}$$

Substituting (16) and (17) into the left-hand side of (16), we obtain:

$$U_i(d=1) - U_i(d=0) = (n-1)(1-\alpha)\,\alpha\delta - \sigma.$$

Equation (15) holds when:

$$(n-1)(1-\alpha)\,\alpha\delta - \sigma < 0$$

or

$$\sigma > (n-1)(1-\alpha)\,\alpha\delta.$$

□

Star Networks

Lemma 3 (Center of a Star)**.** *The center of a star-shaped network i_c plays $d = 1$, when $\sigma < (1-\alpha)(n-1)\,\alpha\delta$, and $d = 0$ otherwise.*

Proof of Lemma 3. The center of a star-shaped network i_c plays $d = 1$ when:

$$U_{i_c}(1) - U_{i_c}(0) > 0. \tag{18}$$

$$U_{i_c}(1) = k_d\delta + k_a\delta - (n-1)\,c - \sigma; \tag{19}$$

$$U_{i_c}(0) = k_d\alpha\delta + k_a\alpha^2\delta - (n-1)\,c. \tag{20}$$

Substituting (19) and (20) into the left-hand side of (18), we obtain:

$$\begin{aligned} U_{i_c}(1) - U_{i_c}(0) &= k_d\delta + k_a\delta - (n-1)\,c - \sigma - k_d\alpha\delta \\ &\quad - k_a\alpha^2\delta + (n-1)\,c = (1-\alpha)(k_d\delta + k_a\alpha\delta) - \sigma. \end{aligned}$$

Equation (18) holds when:

$$(1-\alpha)(k_d\delta + k_a\alpha\delta) - \sigma > 0$$

or

$$\sigma < (1-\alpha)(k_d\delta + k_a\alpha\delta)\,.$$

$\square$

Lemma 4 (Spokes of a Star). *When the link formation cost c allows for star-shaped equilibria:*

i. If the center of a star plays $d = 1$, the spokes play $d = 1$ when $\sigma < (1-\alpha)\left(\delta + \delta^2 (n-2)\right)$, and $d = 0$ otherwise.

ii. Stars with High Type spokes will never have a Low Type center.

Proof of Lemma 4.

i. If the center of a star playes $d = 1$, the spokes of a star play $d = 1$ when:

$$U_{i_v}(1) - U_{i_v}(0) > 0. \tag{21}$$

$$U_{i_v}(1) = \delta + (n-2)\,\delta^2 - c - \sigma. \tag{22}$$

$$U_{i_v}(0) = \alpha\delta + (n-2)\,\alpha\delta^2 - c. \tag{23}$$

Substituting (22) and (23) into the left-hand side of (21), we obtain:

$$\begin{aligned} U_{i_v}(1) - U_{i_v}(0) = \delta + (n-2)\,\delta^2 - c - \sigma - \alpha\delta \\ - (n-2)\,\alpha\delta^2 + c = (1-\alpha)\left(\delta + \delta^2 (n-2)\right) - \sigma. \end{aligned}$$

Equation (21) holds when:

$$(1-\alpha)\left(\delta + \delta^2 (n-2)\right) - \sigma > 0$$

or

$$\sigma < (1-\alpha)\left(\delta + \delta^2 (n-2)\right).$$

ii. If the center of a star plays $d = 0$, "vertices" of a star play $d = 1$ when:

$$U_{i_v}(1) - U_{i_v}(0) > 0. \tag{24}$$

$$U_{i_v}(1) = \alpha\delta + (n-2)\,\alpha\delta^2 - c - \sigma; \tag{25}$$

$$U_{i_v}(0) = \alpha^2\delta + (n-2)\,\alpha^2\delta^2 - c. \tag{26}$$

Substituting (25) and (26) into the left-hand side of (24), we obtain:

$$U_{i_v}(1) - U_{i_v}(0) = (1-\alpha)\left(\alpha\delta + \alpha\delta^2 (n-2)\right) - \sigma.$$

Equation (24) then holds when:

$$(1-\alpha)\left(\alpha\delta + \alpha\delta^2 (n-2)\right) - \sigma > 0$$

or

$$\sigma < (1-\alpha)\left(\alpha\delta + \alpha\delta^2 (n-2)\right).$$

Then, by lemma 3, we should observe a star with an high costs center and low costs spokes when:

$$(1-\alpha)(n-1)\alpha\delta < \sigma < (1-\alpha)\left(\alpha\delta + \alpha\delta^2(n-2)\right). \tag{27}$$

Inequality (27), however, can only hold iff:

$$(1-\alpha)(n-1)\alpha\delta < (1-\alpha)\left(\alpha\delta + \alpha\delta^2(n-2)\right). \tag{28}$$

Suppose (28) is true, then

$$(1-\alpha)(n-1)\alpha\delta - (1-\alpha)\left(\alpha\delta + \alpha\delta^2(n-2)\right) < 0.$$

By simplifying, we obtain:

$$\alpha(1-\alpha)\left(\delta-\delta^2\right)(n-2) < 0 \tag{29}$$

This is a contradiction, because $\alpha > 0$, $(1-\alpha) > 0$, $\left(\delta-\delta^2\right) > 0$, and $(n-2) > 0$ by definition, which means that (29) must be positive.

□

Lemma 5 (Homogeneous Star Networks)**.**

i. Star networks consisting of low type states only are possible when:

$$\sigma < (1-\alpha)\left(\delta + \alpha\delta^2(n-2)\right).$$

ii. Star networks consisting of high costs states are possible when $\sigma > (1-\alpha)(n-1)\alpha\delta$*.*

Proof of Lemma 5.

i. As shown in Lemma 3, the center of a star will play $d = 1$ when

$$\sigma_c < (1-\alpha)(n-1)\delta, \tag{30}$$

and the spokes of a star will play $d = 1$, when

$$\sigma_v < (1-\alpha)\left(\delta + \alpha\delta^2(n-2)\right). \tag{31}$$

One can see, however, that for all possible parameter values, $\sigma_c > \sigma_v$, which means that (30) is always satisfied when (31) is.

We can check this by subtracting (31) from (30).

$$\sigma_c - \sigma_v = (1-\alpha)(n-1)\delta - (1-\alpha)\left(\delta + \alpha\delta^2(n-2)\right)$$

By simplifying, we obtain:

$$\sigma_c - \sigma_v = \delta(1-\alpha)(n-2)(1-\alpha\delta).$$

Note that all of the terms in the above equation are positive: $\delta > 0$, $(1-\alpha) > 0$, $(n-2) > 0$, and $(1-\alpha\delta) > 0$.

This shows that (31) is the necessary condition for formation of stars consisting of low cost states.

ii. Analogously, a star consisting of high cost states is possible when neither its center no its spokes can gain by playing $d = 1$ or when

$$\sigma_c > (1-\alpha)(n-1)\alpha\delta \tag{32}$$

and

$$\sigma_v > (1-\alpha)\left(\alpha\delta + \alpha\delta^2 (n-2)\right). \tag{33}$$

We can show that $\sigma_c > \sigma_v$, which means that (33) is always satisfied when (32) is:

$$\sigma_c - \sigma_v = (1-\alpha)(n-1)\alpha\delta - (1-\alpha)\left(\alpha\delta + \alpha\delta^2 (n-2)\right)$$

By simplifying, we obtain:

$$\sigma_c - \sigma_v = \alpha(1-\alpha)\left(\delta - \delta^2\right)(n-2). \tag{34}$$

Since by definition $\alpha > 0$, $(1-\alpha) > 0$, $\left(\delta - \delta^2\right) > 0$, and $(n-2) > 0$, $\sigma_c - \sigma_v > 0$.

□

Circles

Lemma 6 (Circle Networks.)**.**

i. When n is odd, all states in a circle network will play $d = 1$ when

$$\sigma < 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-1}{2}}}{1-\delta}\right), \tag{35}$$

and $d = 0$ otherwise.

ii. When n is even, state i that is a part if a circle network plays $d = 1$ when $\sigma < 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-2}{2}}}{1-\delta} + \frac{1}{2}\delta^{\frac{n}{2}}\right)$, and $d = 0$ otherwise.

Proof of Lemma 6.

i. When n is odd, state i that is a part of a circle network plays $d = 1$ when:

$$U_i(d=1) - U_i(d=0) > 0. \tag{36}$$

Let us first derive state i's utility from playing $d = 1$ in circle networks, assuming that all other states play $d = 1$. Note that this utility is slightly different for circles made up of odd and even numbers of states n. For an odd number of states, the utility of playing $d = 1$ in a circle network is:

$$U_i(d=1) = 2\delta + 2\delta^2 + ... + 2\delta^{\frac{n-1}{2}} - 2c - \sigma = \sum_{k=1}^{\frac{n-1}{2}} \delta^k - 2c - \sigma.$$

This function can be transformed in the following way using the *geometric series* formula:[q]

$$U_i\left(d=1\right)=2\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)-2c-\sigma.$$

This simplifies to

$$U_i\left(d=1\right)=2\left(\frac{\delta-\delta^{\frac{n-1}{2}}}{1-\delta}\right)-2c-\sigma. \tag{37}$$

Analogously, we can show that the utility of playing $d=0$ (assuming all other players play $d=1$) is defined as:

$$U_i\left(d=0\right)=2\alpha\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)-2c. \tag{38}$$

Substituting (37) and (38) into the left-hand side of (36), we obtain:

$$U_i\left(d=1\right)-U_i\left(d=0\right)=2\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)-2c-2\alpha\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)+2c-\sigma.$$

This simplifies to

$$U_i\left(d=1\right)-U_i\left(d=0\right)=2\left(1-\alpha\right)\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)-\sigma. \tag{39}$$

Equation (36) then holds when:

$$2\left(1-\alpha\right)\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right)\sigma>0$$

or

$$\sigma<2\left(1-\alpha\right)\left(\frac{1}{1-\delta}-\frac{\delta^{\frac{n-1}{2}}}{1-\delta}-1\right).$$

ii. When n is even, if all other states play $d=1$, state i plays $d=1$ in a circle network when:

$$U_i\left(d=1\right)-U_i\left(d=0\right)>0. \tag{40}$$

$$U_i\left(d=1\right)=2\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-2c-\sigma; \tag{41}$$

$$U_i\left(d=0\right)=2\alpha\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-2c. \tag{42}$$

[q]According to the geometric series formula, $\sum_{n=0}^{\infty}x^n=\frac{1}{1-x}$, for $|x|<1$.

Substituting (41) and (42) into the left-hand side of (40), we obtain:

$$U_i\left(d=1\right)-U_i\left(d=0\right)=2\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-2\alpha\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-\sigma.$$

Equation (40) then holds when:

$$2\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-2\alpha\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right)-\sigma>0$$

or

$$\sigma<2\left(1-\alpha\right)\left(\frac{\delta-\delta^{\frac{n-2}{2}}}{1-\delta}+\frac{1}{2}\delta^{\frac{n}{2}}\right).$$

□

Appendix B Predictions

The game has a large number of equilibria (see Table ?? of appendix). This paper's interest in the relationship between indirect/direct links and type is best pursued by focusing on classes of equilibria rather than any equilibrium in particular. The cost of link formation, c, separates equilibria into several main classes distinguished by the shapes of the networks that form.[18] When the cost of link formation c is greater than the total direct and indirect benefits of forming any links, the equilibrium is an *empty* network—or a network in which no player is connected to any other player (see Figure 3.a).

As the cost of link formation, c, decreases, however, there is a threshold, c_c^*, at which actors are indifferent between forming an empty network or a *circle*—a network in which each actor has exactly two direct links (see Figure 3.b). In a circle network, the cost of link formation, c, is still greater than the benefit from any single direct link $\alpha_i\alpha_j\delta$, or $c > \alpha_i\alpha_j\delta$, yet this cost is made up by the additional benefits from the indirect links (recall that indirect links are free).

As the cost of link formation, c, decreases even further, it reaches the second threshold $c_b^* = \alpha_i\alpha_j\delta$, at which the cost of forming a link is made up by the benefit derived from this link. When the cost of link formation c is below this threshold, the equilibrium network configuration also depends on the difference in benefits between a direct and an indirect link or the relationship between c and $c_a^* = \alpha_i\alpha_j\delta - \alpha_i\alpha_l\alpha_j\delta^2$. When the difference in benefits is low or $c_a^* < c_b^*$, which means that the gain in benefits from forming a direct link rather than an indirect link does not outweigh the cost of link formation c, states predominantly rely on indirect links. Within this cost range of c, we will observe *star-shaped* equilibrium networks (Figure 3.c). A *star-shaped* or a *hub–and–spokes* network is a network in which all players are linked to one central player—*the hub*—and there are no other links: $g \subset g^N$ is a star if $g \neq \emptyset$ and there exists $i \in N$ such that if $jk \in g$, then either $j = i$ or $k = i$. State i is the center of the star. The star-shaped equilibria persist within the link formation cost range c, under which the benefits from direct links outweigh the cost of forming them, yet indirect links still yield greater net benefits than direct links (as indirect links are free).

Finally as the link formation cost, c decreases to $c \leq c_a^*$, the discounted benefits associated with indirect links no longer justify the "saving" in cost and all actors choose to form direct links to one another, which results in a *complete* network (Figure 3.d). A *complete* network or a *clique* is a network in which each player has a link to each other player: $g \subset g^N$ is a complete network if $\forall i \in g, j \in g : ij = 1$.

This can be summarized in Proposition 1.

Proposition 1 (See Table **??** of appendix)**.** *There exist threshold values of link formation cost c, such that:*

1. *when $c < c_a^*$, actors form a complete network;*
2. *when $c_a^* < c < c_b^*$, there exists an equilibrium in which actors form a star-shaped or a circle network;*[19]
3. *and when $c_b^* < c$, there exists an equilibrium in which actors form a circle or an empty network.*

Deriving predictions regarding the relationship between indirect/direct links and actor type requires variation in both actors' number of direct/indirect links and actor type choice: i.e. if number of links and type choice are constant among players, we cannot derive predictions about the

[18] Note that while this paper focuses on the symmetrical network shapes, other equilibria shapes are possible. See, for example, Jackson and Wolinsky (1996).

[19] Note that other equilibria, such as circles, are also possible in this cost range.

relationship of interest. Hence, I focus on a class of equilibria, to which I will refer as *heterogeneous equilibria* and define as equilibria, in which at least one actor makes a different type choice than all other actors. More formally, a heterogeneous equilibrium network has the property of $D_i \neq D_{-i}$ for at least one player i. The simplest example of a heterogeneous equilibrium is a star equilibrium, in which the center node plays $D = 1$, while the spokes play $D = \alpha$. As demonstrated in Table 3 of this appendix, such a network is an equilibrium when $\alpha^2\delta - \alpha^2\delta^2 < c < \alpha\delta$ and $(1-\alpha)\left(\delta + \alpha\delta^2 (n-2)\right) < \sigma < (1-\alpha)(n-1)\alpha\delta$.

Heterogeneous Equilibria

Within the link formation cost range of $c_a^* < c < c_b^*$ or, more precisely, $\alpha^2\delta - \alpha^3\delta^2 < c < \alpha^2\delta$, the game has n pure strategy star-shaped equilibria, in each of which one actor serves as the *center* of the star and others act as *spokes*. An interesting property that results from the asymmetry of this equilibrium class is that the center and the spokes obtain different payoffs, and hence have different incentive structures for their type decisions (see Figure 4). Specifically, the center of the star obtains the net benefit of:

$$U_c = (n-1)\left(\alpha^2\delta - c\right). \tag{43}$$

Actors located at the spokes of the star, in the meantime, obtain:

$$U_s = \alpha^2\delta + (n-2)\,\alpha^3\delta^2 - c. \tag{44}$$

This difference in utilities comes into play, because actors' type decision depends on the cost of *High Type*, σ, as actors will choose *High Type* when its cost σ is compensated by the additional benefits that can be accrued as a result of increasing one's own type α_i. The center player will choose *High Type* when:

$$\sigma \leq \alpha\delta\,(1-\alpha)(n-1) = \sigma_c^*. \tag{45}$$

A player located at the spoke, on the other hand, will choose *High Type* when:

$$\sigma \leq (1-\alpha)\left(\alpha\delta + \alpha^2\delta^2 (n-2)\right) = \sigma_s^*. \tag{46}$$

Since σ_c is always greater or equal to σ_s^*, star-shaped equilibria can be further grouped into three sub-classes, based on the values of σ. When $\sigma > \sigma_c^*$, all states will play *Low Type* (i.e., choose not to protect domestic human rights). As the cost of human rights protection, σ, decreases to $\sigma_s^* \leq \sigma \leq \sigma_c^*$, we will observe heterogeneous networks with a human rights protecting *High Type* center, but human rights abusing or *Low Type* spokes. As σ decreases and reaches the range of $\sigma \leq \sigma_s^*$, all actors will play *High Types*, independent of their position.

This can be summarized in Proposition 2.

Proposition 2 (See Table 3 of appendix)**.** *Within the range of link formation cost $c_a^* < c < c_b^*$, there exist threshold values of High Type cost σ, such that:*

1. *when $\sigma < \sigma_s^*$, the star-shaped equilibria will consist of High Types;*
2. *when $\sigma_s^* < \sigma < \sigma_c^*$, the star-shaped equilibria will consist of a High Type center and Low Types spokes;*
3. *and when $\sigma_c^* < \sigma$, the star-shaped equilibria (and all equilibria) will consist of Low Types.*

Type heterogeneity within star-shaped equilibria allows for deriving predictions on the relationship between actors' number of indirect links and type. More specifically, direct and indirect links to *High Types* yield higher utility to other players, which means that (1) in all equilibria, *High Type* states will have the same or higher direct degree, and (2) in equilibria that allow for heterogeneous types, *High Types* will have higher degree than *Low Types.*

Proposition 3. *Within the range of link formation cost $c_a^* < c < c_b^*$, High Type states have weakly higher direct degree.*

Proof of Proposition 3. Proposition 3 can be proven using a proof by contradiction. Suppose there is a pairwise stable network that consists of a *High Type* state H and a *Low Type* state L, so that L has a higher direct degree than H. States H and L will then either be unconnected (Figure 5) or connected (Figure 6).
Scenario 1. H and L are not connected (Figure 5):
For L to have a greater direct degree means that L has at least one direct link. This implies that the cost of link formation c must be at least less than $\alpha\delta$ (if L's direct link is a state of *High Type*). If $c < \alpha\delta$, however, then H and L can both increase their utilities by forming a link between themselves, hence this network is not pairwise stable—a contradiction.
Scenario 2. H and L are connected (Figure 6):
Let us check the type stability part of the equilibrium. State L will not deviate from its type choice $d = 0$ as long as its utility from $d = 0$ is greater than its utility from $d = 1$ or

$$\sigma > \delta (1 - \alpha) (n - 1) . \tag{47}$$

Analogously, H will not deviate from its regime decision $d = 1$ as long as:

$$\sigma < (1 - \alpha) \left(\alpha\delta + \alpha\delta^2 (n - 2)\right) . \tag{48}$$

Hence, this network is regime stable as long as there exists a range of σ, such that:

$$\delta (1 - \alpha) (n - 1) < \sigma < (1 - \alpha) \left(\alpha\delta + \alpha\delta^2 (n - 2)\right) . \tag{49}$$

Such a range exists if:

$$\delta (1 - \alpha) (n - 1) < (1 - \alpha) \left(\alpha\delta + \alpha\delta^2 (n - 2)\right) . \tag{50}$$

Dividing through by $\delta (1 - \alpha)$, we obtain:

$$n - 1 < \alpha + \alpha\delta (n - 2) , \tag{51}$$

or

$$\alpha > \frac{(n - 2) + 1}{\delta (n - 2) + 1}. \tag{52}$$

Since by assumption $0 < \delta < 1$, and $n > 2$ (since the network in Scenario 2 must have at least 3 actors), the numerator of the left-hand side of Inequality (52) is always greater than the denominator, which leads their ratio to be greater than 1. However, $\alpha < 1$, by assumption, which means that Inequality (52) will never hold. Hence, there is a contradiction. □

The intuition behind Proposition 3 is that, all else equal, any direct or indirect benefits that accrue from a trade link with a *Low Type* are discounted by α: conducting business in states with poor human rights practices or weak rule of law is associated with an efficiency loss. Thus, all else equal, when choosing between a *Low* and a *High Type* trade partner, any state will always prefer the *High Type* trade partner, irrespective of its own type. Or, in less technical language, states prefer to make a trade link with a state with more rather than less favorable domestic business climate.

Next, let us explore the relationship between an actor's number of indirect links and its incentive to play *High Type*—the central relationship of interest in this paper. The prediction linking the effect of indirect links is formulated in Proposition 4.

Proposition 4.

Actors with higher indirect degree have a weakly lower incentive to become High Type than states with lower indirect degree.

Proof of Proposition 4. In homogeneous equilibria (i. e. in equilibria, in which all actors play the same strategy), there is no variation in actor's network positions or payoffs. Hence, in homogeneous equilibria, there is also no variation in actors incentive to play *High Type*.

The proof will therefore focus on heterogeneous equilibria. Let us denote an actor's incentive to play *High Type* as I and assume that actor i plays *High Type* when $I_i \geq \sigma_i$, i.e. when the actor i's incentive for playing *High Type* is equal to or outweighs the cost of playing *High Type*.

Let us denote any link of the shortest path $l \geq 2$ as an indirect link, and let us denote actor i's number of direct links as k_i. Since an equilibrium network will always consist of at most one non-empty component Jackson (see Proposition 6.2 of 2008, 161), we can say that actor i will have $n - k$ indirect links. Then, within any heterogeneous equilibrium, an actor's incentive to play *High Type* will be at most:

$$I_i = (1-\alpha)\left(k_i\alpha\delta + (n-k_i)\,\alpha^2\sigma^2\right), \tag{53}$$

assuming that all indirect links are of the shortest path $l = 2$, and where $n = N - 1$, N is the total number of actors. Note that I_i increases with k_i and decreases with $n - k_i$, as k_i and $n - k_i$ act as weights on $\alpha\delta$ and $(\alpha\delta)^2$, and $\alpha < 1$, $\delta < 1$. Hence, an actor's incentive to play *High Type* increases with its number of direct links and decreases with its number of indirect links. □

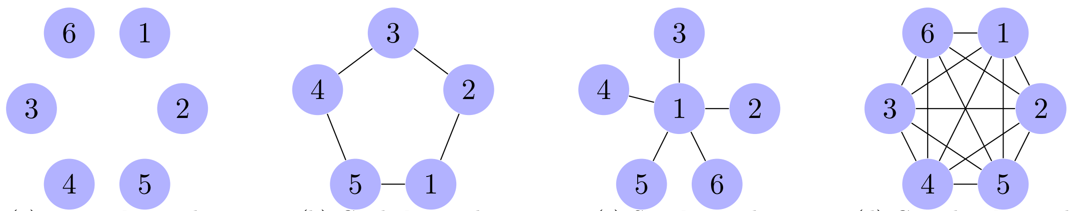
Proposition 4 is counter-intuitive. At first glance, it seems that increases of any type of trade partners—direct or indirect—would increase a state's incentive to choose *High Type*. The equilibria analysis, however, leads to the opposite prediction. The logic is that within the star equilibria, no player can increase its number of indirect links without decreasing its number of direct links. In fact, within the star equilibria, each player's numbers of direct and indirect links have a perfect negative correlation: the center has exactly $n - 1$ direct links and no indirect links, while each spoke has exactly 1 direct link and $n - 2$ indirect links. This relationship holds for a fixed number of players N, which ensures that that players cannot gain in indirect links without losing in direct links. This assumption is reasonable for the study of the international states, whose number remains roughly the same throughout the time-period covered in this paper.

In less formal language, states with less favorable business conditions intentionally select themselves into indirect trade relationships—relationships that, while yielding slightly lower trade benefits, also put less pressure on their domestic affairs, such as governments' commitment to respecting human rights or enforcing the rule of law. All else equal, indirect trade is a conscious choice and a viable alternative to states that do not wish to improve their domestic business conditions. States that choose indirect trade do this strategically, trading in the lost benefit associated with trading through an intermediary for the benefit of avoiding outside influences on their domestic affairs. While the Ukrainian government is well aware of the efficiency losses associated with conducting business through more reliable third parties, such as Cyprus or the Netherlands, it chooses to pay this calculated cost in the face of a larger cost associated with respecting human rights, enforcing domestic rule of law, lowering its corporate taxes, building up its administrative capacity, etc. States that rely on a larger number indirect trade relationships, moreover, have a lower incentive to invest in improving their domestic business conditions. Given the game equilibrium they are in, the cost of making domestic changes is too prohibitive and would not be offset by the resulting improvements in trade benefits. Hence, as the number of a state's indirect trade relationships increases, its incentive to play *High Type* goes down.

Table 3: Symmetrical Strong Nash Stability Equilibria at Varying Costs c and α.

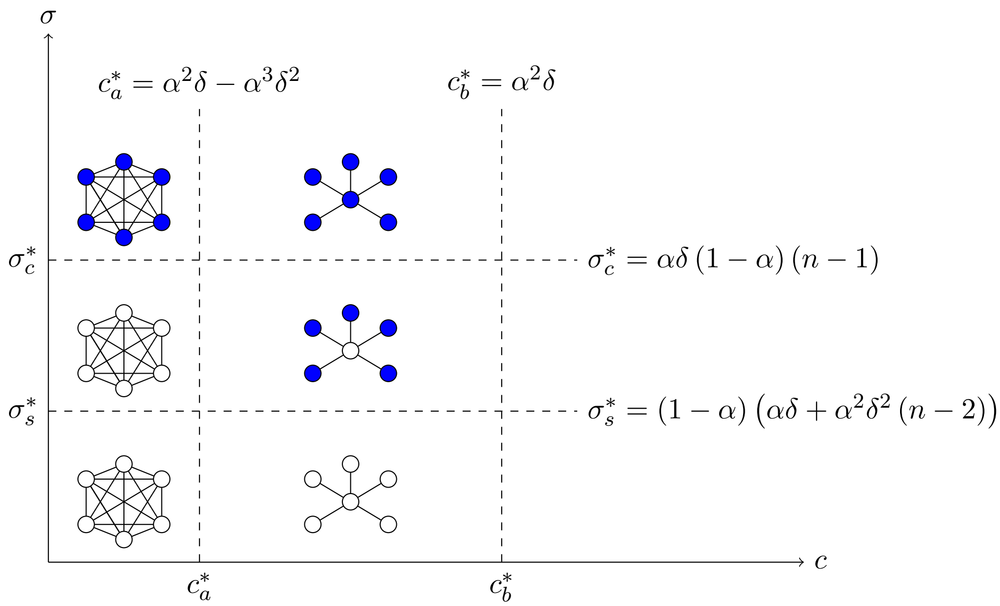
Link Cost c	Switching to *High Type* Price σ	Network Description
Complete Networks		
$c < \alpha^2\delta - \alpha^3\delta^2$	$\sigma > (1-\alpha)(n-1)\alpha\delta$ (Lemma 2.ii)	Complete network of *Low Type* states.
$c < \delta - \delta^2$	$\sigma < (1-\alpha)(n-1)\delta$ (Lemma 2.i)	Complete network of *High Type* states.
Star-Shaped Networks		
$\alpha^2\delta - \alpha^3\delta^2 < c < \alpha^2\delta$	$\sigma > (1-\alpha)(n-1)\alpha\delta$ (Lemmas 3–4, 5.ii)	A star consisting of *Low Type* states.
$\alpha^2\delta - \alpha^2\delta^2 < c < \alpha\delta$	$(1-\alpha)\left(\delta + \alpha\delta^2(n-2)\right) <$ $\sigma < (1-\alpha)(n-1)\alpha\delta$ (Lemmas 3–4)	A star with a *High Type* state at the center and *Low Type* spokes.
$\delta - \delta^2 < c < \delta$	$\sigma < (1-\alpha)\left(\delta + \delta^2(n-2)\right)$ (Lemma 5.i)	A star consisting of *High Type* states.
Circle Networks		
For odd n, $n > 4$: $\alpha^2\delta - \alpha^3\delta^2 < c < \frac{\alpha\left(\alpha\delta - (\alpha\delta)^{\frac{n-1}{2}}\right)}{1-\alpha\delta}$. For even n, $n > 4$: $\alpha^2\delta - \alpha^3\delta^2 < c < \frac{\alpha\left(\alpha\delta - (\alpha\delta)^{\frac{n-2}{2}}\right)}{1-\alpha\delta} + \frac{1}{2}\alpha^{\frac{n}{2}+2}\delta^{\frac{n}{2}}$ for even n.	For odd n and $n > 4$: $\sigma > 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-1}{2}}}{1-\delta}\right)$; for even n and $n > 3$: $\sigma > 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-2}{2}}}{1-\delta} + \frac{1}{2}\delta^{\frac{n}{2}}\right)$. (Lemma 6)	Circle network of *Low Type* states.
$\delta - \delta^2 < c < \left(\frac{\delta - \delta^{\frac{n-1}{2}}}{1-\delta}\right)$ for odd n, or $\delta - \delta^2 < c < \left(\frac{\delta - \delta^{\frac{n-2}{2}}}{1-\delta}\right) + \frac{1}{2}\delta^{\frac{n}{2}}$ for even n.	When n is odd and $n > 4$: $\sigma < 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-1}{2}}}{1-\delta}\right)$; when n is even and $n > 3$: $\sigma < 2(1-\alpha)\left(\frac{\delta - \delta^{\frac{n-2}{2}}}{1-\delta} + \frac{1}{2}\delta^{\frac{n}{2}}\right)$. (Lemma 6)	Circle network of *High Type* states.

Figure 3: Network Shapes



(a) Empty Network (b) Circle Network (c) Star Network (d) Complete Network

Figure 4: Complete and Star-Shaped Equilibria



Note: Blue nodes represent *Low Type* and white nodes represent *High Type* states.

Figure 5: Scenario 1. The Two Nodes are Not Connected

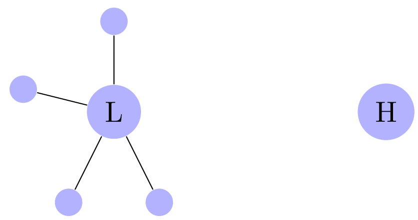


Figure 6: Scenario 2. The Two Nodes are Connected