Guns or Money? Defense Cooperation and Bilateral Lending as Coevolving Networks

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Abstract

How are defense cooperation and economic cooperation related? Research into this important question has focused primarily on trade and militarized conflict or, more relevantly, trade and military alliances. Yet, these approaches suffer from "apples to oranges" comparisons. Militarized conflict and defense pacts are both intergovernmental phenomena, monopolized by public actors, while trade is largely the realm of private economic actors. Furthermore, existing research is limited to bilateral relations, ignoring the more complex ways in which economics and defense influence one another. This paper introduces two broad innovations. First, we shift attention from trade and conflict to defense cooperation agreements (DCAs) and bilateral loans. Importantly, both DCAs and loans reflect deliberate governmental policies, which facilitates direct comparisons between the two. Second, we conceptualize DCAs and loans as "coevolving multiplex networks." We model not only the simultaneous bilateral relationship between DCAs and loans, but also more complex higher-order influences, where ties to third parties affect governments' willingness to sign defense agreements with, or make loans to, one another. Our analysis reveals that (1) defense and economic cooperation mutually increase the other, (2) countries that are highly active creditors in the loan network make for unattractive defense partners, (3) countries that borrow from the same creditors are more likely to cooperate in defense, and (4) governments tend to make loans to the same debtors as their defense partners. In light of significant changes in the international landscape, such as the rise of China and India as new creditors, this study refines our understanding of how governments wield the dual tools of defense and financial policy.

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In December 2001, the United States opened a military airbase at the Manas airport in Kyrgyzstan. Over the following decade, 5.3 million soldiers traveled through Manas on their way to or from Afghanistan. Yet, on February 19, 2009, the Kyrgyz parliament voted to close the airbase and evict US forces from the country. While immediate closure was averted, the US eventually vacated the base in June 2014. During the same period, Russia continuously operated the Kant airbase, also established in 2001 and located only about 50 kilometers from Manas. Not only was Russia allowed to retain use of Kant, but in December 2012 Kyrgyzstan renewed the lease for another 15 years.

Why did the Kyrgyz government evict the US but extend cooperation with Russia? Financial considerations may have played a role. On January 14 2009, just prior to the vote to close the US airbase, Kyrgyz officials informed the US Ambassador to Kyrgyzstan that Russia had offered the Kyrgyz government $2 billion in loans and $150 million in financial aid. And just prior to the renewal of the lease for Kant, Moscow agreed to void $500 million in Kyrgyz debt. Prior to these deals, Russia extended loans of $16 million in 1993, $48 million in 1997, and $241 million in 2009. In contrast, the US provided not a single loan during this period. Unsurprisingly, numerous commentators have suggested that the loan agreements were the primary reason for Kyrgyzstan's continued cooperation with Russia.[1]

This anecdote offers a microcosmic glimpse into longstanding questions about how economic and defense relationships interact. Questions about defense and economic cooperation have inspired substantial research, including the voluminous literature on trade and conflict (Schneider 2013). Of particular relevance to this project is the study of trade and alliances, which deals directly with the question of whether economic and defense relations are interdependent (e.g., Long 2003). Though this literature has yielded valuable insights, it has important limitations. Trade is carried out largely by private actors, while military alliances are intergovernmental agreements. Connecting these phenomena across levels of analysis requires nontrivial micro-level assumptions about interest groups, lobbying, and collective action. Further, existing models of trade and conflict do not sufficiently address the myriad endogenous influences that plague economic and defense ties. These

[1] See "Kyrgyzstan to shut US military base," *Financial Times,* 3 February 2009; "Kyrgyz MPs vote to shut US base," *BBC News,* 19 February 2009.

endogenous influences may be straightforward, as with reciprocal causation between bilateral trade and alliances (Long 2003). But they also may be highly complex, as both trade and alliances are themselves rife with statistical dependencies (Ward, Ahlquist and Rozenas 2013; Warren 2010).

Our analysis of economic and defense cooperation shifts attention from trade and alliances toward issue areas that reflect deliberate efforts by governments to synchronize their interdependence. Instead of trade, we focus on bilateral loans, which are sovereign loans made by one government to another. Bilateral loans are an overtly public form of economic cooperation that requires no assumptions about private actors. Indeed, they directly reflect governments' foreign policies. Instead of formal alliances, we focus on a new form of defense cooperation known as defense cooperation agreements, or DCAs. Governments rarely sign new alliances or activate existing alliances. DCAs, on the other hand, have proliferated dramatically since the end of the Cold War. Further, unlike alliances, DCAs are always active, as they manage the day-to-day military interactions of governments, such as defense policy coordination, joint exercises and training, weapons development and procurement, and exchange of classified information. DCAs especially emphasize emerging nontraditional security threats, such as transnational terrorism, trafficking, piracy, weapons proliferation, and cyberwar, which makes them highly relevant in the post-Cold War world. Focusing on phenomena at the level of intergovernmental relations allows us to compare "like to like" and avoid problematic assumptions about private actors.

How, specifically, are bilateral loans and defense cooperation connected? Do governments first provide bilateral loans then increase defense cooperation? Or are loans instead *post hoc* rewards for existing defense ties? Are there more complex influences than this simple bilateral logic suggests? To answer these questions, we treat bilateral loans and bilateral DCAs as global networks, where governments are the "nodes" in the networks and DCAs and loans are the "edges." We thus build upon growing recognition that international relations are best theorized and modeled as *network* relations (Cranmer, Desmarais and Kirkland 2012; Dorussen and Ward 2008, 2010; Ward 2006; Ward, Siverson and Cao 2007). Our approach assumes that these two networks "coevolve"—that is, the ties in one network influence, and are in turn influenced by, the ties in the other network. Throughout, we integrate network concepts with insights drawn from cooperation theory, formulating testable hypotheses at increasing levels of complexity. We advance three general claims. First, we argue that issue linkages and side payments generate bilateral *direct effects*, where governments are more likely to share a tie in the defense network if they also share a tie in the loan network, and vice versa. Second, moving to higher order dynamics, we argue that *positional effects* exist between the two networks, where governments that occupy "central positions" in one network—that is, they frequently make loans or sign DCAs—are less likely to form ties to prominent nodes in the other network. Third, at the highest level of complexity, we argue that common ties to third parties generate *informational effects*, which encourage cooperation by revealing information to potential cooperators about one's trustworthiness, creditworthiness, and value as a strategic partner.

We proceed in five parts. First, we review the scholarship on defense cooperation and economic interdependence. Second, we introduce a network-oriented theory of defense and economic cooperation, and we derive several testable hypotheses. Third, we introduce the data and discuss the inferential network model. Fourth, we discuss the empirical results. The fifth section concludes. We find strong evidence for both direct effects and informational effects, but only marginal support for positional effects. Overall, the results show not only that defense cooperation and economic cooperation are highly interdependent, but that they are interdependent in complex, nuanced ways.

1 Literature

Although bilateral lending and DCAs have received little scholarly attention, there exists a multifaceted literature on economic and security interdependence. Perhaps the most prevalent strain of this literature focuses on international trade and interstate conflict. Proponents of the so-called commercial peace argue that trade reduces conflict by increasing the opportunity costs of war and by providing states with novel avenues for signaling resolve (e.g., Hegre, Oneal and Russett 2010; Morrow 1999; Polachek and Xiang 2010; Russett and Oneal 2001; Schneider 2013). Scholars have extended these insights to foreign direct investment (FDI), arguing both that FDI reduces the probability of war (Lee and MItchell 2012; Polachek, Seiglie and Xiang 2007), and that conflict, in turn, reduces FDI (Li 2008; Nigh 1985; Schneider and Frey 1985)

However, militarized conflict is not an appropriate proxy for cooperation. Non-conflict may be the result of deliberate policy choices, but it may also be the result of inattention. Military alliances, in contrast, are deliberate efforts at cooperation. The narrower literature on trade and alliances thus holds special relevance to this project. The primary question of this literature is whether trade encourages alliances or whether, conversely, alliances promote trade. Employing multiple regression models, Mansfield and Bronson (1997) find that the presence of an alliance greatly increases bilateral trade flows but trade does not reciprocally increase the probability of an alliance. Additional studies by Gowa (1995), Gowa and Mansfield (1993, 2004), Long (2003), and Long and Leeds (2006), among others, reconfirm this basic finding. However, a handful of studies, such as Morrow, Siverson and Tabares (1998) and Fordham (2010), offer evidence that alliances in fact have little to no impact on trade. Ultimately, the question remains unanswered, as illustrated by recent contributions to the topic (Vijayaraghavan, Noél, Maoz and D'Souza 2015).

These existing approaches suffer from at least three weaknesses. First, while trade and investment are ubiquitous features of the global economy, they are only indirectly related to governmental policy. The vast majority of import, export, and investment is conducted by private actors. Indeed, trade often occurs despite prohibitory policies (Early 2009). In contrast, most security relations, including militarized conflicts and alliances, are monopolized by governments. In connecting private actors to public institutions, liberal theorists have relied on the microlevel assumption that economic actors lobby their governments for pacific policies (Hirschman 1980; Kirshner 2007; Levy 2003; McDonald 2009; Russett and Oneal 2001; Simmons 2003). Yet, as Brooks (2013) argues, that assumption is overly simplistic, as the preferences of firms must contend with the government's own preferences. Further, firms have an incentive to freeride on the lobbying of others, which raises the spectre of collective action problems.

We circumvent these complications by employing an explicitly public measure of economic interdependence: government-to-government loans. Like security policy, bilateral lending emanates directly from the government's foreign policy apparatus. Indeed, as we later illustrate, bilateral loans are inherently strategic, just as defense agreements are. Focusing on qualitatively similar forms of cooperation allows us to circumvent strong assumptions about the interests and activities of subnational actors and to more cleanly theorize—and empirically test—the influence of defense and economic relations on one another.

Second, formal military alliances do not sufficiently represent the scope of governments' foreign security and defense policies. Some alliances, such as the North Atlantic Treaty Organization (NATO), remain vitally important. However, the contemporary global security environment contains numerous nontraditional security threats, including transnational terrorism, human and weapons trafficking, cyberwar, proliferation of nuclear weapons, and maritime piracy, among others. Traditional military alliances focus on interstate military threats; they are not designed to address emerging nontraditional threats. Governments are acutely aware of these limitations. For example, the French government considers all eight of its defense pacts with African countries to be virtually obsolete.[2] The mutual defense provisions are especially troublesome, with one French presidential advisor noting that, "If France is attacked, are we really going to expect, much less rely on, Togo to go to war with whoever attacks us?" African governments appear to be receptive to innovations in their defense relations. In 2008, Comoros' Army chief of staff argued that the defense treaty with France should be scrapped in favor of a pragmatic agreement on "training and exchange programs."[3]

Defense cooperation agreements (DCAs), a new form of defense cooperation, coordinate and institutionalize governments' routine, day-to-day defense relations. For example, a 2011 DCA between the US and Brazil "promote[s] cooperation in [...] research and development, logistics support, technology security, and the acquisition of defense products and services," as well as"information exchanges, combined military training and education, joint military exercises, exchanges of students and instructors, naval ship visits, and defense-related commercial initiatives."[4] A 2006 DCA between France and India ambitiously states that it "shall establish a framework which aims to cover all cooperation activities conducted by the Parties in the field of defence."[5] While DCAs

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2 The agreements are with Cote d'Ivoire (signed in 1960), C.A.R. (1960), Djibouti (1977), Gabon (1960), Senegal (1960, revised 1974), Cameroon (1960, revised 1974), Comoros (1973, revised 1978), and Togo (1963).

3 "France's changing Africa policy: Part III (Military Presence and other Structural Changes)," *U.S. Embassy in France*, September 9, 2008.

4 "Fact Sheet: US-Brazil Defense Cooperation," United States Department of Defense, March 14, 2011.

5 *Agreement between the Government of the French Republic and the Government of the Republic of India on Defence Cooperation*, signed February 20, 2006, New Delhi.

vary in structure, they commonly address defense policy coordination, joint exercises and training, defense-related research and development, weapons acquisition and procurement, and exchange of classified information. To achieve these goals, DCAs typically require signatories to establish committees and working groups, and to draft annual cooperation plans.[6]

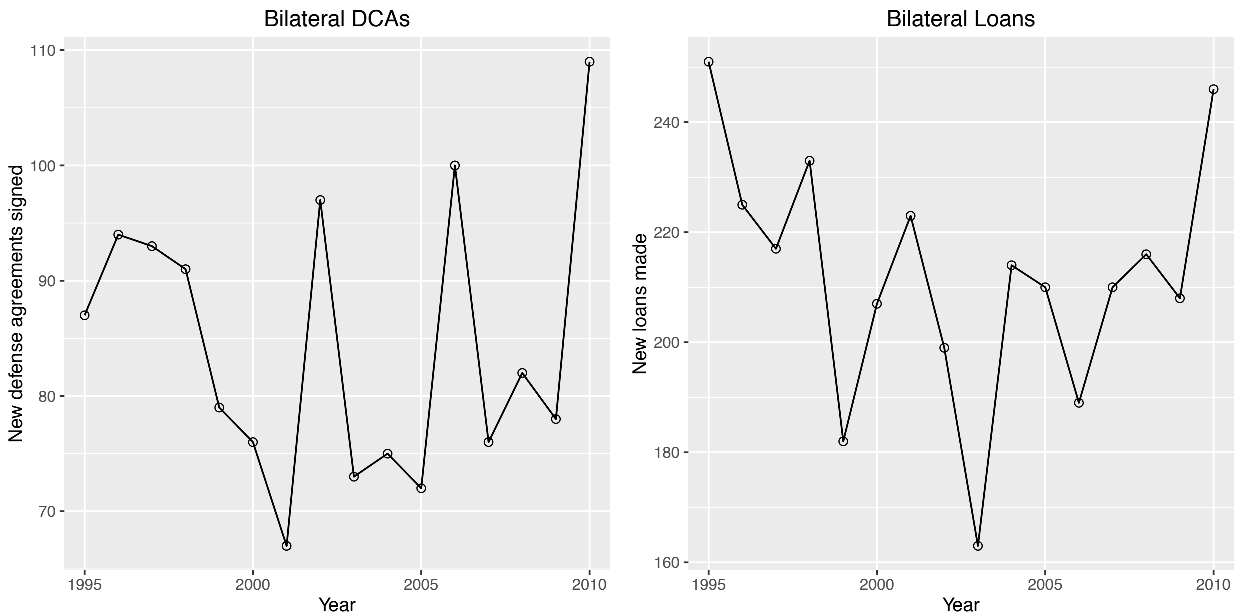
Importantly, DCAs are not alliances. They involve no mutual defense commitments. Indeed, alliances are neither sufficient nor necessary for DCAs. (The correlation between alliances and DCAs is typically < 0.2.) DCAs have been signed between such diverse partners as Indonesia and Turkey, South Africa and Liberia, and Argentina and Russia. DCAs tend to be highly symmetric, employing neutral language (e.g., "the Parties") in lieu of proper nouns. They are also long-term arrangements. Among those DCAs with a stated duration, the median length is six years. Many DCAs are indefinite.

Figure 1 illustrates trends in DCA formation and bilateral lending over the 1995-2010 period. DCAs proliferated consistently over this period, with especially pronounced spikes in 2002, 2006, and 2010. Bilateral lending experienced an unsteady decline during the 1990s and early 2000s, but has now returned to 1995 levels. Currently, governments are highly active in both of these areas.

Third, the empirical models typically used to explore economic-defense relations do not adequately address the complex endogenous relationships that pervade these data. Endogeneity takes multiple forms. Reciprocal causation is a well-known concern in both the study of trade and conflict and in the study of trade and alliances (e.g., Davis 2004; Keshk, Pollins and Reuveny 2004; Kim and Rousseau 2005). Simultaneous equations are the most commonly used method for disentangling two-way relationships, but the results of these models are inconsistent and sensitive to model specification (Bussmann 2010; Hegre, Oneal and Russett 2010). More importantly, these approaches are limited to narrowly defined bilateral endogeneity. In practice, economic and defense relations exhibit complex endogeneities. For example, models of international commerce show that the level of trade between a given pair of countries depends upon levels of trade throughout the global trade network (Ward, Ahlquist and Rozenas 2013). Similarly, countries form military alliances in

[6] Formally, DCAs are "framework" agreements; i.e., they outline the broad contours of cooperation but leave specific details—e.g., training programs, weapons contracts, policy coordination—to subsequent protocols and implementing arrangements. See Matz-Lück (2009).

Figure 1: Trends in Bilateral Defense Cooperation and Lending, 1995–2010



Note: Left-hand panel illustrates number of new DCAs signed annually. Right-hand panel illustrates number of new loans made annually.

response to the alliance activity of others (Warren 2010). We anticipate similar endogeneity issues in the DCA and loan networks. Empirically modeling these type of influences requires appropriate methodologies.

2 Theory

We first discuss the reciprocal bilateral effects of loans and DCAs. We then discuss positional effects, where the status of a country in either the loan or DCA network affects that country's ties in the other network. Finally, we consider higher-order informational effects, where governments use their financial and defense ties to glean information about future partners.

2.1 Direct effects

Bilateral loans increase the probability of defense cooperation. Government-to-government loans increase the probability of defense cooperation in at least two ways. First, bilateral loans are a type of *side payment.* According to Davis (2008), "side payments [are] the subset of positive sanctions in which there is asymmetric economic gain for one side. Aid and loans are a clear example." As a unidirectional transfer, side payments do not involve an immediate return, but they nonetheless aim to transform the preferences of the recipient. As Kahler and Kastner (2006) note, "countries deploy economic links in the hopes that economic interdependence itself will, over time, change the target's foreign policy behavior."

Side payments are a common means of alliance building (Long and Leeds 2006; Papayoanou 1999), and this practice also extends to loans and defense agreements. For example, in describing a high-level 2007 meeting between the Japanese and Indian governments, the US embassy in Japan stated that Japans's prime minister, Shinzo Abe, would "announce the provision of a 600 billion yen ($5 billion) loan over five years to help facilitate the construction of a 2,800 kilometer high-speed freight railway linking Mumbai, Delhi and Kolkata," while at the same time discussions of the security relationship between Japan and India would be discussed "only in general terms," with the goal of confirming that "India and Japan share the same intentions with regard to naval and other military cooperation."[7] While the Japanese loan is a one-way transfer, it comes with the hope of shaping India's preferences toward future defense cooperation. Similarly, the US embassy in the United Arab Emirates observed that a proposed $270m loan from the UAE to Oman loomed over discussions on security cooperation between the two countries, with government representatives frequently meeting to "discuss the two countries' future security cooperation and other bilateral issues." The embassy further noted that "[t]he UAE sees the relationship with Oman as one of its primary strategic relationships. Together, they could have a strong influence on the stability and security of the region."[8]

[7] "Weakened Prime Minister Abe To Visit India, Indonesia, Malaysia," *US Embassy in Japan*, August 15, 2007.

[8] "UAE, Oman discuss common security concerns, development assistance," *U.S. Embassy in the United Arab Emirates*, December 15, 2003.

Second, bilateral loans may influence defense cooperation through *issue linkage*, defined as the simultaneous discussion of two issues for joint settlement (Sebenius 1983). In bargaining, issue linkage can create new zones of agreement and increase opportunities for mutual gain (Davis 2004; Fearon 1998; Koremenos 2001). As Putnam (1988: 446) observed, "The possibility of package deals opens up a rich array of strategic alternatives for negotiators." Economic linkages are commonly used to encourage defense cooperation (Long and Leeds 2006). With regard to alliances, Davis (2008) observes that "one ally uses the special security relationship to justify a demand for better economic outcomes, and the other ally may offer a concession to avoid negative spillover from an economic dispute that could harm the security relationship."

A 2003 loan negotiation between the US and Turkey offers an in-depth example. In its appeal for financial support from the US, the Turkish government drew an explicit connection to the security relationship, as noted by the US embassy in Ankara:

> Turkey believes that we cannot divorce the security cooperation program from broader concepts of economic support/strategic alliance. The Turkish view is that modernization and related programs are not just business, but are critical investments in the common strategic interest. Turkish expectations about US economic support remain high.[9]

The prospect of increased security cooperation appealed to the US, which was preparing military action in neighboring Iraq. The subsequent draft loan agreement directly incorporated security provisions, with the intention that the loan facility would "help the Republic of Turkey maintain confidence, support the Turkish economy, and contain and offset the economic impact of a conflict in Iraq."[10] The Erdogan government intended to submit an authorization for US troops to the Turkish parliament, which would then "unlock a very sizable US package to include the $8.5 billion bridge loan."[11] An unexpected delay in the troop authorization led a US official to reassuringly

[9] "Joint Chiefs of Staff Visit to Turkey: Domestic and Regional Political Issues, Economic Situation, and Security Assistance," *US Embassy in Turkey*, January 16, 2003.

[10] "Draft Term Sheet for Turkey Grant/Loan Facility ," *US Embassy in Turkey*, February 8, 2003.

[11] "Turkish Economy COB 3/18: Return to Never Never Land; Central Bank Governor's Concerns," *US Embassy in Turkey*, March 18, 2003.

Figure 2: Anticipated Bilateral and Degree Effects

(a) Effect of loans on DCAs

(b) Effect of DCAs on loans

Note: Actor i is the potential "initiator" of cooperation; j is the respective target; and k represents third parties. Solid red line indicates a loan in force. Solid black line indicates a DCA in force. Dashed red lines indicate potential loans. Black dashed lines indicate potential DCAs. Thickness of dashed lines indicates probability of tie creation.

clarify that "military and economic cooperation have always been part of the loan package."[12]

While the above example illustrates the effect of issue linkage on bargaining, issue linkage can also improve enforcement over time. Even when cooperative outcomes are collectively beneficial, governments often face incentives to defect (Fearon 1998). Enforcement linkages reduce these incentives (Stein 1980). For example, a partner that reneges on a defense commitment may face retaliation in the form of canceled loan disbursements. An explicit quid pro quo ensures that collaborators keep the bargain (Kahler and Kastner 2006). Leeds and Savun (2007) find that security alliances are less likely to be opportunistically terminated when they include economic provisions, while Poast (2013) finds that alliances that include economic provisions experience fewer territorial integrity violations.

In general, we anticipate that enforcement linkage exerts less of an influence than either side payments or bargaining linkage, as we do not find extensive evidence of enforcement-oriented linkage in the texts of DCAs and loan agreements themselves. Nonetheless, some loans do appear to encourage enforcement. For example, the draft loan agreement between the US and Turkey states that if the latter does not fully cooperate with the US on military matters, the US will "suspend

[12] "Ankara Media Reaction Report," *US Embassy in Turkey*, August 28, 2003.

[...] Turkey's right to obtain disbursements" and may terminate the loan facility itself.[13] Further, linkages may be *implicit*, meaning that "states agree to link agreement on separate issues," but, rather than sign a single agreement covering multiple issues, they instead "sign individual treaties for each issue" (Koremenos 2001: 770). Implicit linkages may or may not be publicly acknowledged.

Side payments and issue linkage should generally increase the probability of defense cooperation. Figure 2(a) illustrates the anticipated relationship. Consider a hypothetical scenario where i must choose between two potential DCA partners. Ceteris paribus, if i and j share a loan tie (illustrated by the solid red line), the probability of a corresponding DCA tie should be higher (illustrated by the larger dashed black line).

> **Hypothesis 1** *Governments are more likely to sign DCAs with countries to which they have bilateral loan ties*

Defense cooperation increases the probability of bilateral loans. Simultaneously, we expect existing defense cooperation to increase the probability of a bilateral loan. Governments have long used economic relationships to enhance the capacity of their allies and thereby strengthen those allies' contributions to mutual defense. Gowa and Mansfield (1993) argue that the security externalities generated by free trade—such as increased efficiency, which "frees economic resources for military uses"—compel states to focus trade relations on allies rather than potential adversaries. Empirical work generally confirms these predictions (Gowa and Mansfield 2004; Long 2003; Mansfield and Bronson 1997; Morrow, Siverson and Tabares 1998; Poast 2012; Skålnes 2000).

While DCAs do not address mutual defense, states nonetheless sign them in the hope of improving their defense capacities. For example, US Secretary of Defense Leon Panetta argued that "networks of cooperation with emerging partners" help to "ensure collective capability and capacity for securing common interests" (Panetta 2012: 2). Panetta's predecessor, Robert Gates, similarly asserted the need for "cooperation across a range of [...] issues to ensure that with our combined military capabilities, we'll be ready to address the new security challenges in the years to come."[14] Bilateral

[13] "Draft Term Sheet For Turkey Grant/Loan Facility," *US Embassy in Turkey*, February 8, 2003.

[14] "US Department of State: Remarks At the Australia-United States Ministerial," in *M2 Presswire*, November 8,

loans are a key strategy for contributing to defense capacity. On the demand side, the economic development spurred by loans generates domestic demands for higher security, incentivizing loan recipients to participate more deeply in security cooperation. On the supply side, economic development increases revenues, technological standards, and organizational abilities, which filter into defense spending, allocations to military research, and military readiness.

Historical evidence suggests that governments take these complementarities seriously. In a 2014 speech on US-India cooperation, Secretary of Defense Chuck Hagel explicitly connected financial and military cooperation, first asserting that US-India cooperation "is critical for sustained peace and prosperity," then arguing that "[i]ncreased investment towards defense industrial partnership with India is the way of going forward" and, further, that "a robust defense partnership and joint military capabilities" would be "the cornerstone of [the] Indo-U.S. relationship."[15] Governments often tie defense cooperation to loans specifically. In 2010, in a stated effort at "strengthening and deepening" their strategic partnership, Pakistan and China issued a joint statement in which they mutually "agreed to step up personnel training, joint exercises, training and cooperation for national defense, science and technology, and collaboration in defence production," while China separately committed to "provide 100 million US Dollars in preferential loans and 300 million US Dollars in preferential buyers credit for projects of great importance to Pakistan."[16] Similarly, recognizing the need to modernize its military relations toward African governments, France in 2008 extended to Suriname loans for law-enforcement projects involving "intensified technical cooperation on border security, setting up a firefighting/first-aid rescue unit in Albina, and English and French language courses for law enforcement officials working on security cooperation."[17] In short, governments use loans, in part, to strengthen their defense partners.

A second mechanism connecting DCAs to bilateral loans involves the same issue linkages discussed earlier, but with the direction of causality reversed, such that the need for defense cooperation encourages linkages to financial cooperation. For example, in 2009 the US embassy in Beijing

2010.

[15] "Hagel Supports India's Larger Footprint in Region," in *New Indian Express*, August 9, 2014.

[16] "Pakistan, China resolve to consolidate strategic ties," in *Frontier Post*, December 20, 2010.

[17] "National Interest Fuels French Expansion Of Development Aid To Suriname," *US Embassy in France*, January 30, 2008.

reported that military cooperation between China and Russia enabled a massive $25 billion loan-for-oil deal. Reportedly, "China had agreed to the deal partly for political reasons," and "the military's support for the deal had weighed heavily in the central government's decision to move forward with it."[18] In a similar example, in 2002 Russia tied security cooperation with Vietnam to financial incentives, linking agreements on law enforcement and border defense to a subsequent loan for construction of hydroelectric plants in Vietnam's central highlands.[19]

Both mechanisms—increasing the capacity of defense partners and linking defense partnerships to subsequent loans—increase the probability of bilateral loans. Figure 2(b) illustrates this anticipated relationship. Ceteris paribus, faced with a choice between two partners, i is more likely to extend a loan to its DCA partner, j_1, than to j_2.

Hypothesis 2 *Governments are more likely to extend loans to governments with which they have defense agreements*

2.2 Positional effects

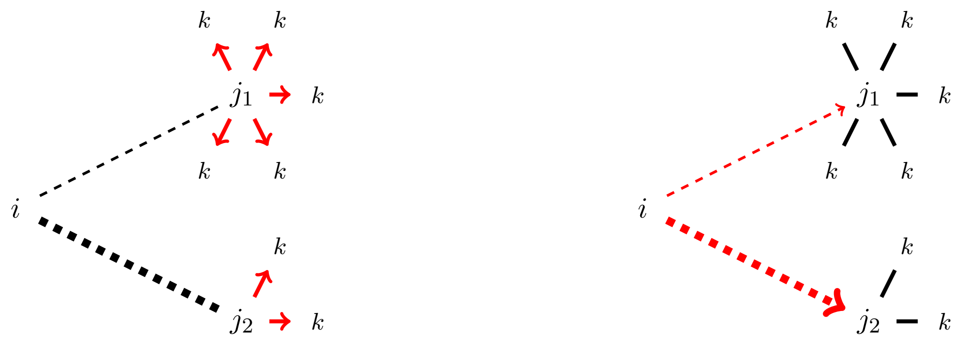
The discussion thus far has focused on financial and defense ties at the bilateral level. However, the network approach allows us look beyond bilateral relations. Here, we consider positional effects. Some countries are highly active in DCA creation, which gives them central positions in the DCA network. Others are highly active as either creditors or debtors, which gives them central positions in the loan network. How does a country's position in one network influence its ties in the other?

Active creditors are unattractive defense partners. Governments must choose defense partners wisely. Although DCAs do not impose mutual defense commitments, they nonetheless involve defense policy coordination, defense-related research and development, exchange of classified information, and other sensitive issues. Further, DCA partners do not merely agree to cooperate sporadically, when mutual threats materialize, but routinely. For all these reasons, DCA partner-

[18] "China/Russia: Strange Bedfellows Or Strategic Partners?" *US Embassy in China*, April 28, 2009.

[19] "Vietnam-Russia: Strong but 'pragmatic' relationship," *US Embassy in Vietnam*, November 8, 2002.

Figure 3: Anticipated Bilateral and Degree Effects



(a) Effect of lending activity on DCAs (b) Effect of DCA activity on loans

Note: Actor i is the potential "initiator" of cooperation; j is the respective target; and k represents third parties. Solid red lines indicate loans in place. Solid black lines indicate DCAs in force. Dashed red lines indicate potential loans. Black dashed lines indicate potential DCAs. Thickness of dashed lines indicates probability of tie creation.

ships require trust (cf. Kydd 2005). In an information-scarce environment, a government's various foreign relations provide insight into trustworthiness and reliability.

We argue that, all else equal, governments *avoid* signing DCAs with highly active creditors, for two reasons. First, active creditors exhibit diffuse political commitments. Loans are not merely financial instruments. Rather, they are deployed strategically, in order to exercise political influence (Bunte and Kinne 2015). A highly active lending portfolio suggests that a government has complex strategic interests, which generates uncertainty about intentions and raises issues of trustworthiness. Governments prefer defense partners that are not stretched thin by their global activities. Second, and relatedly, defense cooperation may be undermined by overzealous lending by DCA partners. For example, the US is frequently frustrated by the financial activities of such long-time allies as Saudi Arabia, Turkey, and Egypt. Governments prefer not to enhance the capacity of an adversary, directly or indirectly (Hufbauer, Schott and Elliott 1990). At the very least, providing economic benefits to adversaries sends mixed signals (Skålnes 2000). All else equal, highly active creditors increase the potential for conflicts of interest between military and financial goals.

Figure 3(a) illustrates our empirical expectation. As j's lending activity increases, i becomes increasingly uncertain of j's commitment to defense cooperation and increasingly concerned that

j's lending activities may ultimately help i's own adversaries, thus reducing the value of a specific ij DCA tie.

Hypothesis 3 *Governments avoid DCA partners that are highly active creditors in the loan network*

Frequent DCA participants are unattractive debtors. Similarly, countries that occupy central positions in the defense network—i.e., by virtue of signing many DCAs—are less likely to receive loans. Figure 3(b) illustrates this empirical expectation, where a creditor i is more likely to lend to a government with few DCAs (j_2) than to a government with many DCAs (j_1). As noted above, governments use loans strategically, as a way of "purchasing" political influence. From the perspective of a potential creditor, countries with large, diverse DCA portfolios are, ceteris paribus, less open to influence; the creditor's ability to exercise leverage declines proportionally to the debtor's defense commitments. As Aristotle famously observed, "A friend to all is a friend to none." Further, from the debtor j_1's perspective, the logic of H2 implies that each of j_1's third-party defense partners, k, are better sources of loans than an otherwise untested partner. In short, both supply-side and demand-side influences reduce the probability of loans to countries that are highly active in the DCA network.

This expectation is consistent with the long-standing observation that large, influential countries, such as net creditors, prefer partners they can exercise influence over (Keohane 1969). For example, in a 2009 report on Japan-Indonesia relations, the US embassy in Tokyo observed that Japanese officials "see Indonesia as taking a cautious approach to China, in contrast to other ASEAN members, particularly those in the Mekong region, which seem to be falling under China's orb of influence." Motivated in part by this spurning of Chinese influence, "Japan gives Indonesia a number of loans," totaling "roughly 120.5 billion yen [...] to promote economic and social reform" and "to support various social development projects in areas such as urban flood control, dam preservation, mass transportation, and electrical power."[20] A similar logic motivates the US partnership with Thailand, which, in the view of the US embassy in Bangkok, "preserves political and economic security

[20] "Japan Placing Importance On Ties To Indonesia," *US Embassy in Japan*, May 11, 2009.

in the region and maintains a leading US role in Thailand and Southeast Asia." US loans to Thailand thus help maintain US influence, despite "increasing competition in this regard from China."[21] This logic yields a straightforward hypothesis:

Hypothesis 4 *Governments avoid loan partners that are highly active in the DCA network*

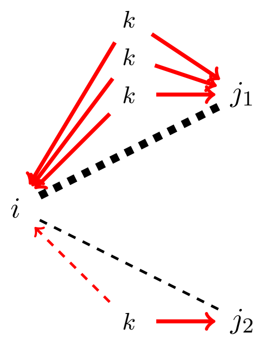
2.3 Informational effects

H3 and H4 move beyond purely bilateral considerations, but they do not exhaust the complexity of ways in which DCAs and loans influence one another. For example, positional effects consider the possibility that an $i \rightarrow j$ bilateral loan depends on j's DCA partnerships with k third parties, but they do not consider the possibility that i may have defense ties to those same k third parties. Indeed, if a debtor's defense partners are the same as the creditor's, third-party ties may increase rather than decrease the probability of a direct bilateral tie. Growing research shows that international relations data are rife with third-party effects (e.g., Cranmer, Desmarais and Kirkland 2012; Kinne 2013; Ward, Siverson and Cao 2007). In the case of loans and DCAs, third-party ties provide governments with strategically valuable information about the risks and benefits of partnering with some governments over others.

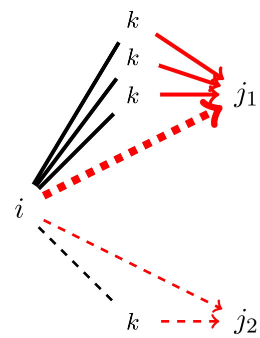
Similar loan portfolios reflect shared interests. We first consider DCAs as the dependent variable. How might a given i and j's mutual financial ties to k third parties affect their probability of bilateral defense cooperation? Figure 4(a) illustrates *borrowing similarity*, where receiving loans from the same k third parties makes i and j more likely to sign a defense agreement (as reflected by the thicker dashed black line). Defense cooperation requires trust, and lending and borrowing portfolios reveal information about trustworthiness. Creditors deploy loans strategically. Other governments know this fact. Creditors worry about default and about the political alignment of their financial partners. A bilateral loan thus acts as a "stamp of approval." A debtor that turns

[21] "Foreign Minister Kasit's Visit to Washington," *US Embassy in Thailand*, April 20, 2009.

Figure 4: Anticipated Closure and Similarity Effects



(a) Borrowing similarity



(b) Mixed DCA closure

Note: Actor i is the potential "initiator" of cooperation; j is the respective target; and k represent third parties. Solid red lines indicate existing loans; red dashed lines indicate prospective loans. Solid black lines indicate existing DCA agreements; dashed black lines indicate prospective DCAs. Thickness of dashed lines corresponds to probability of tie creation.

to China or Russia for credit exhibits different political commitments than a debtor that turns to the US, UK, or Germany. An overlap between i's and j's respective borrowing portfolios thus suggests a compatibility of interests. Employing a similar logic, Gray (2013) argues that "the company states keep" is important to third-party governments; that is, associating with reputable partners generates positive spillover effects. Similarly, Brooks, Cunha and Mosley (2014) show that professional investors use information about a potential recipient's peer group as a decision-making shortcut. And Kinne (2013) finds that when governments increase their ties to third parties, trust also increases, which encourages further bilateral cooperation. Thus:

Hypothesis 5 *Countries with similar borrowing portfolios are more likely to sign DCAs*

Defense partners lend to the same third parties. Finally, we consider bilateral loans as the dependent variable. We focus on mixed DCA-related closure, illustrated in Figure 4(b). Specifically, we anticipate that as loans from i's defense partners, denoted k, to a j debtor increase in number, the probability of i extending a loan to j also increases. A government's DCA partnerships reflect its foreign-policy alignments. For example, a 1994 DCA between Lithuania and Denmark was described by the latter's defense minister as an attempt to "push [...] Lithuania nearer to Western Europe."[22] Similarly, following a massive 2010 DCA between the US and Brazil, a Brazilian security analyst observed, "With this accord Brazil is aligning itself strategically with the US, like the European nations have done with NATO."[23] In short, a country's DCA partners—i.e., the k nodes in Figure 3(b)—constitute its global peer group, or the cluster of countries with which its foreign policy most closely aligns.

The foreign relations of one's own defense partners provide valuable information. As with DCAs, trust issues plague financial cooperation. Creditors wish to avoid debtor default, which may occur for either economic or political reasons. A debtor's *capacity* to repay is not always commensurate with its *willingness* to repay (Reinhart and Rogoff 2009; Tomz 2007). Even when a debtor has sufficient resources to service its debts, political pressures may encourage diversion of those resources to domestic programs. Since the probability of repayment is ultimately unobservable, the lending practices of trusted collaborators—in this case, DCA partners—provide insight into a potential borrower's reliability (Bunte and Kinne 2015).

Further, as argued in H2, governments use loans to improve their partners' defense capacity. Extending this logic, improving the capacity of the *partners of one's partners* increases overall levels of defense cooperation and leads to synergies and beneficial security externalities (Cranmer, Desmarais and Kirkland 2012). Indeed, defense partners often target their bilateral loans toward the same third parties. In Africa, for example, France and the US have coordinated in "supporting host country counterterrorism efforts," combining "discussions of military cooperation [and] enhanced intelligence sharing" with "complementary development assistance."[24] Coordinated efforts by the US and Japan in the 1980s to boost South Korea's defense capacity provide an even starker example. The US and Japan share close defense ties, and, at the same time, the US has a history of lending to South Korea. In 1983, Japan's prime minister signed a $4 billion loan to South Korea, engaging in precisely the sort of defense-oriented closure illustrated in Figure 3(b). Tellingly, North

[22] "Lithuania and Denmark Sign Military Cooperation Agreement," *BBC Monitoring Service: Former USSR,* March 19, 1994.

[23] "Why Brazil Signed a Military Agreement with the US," *Christian Science Monitor,* April 13, 2010.

[24] "AFRICOM Commander's Discussions With French Officials on al-Qa'ida In The Islamic Maghreb And Other Africa Security Threats," *U.S. Embassy in France*, January 11, 2010.

Korea condemned the move—and the subsequent visit to Japan by South Korea's president—as a "ruse to strengthen a 'triangular' alliance between Japan, South Korea and the United States."[25] Thus:

Hypothesis 6 *Creditors are more likely to lend to their defense partners' debtors*

3 Data and Research Design

The DCA data are drawn from (1) the United Nations Treaty Series (United Nations Treaty Collection 2012) and World Treaty Index (Bommarito, Katz and Poast 2012); (2) individual country publications, gazettes, and treaty series; and (3) global news archives (Kinne 2016). The DCA network is operationalized as a $T = 16$ stack of binary matrices, covering the period 1995–2010,[26] where an $x_{ij,t} = 1$ entry in a given $\mathbf{x}_t$ DCA network indicates that a DCA has been signed between i and j in either the current year or the prior four years. We use this five-year window primarily because the durations of many DCAs are not known precisely. Of those agreements with a known duration (i.e., where full treaty texts are available), over 90% endure for at least five years. Many DCAs are indefinite. The five-year window is thus conservative. Insofar as DCAs influence loans beyond five years, the model will underestimate the true strength of these effects, which biases estimates toward zero. Estimates significantly different than zero are thus especially strong evidence of network effects. At the same time, we expect the cross-network influence of DCAs to be especially pronounced in the first few years of their signature, when public and political attention is greatest.[27]

We use lending data from the Debtor Reporting System (DRS) of the World Bank.[28] The World Bank requires all members to report detailed information on their financial positions, including information on bilateral government-to-government loans. To match the DCA dataset, we use loan

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[25] "South Korean President to Make First Visit to Japan in 39 Years,"' in *Washington Post*, September 3, 1984.

[26] Although we have DCA data since 1980, the DCA network is extremely sparse in the 1980s and early 1990s, which causes convergence problems in the estimation algorithm.

[27] The empirical results are robust to increasing or decreasing this five-year window.

[28] We intentionally include government-to-government loans granted for any purpose. Some loans are designated for purchase of military equipment, but the vast majority of loans are meant to spur economic development (e.g., via infrastructure, power plants, and so on). Our theory is agnostic about the specific use of loans.

data for the period 1995–2010, and we similarly operationalize the loan network as a stack of 16 matrices, where an $y_{ij,t} = 1$ entry in a given $\mathbf{y}_t$ loan network indicates that an $i \rightarrow j$ loan agreement has been signed in the current year or prior four years. As with DCAs, the cross-network impact of loans is likely greatest immediately following their signature. Indeed, a loan's influence may decline precipitously when repayment begins and governments face the financial costs of borrowing. In the loan data, the mean grace period (i.e., time to repayment) is five years. Thus, as with DCAs, the five-year window represents a higher hurdle for our analysis, as it captures only cross-network influences that materialize within the first few years of a loan agreement's signature. Note that, unlike DCAs, loans are directed from an i creditor to a j debtor. Thus, the $\mathbf{y}_t$ matrix is asymmetric, such that $y_{ij,t} \neq y_{ji,t}$.

Empirically modeling bilateral loans and DCAs raises two methodological problems. First, because the two networks mutually influence one another, ties in one network are complex functions of ties in the other network. We thus cannot simply treat one network as an exogenous covariate in a traditional regression model. Second, as networks, both bilateral loans and DCAs exhibit powerful intra-network statistical dependencies. A given $i \rightarrow j$ bilateral loan tie is likely influenced by myriad other loan ties (Bunte and Kinne 2015). Similarly, the creation of DCAs among some states incentivizes DCA creation among others (Kinne 2016). These dependencies violate the basic assumption, common to most regression models, of independent and identically distributed data (e.g., Greene 2003: 66, 878). Any such dependencies must be properly modeled in order to obtain unbiased estimates of cross-network effects.

To address the above issues, we model the coevolutionary dynamics of loan and DCA networks using a modified stochastic actor-oriented model (SAOM) of network evolution (Snijders 2005). The SAOM is perhaps most intuitively described as an agent-based model that achieves statistical inference by comparing simulated networks to real-world networks, with the goal of selecting model parameters that generate simulated networks that resemble as closely as possible the observed networks. A standard SAOM relies upon a single nodal utility function, $f_i(\mathbf{x})$, which is assumed to apply identically to all nodes in the network $\mathbf{x}$. In creating, maintaining, and/or terminating ties in the $\mathbf{x}$ network, actors seek to maximize this function. To extend this single-equation model to the problem of two coevolving networks, we consider an additional network, $\mathbf{y}$, with a separate corresponding utility function. We thus model two utility functions, $f_i^X(\mathbf{x}, \mathbf{y})$ and $f_i^Y(\mathbf{x}, \mathbf{y})$, which effectively transforms the SAOM into a model of multiplex network coevolution (Snijders, Lomi and Torló 2013). For notational purposes, $f_i^X(\mathbf{x}, \mathbf{y})$ always refers to the DCA network, and $f_i^Y(\mathbf{x}, \mathbf{y})$ always refers to the loan network. Each function consists of a linear combination of various effects,

$$f_i^X(\mathbf{x}, \mathbf{y}) = \sum_{h=1} \beta_h^X s_{ih}^X(\mathbf{x}, \mathbf{y}) \tag{1}$$

and

$$f_i^Y(\mathbf{x}, \mathbf{y}) = \sum_{h=1} \beta_h^Y s_{ih}^Y(\mathbf{x}, \mathbf{y}), \tag{2}$$

where $s_{ih}^X(\mathbf{x}, \mathbf{y})$ represents those variables that determine the formation, maintenance, and/or termination of ties in the DCA network, and $s_{ih}^Y(\mathbf{x}, \mathbf{y})$ represents those variables that determine the formation, maintenance, and/or termination of ties in the loan network. In practice, these functions consist of one of three types of effects: (1) endogenous network influences, such as transitivity or reciprocity; (2) exogenous influences like geographic distance, regime type, or economic development; and (3) cross-network influences, such as those illustrated in Figures 2, 3, and 4. Each specified s_{ih}^X or s_{ih}^Y effect is weighted by a respective β_h^X or β_h^Y parameter. Typically, a negative β parameter estimate indicates that a specified effect discourages network tie formation, while a positive estimate indicates that a specified effect encourages tie formation.

Given the model's complexity, parameters must be estimated via simulation. We employ simulated method of moments estimation, as recommended by Snijders (2005). Briefly, this approach uses an iterative Robbins-Monro Markov-chain Monte Carlo algorithm to search the parameter space and locate $\hat{\beta}$ values that generate simulated networks that, according to calculated target statistics, closely resemble the observed networks (Snijders 2005). The estimation algorithm incorporates a number of fundamental assumptions. First, the network evolves continuously, one tie at a time, with potentially large numbers of tie changes occurring unobserved between observation moments.

Second, nodes exercise individual agency in that they choose x_{ij} or y_{ij} ties in such a way as to maximize the payoff from their respective utility function. Third, the opportunity for actors to change their ties in either network is stochastically determined by separate rate functions, which allows for the rate of change in one network to be substantially different than in the other. Fourth, once an actor changes a tie in either the $\mathbf{x}$ or $\mathbf{y}$ network, that change is immediately reflected in the other network, which ensures that the ties between the two networks interact in a continuously evolving process.

For the loan utility function, $f_i^Y(\mathbf{x}, \mathbf{y})$, we specify a series of cross-network effects, where structures within the DCA network influence ties in the loan network. For example, to assess the effect of a tie in the DCA network on a tie in the loan network, which tests H2, we include the dyadic cross-product of the two networks, defined as

$$\text{DCA bilateral} = s_{i1}^Y = \sum_j y_{ij} x_{ij}. \tag{3}$$

If a given i extends a tie in the $\mathbf{y}$ network (i.e., makes a loan to a j partner), s_{i1}^Y equals 1 if i and that j partner also have a DCA in place and equals zero otherwise. Put differently, a y_{ij} loan tie to a state with which i also has a x_{ij} DCA tie should be preferred over a tie to a j state with which i has no x_{ij} tie, given the relatively greater contribution of the former to i's utility function.

To assess higher-order impacts of the DCA network on the loan network, we include the following two additional statistics:

$$\text{DCA degree}_j = s_{i2}^Y = \sum_j y_{ij}(x_{j+} - \bar{x}) \tag{4}$$

$$\text{DCA closure}_{ikj} = s_{i3}^Y = \sum_{j \neq k} y_{ij} x_{ik} y_{kj} \tag{5}$$

The statistic s_{i2}^Y captures the influence of a potential loan partner's position in the DCA network on i's probability of making a loan, which tests H4. A negative parameter estimate indicates that as j's DCA ties increase, it becomes less attractive as a debtor. s_{i3}^{Y} incorporates i and j's mutual ties to relevant k third parties, which tests H6. A positive estimate for this effect indicates that the more of i's defense partners that make loans to j, the more likely i is to make a loan to j.

For the $f_i^X(\mathbf{x}, \mathbf{y})$ DCA equation, where DCA ties are the dependent variable of interest, we include the following effects:

$$\text{Loan bilateral} = s_{i1}^{X} = \sum_j x_{ij} y_{ij}. \tag{6}$$

$$\text{Loan outdegree} = s_{i2}^{X} = \sum_j x_{ij} (y_{j+} - \bar{y}) \tag{7}$$

$$\text{Loan similarity} = s_{i3}^{X} = \sum_j x_{ij} \left(\frac{\sum_k y_{ki} y_{kj}}{y_{+i} + y_{+j} - \sum_k y_{ki} y_{kj}} \right) \tag{8}$$

The statistic s_{i1}^{X}, which tests H1, is the cross-product of the two networks, operationalized with DCAs instead of loans as the dependent variable. The statistic s_{i2}^{X} operationalizes the overall lending activity or "outdegree" of states in the loan network, which tests H3. Finally, s_{i3}^{X} measures the similarity of i and j's respective borrowing portfolios, which tests H5.

We also control for endogenous influences *within* each of the respective DCA and loan networks. Both Equations 1 and 2 include an endogenous transitivity term, which controls for the tendency of governments to make loans or sign DCAs with "friends of friends." The DCA equation further includes a degree term, while the loan equation includes indegree and outdegree terms, all of which control for the relative activity of nodes. The DCA equation includes an "isolates" term, which accounts for the relative sparsity of the DCA network. Finally, the loan equation includes a reciprocity term, which controls for the tendency of nodes to reciprocate ties they receive from others.[29] These various endogenous terms improve inference by ensuring that estimated cross-network effects and covariates are not epiphenomenal to endogenous network dynamics.

We include a battery of exogenous covariates to control for known influences on bilateral lending and

[29] We fix the reciprocity parameter to an arbitrarily low negative value, thus accounting for governments' aversion to reciprocal loan ties.

defense cooperation. Following Kinne (2016), the DCA equation includes dyadic controls for former colonial ties (Hensel 2014), log-transformed geographic distance (Weidmann, Kuse and Gleditsch 2010), absolute difference between voting points in the UN General Assembly (Bailey, Strezhnev and Voeten 2015), log-transformed bilateral trade (Barbieri and Keshk 2012), mutual susceptibility to terror attacks (START 2016), common third-party enemy (Palmer, D'Orazio, Kenwick and Lane 2015), NATO and non-NATO military alliances (Gibler 2009), and joint membership in NATO and NATO's Partnership for Peace program. At the monadic level, we control for democracy (Boix, Miller and Rosato 2012), military capabilities (Singer, Bremer and Stuckey 1972), and per-capita gross domestic product (Feenstra, Inklaar and Timmer 2015).

The loan equation similarly includes controls for former colonial ties, distance, military alliances, and voting affinity in the UN General Assembly. We further separately control for log-transformed bilateral imports and exports (IMF 2015). At the monadic level, we control for the potential debtor's credit rating (Bloomberg 2015), history of default (Reinhart and Rogoff 2009), existing oil reserves (EIA 2015), and prevalence of corruption (World Bank 2014), all of which should strongly influence lending decisions. Finally, we control for both the creditor's and debtor's per-capita GDP, and for their similarity in regime type.

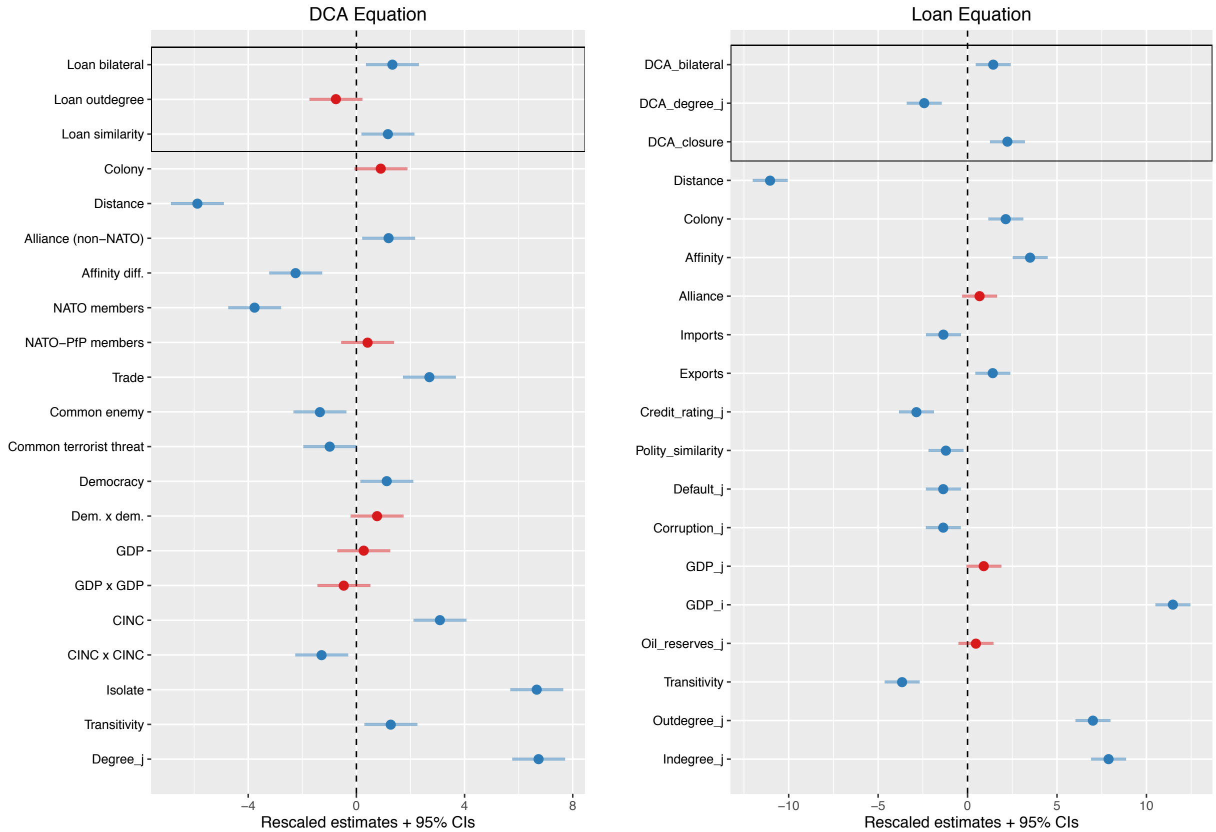
4 Empirical Results

Figure 5 presents the main results of our analysis, with estimates for the DCA equation (i.e., with DCAs as the dependent network variable) in the left-hand panel and estimates for the loan equation in the right-hand panel. Dots are rescaled point estimates and lines are standardized 95% confidence intervals. We focus first on H1 and H2, which together anticipate a reciprocal relationship between DCAs and loans at the bilateral level. The estimates for *DCA bilateral* in the left-hand panel and *Loan bilateral* in the right-hand panel are both positive and statistically significant, which supports both of the dyad-level hypotheses. Substantively, a bilateral loan increases the probability of a bilateral DCA by about 38%. Reconsider the hypothetical scenario in Figure 2(a). All else equal, i is about 38% more likely to form a DCA with j_1 over j_2. Note that this effect is over twice as strong as the effect of (non-NATO) defense pacts, which increase the probability of a DCA by only 17%. The reverse effect is even stronger. A bilateral DCA increases the probability of a bilateral loan by over 42%, all else equal. This effect is roughly equal to the effect of former colonial ties on bilateral lending, and nearly three times as strong as the effect of a military alliance. Importantly, because these estimates are made simultaneously, they are not driven by unmodeled reciprocal causation. Rather, issue linkage and side payments work both ways.

We next consider the positional effects discussed in H3 and H4. The parameter estimate for *Loan degree*, shown in the left-hand panel of Figure 5, is negative, as expected, but is insufficiently precise to establish statistical significance. Thus, we find only partial support for H3. In contrast, the estimate for *DCA degree*$_j$ is both negative and highly significant, which supports H4's contention that creditors avoid lending to governments that occupy highly central positions in the DCA network. Substantively, a potential debtor with one DCA membership is about 13% less likely to be selected as a loan partner than a potential debtor that has no DCA ties. This effect compounds nonlinearly. For example, in the hypothetical illustration in Figure 3(b), node j_1 has five DCA ties while node j_2 has only two DCA ties. All else equal, i is about 35% less likely to lend to j_1 than to j_2. Thus, as expected, governments prefer not to lend to debtors that are highly active in the DCA network, likely due to a limited ability to subsequently influence those debtors' policies. Again, because the SAOM models network coevolution simultaneously, these estimates are unlikely to be artifacts of umodeled endogeneity.

Finally, we consider the informational effects of H5 and H6. The estimate for *Loan similarity*, shown in the left-hand panel of Figure 5, is positive and significant, which supports our argument that potential defense partners glean information from one another's financial ties. The more similar i and j are in their lending from third parties, the more likely they are to share strategic interests, and, thus, the more likely they are to formalize their defense relations. We also find strong support for H6, as reflected by the positive and significant estimate for *DCA closure*. Recall that this term measures whether states are more likely to make loans to the current debtors of their DCA partners. The parameter estimate indicates that if i has a DCA with a third party k, and that third party in turn lends to j, i is about 14% more likely, all else equal, to extend a loan to j than

Figure 5: Stochastic Actor-Oriented Model of DCA-Loan Coevolution, 1995–2010



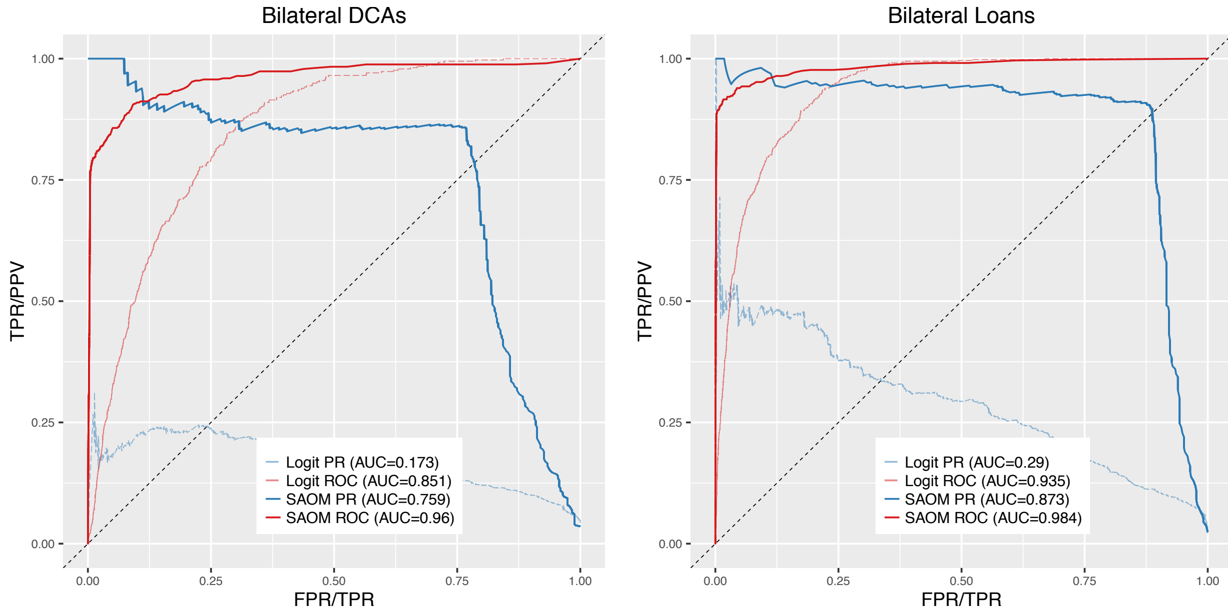
Note: Dots are rescaled parameter estimates. Lines are standardized 95% confidence intervals. Estimates in blue are statistically significant at the 5% level. All convergence diagnostics < 0.1 (excellent convergence). 3,598 iterations for $\hat{\beta}$. 3,000 iterations for s.e.$(\hat{\beta})$. Density and (fixed) reciprocity estimates not shown.

if no third-party tie existed. Because a given i may have many third-party ties, the substantive impact of this effect can grow quite large. For example, in the hypothetical illustration in Figure 4(b), i is about 50% more likely to make a loan to j_1 than to j_2, due to i having DCA ties with three of j's current creditors. Further, the effect of *DCA closure* endures even after controlling for credit rating, default risk, corruption, and other measures of creditworthiness, which suggests that, as hypothesized, DCA portfolios reveal otherwise unavailable information about potential debtors.

4.1 Goodness of fit

The SAOM accounts for simultaneous influences at the bilateral level, higher-order cross-network influences, and intra-network endogenous influences. But do the results of the model justify its

Figure 6: Goodness of Fit, SAOM vs Logistic Regression



Note: An area under the curve (AUC) closer to one indicates better fit. Logit fits derived from two separate models of DCAs and loans, respectively. SAOM fits derived from multi-equation coevolutionary model. Both methods use 2010 as the out-of-sample validation set, with 1995–2009 as the training set.

complexity? To assess the value-added of the SAOM, we employ the out-of-sample prediction technique developed by Kinne (2013), which uses a "moving window" of cross-sectional networks as a training set and then uses a subsequent, unmodeled time period as a validation set. We reserve the year 2010 as the validation set, and we use the prior 1995-2009 period as the training set. Thus, we predict loans and DCAs in 2010 using estimates drawn from prior years. We then compare these results to predictions generated from separate logit models of DCAs and bilateral loans. The logit models include the same exogenous covariates as the respective SAOM equations, but without endgeonous network terms or higher-order cross-network terms. To clarify, while the SAOM predictions come from a multi-equation model, the logit predictions come from two separately estimated models. The goal is to compare the SAOM to the most common alternative modeling strategy (in this case, logistic regression).

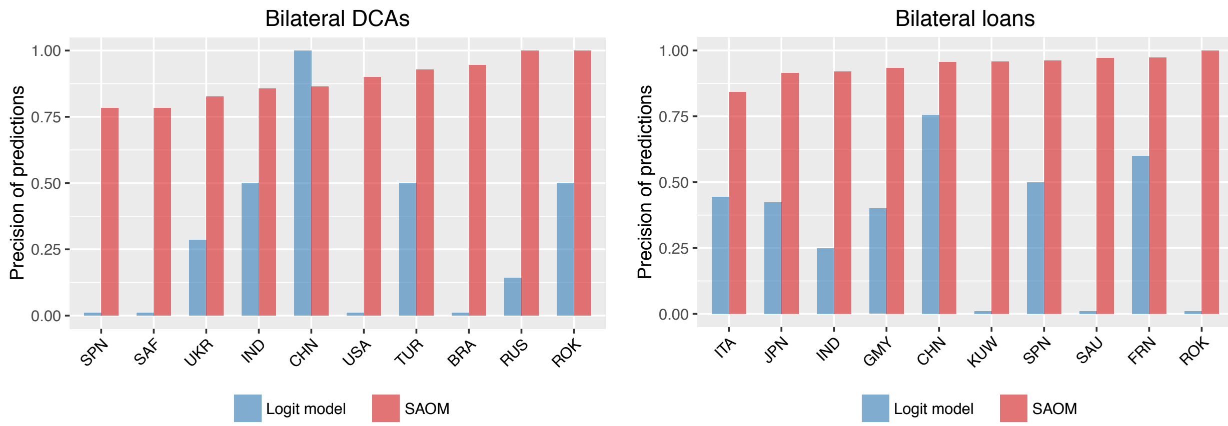
Figure 6 illustrates the results using a series of receiver operating characteristic (ROC) and precision-recall (PR) curves. The left-hand panel focuses on defense agreements as the dependent variable, and the right-hand panel focuses on loans. ROC curves compare the true positive rate (TPR) of a model's predictions to the false positive rate (FPR) for successively larger prediction thresholds. An area under the curve (AUC) closer to one—as reflected by a curve that pushes toward the top-left corner of the graph—indicates better performance. For DCAs, for example, the area under the SAOM's ROC curve is approximately 0.96, which is much higher than the area under the logit model's ROC curve (0.85). The logit model's out-of-sample predictions yield fewer true positives and more false positives.

However, ROC curves may be inappropriate for sparse networks or rare-events data, as a high AUC may simply reflect the relative ease of predicting zero values. We thus also fit PR curves, which compare positive predictive value or "precision" (PPV) to the TPR. The PPV is defined simply as $\frac{\text{true positives}}{\text{true positives+false positives}}$, or the ratio of the model's correctly predicted positive values to the model's total predicted positive values. A high PPV indicates that the model classifies outcomes with high precision, which is especially beneficial for sparse networks, where positive outcomes are difficult to predict. As the left-hand panel of Figure 6 illustrates, the SAOM dramatically improves the precision of out-of-sample predictions. For the logit model, the area under the PR curve is only 0.17, which indicates extremely poor performance; the vast majority of the logit model's positive predictions are in fact false positives. In contrast, the SAOM increases the area under the PR curve to 0.76.

The right-hand panel of Figure 6 illustrates the goodness-of-fit for loans. As with DCAs, the SAOM increases the area under the ROC curve. Interestingly, the logit model's performance, with a ROC AUC of 0.94, is quite good. However, the loan network is also relatively sparse, which suggests that this high AUC may be an artifact of rare events. The PR curves reveal a stark difference between the two models. The logit model is extremely imprecise, yielding a PR AUC of only 0.29; again the logit model yields far too many false positives. The SAOM, on the other hand, increases the PR AUC to 0.87. Viewed through the lens of out-of-sample prediction, the SAOM is unambiguously superior to logistic regression.

As a final consideration of goodness-of-fit, we focus on individual countries. We selected the ten most active countries in each of the DCA and loan networks, and we compared the two models' predictions for each country's respective DCA and loan portfolios. Given that both networks are

Figure 7: Out-of-Sample Predictions for Individual Countries



Note: Out-of-sample prediction of each country's respective 2010 DCA or loan ties, using 1995-2009 period as training set.

relatively sparse, and that predicting zeros is comparatively easier than predicting positive events, we again use PPV. Figure 7 illustrates the results, where a PPV of one indicates that all of the model's positive predictions are correct (i.e., there are no false positives). Interestingly, the logistic regression model predicts China's 2010 defense ties with 100% precision, which is a better fit than the SAOM's 90% precision. However, this is the only case where logistic regression outperforms the SAOM. In all other cases, the SAOM yields a much higher PPV. Indeed, in some cases the precision of the logit model is virtually zero—i.e., the model fails to correctly predict any ties at all. The superior fit of the SAOM is due to a combination of factors, including (1) the simultaneous modeling of DCAs and loans at the bilateral level, (2) the simultaneous modeling of DCAs and loans at the cross-network level, and (3) the inclusion of endogenous network influences.

5 Conclusion

The relationship between defense cooperation and economic cooperation remains a critical area of inquiry. Our analysis provides a microcosmic insight into complementary dynamics across issue areas. Although we address only defense cooperation agreements and bilateral loans, these two types of relations are particularly representative of governments' foreign economic and security policies.

DCAs are now the primary means of defense cooperation for states, and bilateral loans offer a highly strategic avenue for connecting financial relations to political influence. At the same time, DCAs and loans pose few levels-of-analysis problems. They are both strictly intergovernmental forms of cooperation, which avoids complications of nonstate actors, domestic politics, and preference aggregation.

We emphasize several main conclusions. First, economic and defense relations are inextricably linked. Five of our six hypotheses find strong empirical support. And the substantive impacts of defense and financial ties on one another are nontrivial. Indeed, in some cases the cross-network influences are of greater magnitude than such traditional influences as geography, colonialism, and military alliances. The empirical connection between these two issue areas is strong.

Second, while the empirical evidence linking defense and financial ties is generally strong, the relationship between them is complex. Virtually all prior analyses limit their focus to purely bilateral relations. Our analysis confirms this bilateral component but further shows that a country's defense and financial ties exert more subtle higher-order effects. Even when states lack bilateral ties, they are able to use third-party ties to inform their perceptions of a potential partner's strategic value, reliability, and trustworthiness. Given the high levels of interdependence in world politics, these complex network influences are perhaps not surprising. Diplomatic histories and historical anecdotes are rife with examples of such complexity. Nonetheless, without the advent of appropriate methodologies to model these effects, scholars have thus far been unable to confirm their existence on a generalizable scale.

Finally, our findings have normative significance. Parallel to the shifts in international security after the end of the Cold War, the rise of new lenders, such as China and India, presents a formidable challenge to traditional creditors. As the international financial architecture undergoes potentially dramatic changes, our theory and methods offer a way to analyze these evolving financial ties in order to predict political cooperation and conflict. Similarly, states now face increasingly intimidating security challenges, such as trafficking, cyberwar, and transnational terrorism. The transnational dimensions of these problems require multilateral coordination among states. Our analysis shows how governments, faced with longstanding collective action and coordination problems, can use financial ties to incentivize, strengthen, and maintain security cooperation in times of uncertainty.

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