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Guns or Money? Defense Co-operation and Bilateral Lending as Coevolving Networks

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Abstract

How are defense co-operation and economic co-operation related? To answer this question, this article analyzes the coevolution of defense co-operation agreements (DCAs) and government-to-government loans. It argues that governments pursue two distinct sets of interests. At the *bilateral level,* governments use issue linkages and side payments to encourage spillover from defense co-operation to economic co-operation, and vice versa. That is, governments' bilateral interests in DCAs and loans are largely complementary. However, at the *network level,* interests may diverge. Specifically, governments use DCAs to build clubs of like-minded defense collaborators or 'security communities', while they use loans to impose asymmetric forms of political authority or 'hierarchies'. In some contexts, these network-level interests are, like bilateral interests, complementary. For example, defense partners rely on loans to co-ordinate their foreign policies and better respond to security threats, and debtors rely on lending patterns to identify suitable defense partners. In other cases, however, these interests strongly conflict. For example, governments that are highly active in the loan network are especially likely to rely on asymmetric exercises of political authority, which is incompatible with the network-level goal of using DCAs to establish communities of defense collaborators. Similarly, governments that are highly active in the DCA network are, due to their complex multilateral political commitments, less vulnerable to the asymmetric influences that loans enable. To empirically test these claims, the study develops a longitudinal model of multiplex network coevolution. Overall, the results show that while economic and defense co-operation often reinforce one another, they sometimes conflict in unexpected ways.

Keywords bilateral loans; defense cooperation agreements; network analysis; stochastic actor oriented model; network coevolution; hierarchy; security communities

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 19 February 2009, the Kyrgyz Parliament voted to close the airbase and evict US forces from the country. During the same period, Russia continuously operated the Kant airbase, also established in 2001 and located only about 50 km from Manas. Not only was Russia allowed to retain use of Kant, but in December 2012 Kyrgyzstan renewed the lease for another fifteen years.

Why did the Kyrgyz Government evict the United States but extend co-operation with Russia? Financial considerations may have played a role. On 14 January 2009, just prior to the vote to close the US airbase, Russia offered the Kyrgyz Government $2 billion in loans and $150 million in financial aid. Russia had previously extended Kyrgyzstan loans of $16 million in 1993, $48 million in 1997 and $241 million in 2009. In contrast, the United States provided no loans

during this period. Unsurprisingly, commentators have suggested that the loan agreements were the primary reason for Kyrgyzstan's continued co-operation with Russia.[1]

This anecdote offers a microcosmic glimpse into bilateral linkages between economic and military issue areas. It also raises deeper puzzles, such as why the United States, despite an obvious interest in partnering with the Kyrgyz Government, failed to provide a single loan, while Russia did so repeatedly. Questions about defense and economic co-operation have inspired substantial research, including the voluminous literature on trade and conflict and the narrower – but, for our purposes, more relevant – literature on trade and alliances.[2] Though these literatures have yielded valuable insights, they have important limitations. Many previous studies assume that private actors lobby their governments to avoid conflict and pursue alliances, which in turn requires non-trivial assumptions about the ability of those actors to overcome collective action problems. Further, existing empirical models do not sufficiently address the myriad endogenous influences that plague economic and defense ties. These endogenous influences may be straightforward, such as reciprocal causation between bilateral trade and alliances.[3] But they may also be highly complex. Scholars increasingly recognize that relations between states resemble interdependent networks.[4] Indeed, both trade and alliances are particularly rife with statistical dependencies.[5]

Our analysis of economic and defense co-operation 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 government-to-government loans. Such bilateral loans are an overtly public form of economic co-operation 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 bilateral defense co-operation known as defense co-operation agreements, or DCAs, which manage the day-to-day military interactions of governments, such as joint exercises and training, weapons development and procurement, and exchanges of classified information.[6] Focusing on phenomena at the level of intergovernmental relations allows us to compare 'like to like'.

To determine specifically how bilateral loans and defense co-operation are connected, we are the first to distinguish between *bilateral interests* and *network interests*. At the bilateral level, governments focus on the purely dyadic costs and benefits of connecting loans with DCAs. Drawing on the logics of issue linkages and side payments, we show that governments link DCAs with loans in order to ease bargaining problems and improve prospects for co-operation. But states also have larger, more structural or macro-level goals in mind when they make loans and sign DCAs. Specifically, creditor governments use loans to establish informal hierarchies and exercise political authority over subordinate debtors. By contrast, governments use DCAs to establish cohesive groups of defense collaborators and nascent security communities.

This distinction allows for potential incompatibilities between bilateral and network-level interests, such that loans and DCAs may fail to materialize even when there are strong bilateral incentives. Further, these distinct network interests are often incompatible with one another. In general, governments should be averse to making loans to, or signing DCAs with, partners that pose a risk to their larger network interests. For example, a country that is highly active in the DCA network – by virtue of signing many defense agreements – may be less susceptible to a creditor's efforts to exercise hierarchical political influence. Similarly, highly active creditors, given their emphasis on using loans to asymmetrically exercise political authority, may make for

[1]See 'Kyrgyz MPs vote to shut US base', *BBC News*, 19 February 2009.
[2]For example, see Gowa and Mansfield 1993; Schneider 2013.
[3]Long 2003.
[4]Cranmer and Desmarais 2016; Dorussen, Gartzke, and Westerwinter 2016; Dorussen and Ward 2008; 2010; Kinne 2013; Ward 2006; Ward, Siverson, and Cao 2007.
[5]Ward, Ahlquist, and Rozenas 2013; Warren 2010.
[6]Kinne 2017a; Kinne 2018.

unreliable defense partners. In short, network-level interests mean that in some cases, activity in one network decreases activity in the opposing network.

Nonetheless, some network structures *do* increase activity in the opposing network. For example, DCA partners can co-ordinate their lending practices in order to improve their ability to respond to shared security threats. Similarly, debtors can use patterns in lending portfolios to identify compatible defense partners. Our theoretical framework explains the various conditions under which the network-level goals of defense and financial co-operation either reinforce or confound one another. Overall, we argue – and empirically show – that the *structure* of the DCA network itself influences new lending, and that the *structure* of the loan network influences new DCAs. These influences largely stem from the divergent macro-level interests that define each network.

We proceed in five parts. First, we review the scholarship on defense co-operation and economic interdependence. Secondly, we introduce a network-oriented theory of defense and economic co-operation, and derive several testable hypotheses. Thirdly, we introduce the data and discuss the inferential network model. Fourthly, we discuss the empirical results. The fifth section concludes. A separate online appendix contains extensive information on loan and DCA data, control variables, the network model and robustness checks.

Literature on Defense and Economic Relations

The most prevalent strain of the multifaceted literature on economic and security inter-dependence focuses on international trade and interstate conflict, and finds that trade reduces conflict by increasing the opportunity costs of war and/or enabling contests of resolve.[7] However, militarized conflict is not an appropriate proxy for co-operation, as an absence of conflict may result just as easily from inattention as from deliberate policy choices. Military alliances, by contrast, *do* reflect deliberate policy choices. In the study of trade and alliances, the key empirical question is whether trade encourages alliances or whether, conversely, alliances promote trade. Employing multiple regression models, Mansfield and Bronson find that the presence of an alliance greatly increases bilateral trade flows, but that trade does not reciprocally increase the probability of an alliance.[8] Additional studies generally confirm this basic finding,[9] despite occasional contradictory results.[10] Recent network approaches to this question conclude both that alliances have a much stronger effect on trade than vice versa,[11] and that the network aspects of alliances are even more influential than the dyadic aspects.[12]

The alliances-and-trade literature suffers from at least three weaknesses. First, while trade is a salient feature of the global economy, it is only indirectly related to governmental policy. The vast majority of commerce is conducted by private actors. In contrast, governments monopolize defense and security relations. By connecting private actors to public institutions, theorists have relied on the micro-level assumption that economic actors lobby their governments for pacific policies.[13] Yet this assumption is not always tenable. The connection between private actors and trade may be confounded by: (1) diffuse gains from trade, which reduce beneficiaries' willingness to undertake costly lobbying activities, given the relatively small benefits;[14] (2) the possibility that

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[7]For example, see Hegre, Oneal, and Russett 2010; Kinne 2014; Morrow 1999; Polachek and Xiang 2010; Russett and Oneal 2001; Schneider 2013.

[8]Mansfield and Bronson 1997.

[9]Gowa 1995; Gowa and Mansfield 1993; Gowa and Mansfield 2004; Long 2003; Long and Leeds 2006.

[10]Fordham 2010; Morrow, Siverson, and Tabares 1998.

[11]Vijayaraghavan et al. 2015.

[12]Haim 2016.

[13]Hirschman 1980; Kirshner 2007; Levy 2003; McDonald 2009; Russett and Oneal 2001; Simmons 2003.

[14]Alt and Gilligan 1994.

a given political environment is inhospitable to lobbying;[15] or (3) the fact that the costs of economic integration are often concentrated in specific industries.[16] Overall, the role of private actors adds layers of complexity that, despite their substantive importance, complicate the task of drawing causal arrows from one phenomenon to the other.

We circumvent these complications by focusing on government-to-government loans, an explicitly public measure of economic interdependence. 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 co-operation allows us to avoid 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.

The second weakness of the alliances-and-trade literature is that formal military alliances do not sufficiently represent the scope of governments' security and defense policies. Some alliances, such as the North Atlantic Treaty Organization (NATO), remain vitally important. Yet the global security environment is now rife with non-traditional threats, including transnational terrorism, human and weapons trafficking, cyberwar, proliferation of nuclear weapons, failed states and maritime piracy, among others. Such threats typically fall outside the purview of traditional military alliances, which focus on interstate conflict.[17]

Bilateral DCAs provide a valuable alternative measure of defense co-operation.[18] Well over 1,000 DCAs have been signed since the end of the Cold War, connecting partners as diverse as Indonesia and Turkey, South Africa and Liberia, and Argentina and Russia. In contrast to alliances, which often lie dormant unless triggered by an interstate conflict, DCAs facilitate concrete, day-to-day interactions. For example, a 2011 DCA between the United States and Brazil sets guidelines for 'research and development, logistics support, technology security, and the acquisition of defense products and services, […] information exchanges, combined military training and education, joint military exercises, exchanges of students and instructors, naval ship visits and defense-related commercial initiatives'.[19] The online appendix provides extensive additional details on the distinguishing characteristics of DCAs. In short, DCAs are an increasingly prevalent means of institutionalizing the entirety of signatories' co-operative defense relations.

Historical evidence shows that leaders care deeply about DCAs, crediting them with improvements in military capacity, advances in defense policy, and enhanced access to new weapons and technologies.[20] Further, DCA partners are more likely to hold joint military exercises, to jointly contribute to peacekeeping missions, and to engage in arms trade, and less likely to fight one another in militarized interstate disputes.[21] Thus while DCAs are substantively important, they are not alliances. They involve no mutual defense commitments. While alliances focus on the potential or actual use of militarized force,[22] DCAs focus on routine defense co-operation.[23] Given our interest in how economic and security policies interact in the daily workings of government, DCAs are the more appropriate measure.

The third weakness is that the empirical models typically used to explore economic–defense relations do not adequately address the complex endogenous relationships that pervade these

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[15]Bearce 2003.

[16]McDonald 2004, 554.

[17]Leeds 2005; Leeds et al. 2002.

[18]Kinne 2017a.

[19]'Fact Sheet: US-Brazil Defense Cooperation', *United States Department of Defense*, 14 March 2011.

[20]For example, see 'Philippines, Australia Agree on New Security Pact', *Reuters News*, 27 November 2006; 'Why Brazil Signed a Military Agreement with the US', *The Christian Science Monitor*, 13 April 2010.

[21]Kinne 2016; Kinne 2017b; Kinne 2018.

[22]Leeds 2005.

[23]Empirically, alliances are neither sufficient nor necessary for DCAs. The correlation between alliances and DCAs is typically <0.2. Only about 4–5 per cent of allies share DCAs, and only 10–12 per cent of DCA partners share alliances.

data, which in turn limits our ability to understand economic–security interdependencies.[24] Endogeneity takes multiple forms. Reciprocal causation is a particularly prominent concern.[25] Simultaneous equation models are the most commonly used method to disentangle two-way relationships, but the results of these models are sensitive to specification.[26] More importantly, these approaches are limited to narrowly defined bilateral endogeneity. In practice, economic and defense relations exhibit complex statistical dependencies. For example, models of international commerce show that the level of trade between a given pair of countries depends on trade connections throughout the global trade network.[27] Similarly, countries form military alliances in response to the alliance activity of others.[28] The ever-growing literature on networks in international relations shows that such effects are the rule rather than the exception.[29] We anticipate similar endogeneity issues in the DCA and loan networks.

A Network Theory of Lending and Defense Co-operation

Our theory hinges on a crucial distinction between *bilateral* interests and *network* interests. At the bilateral level, the influence of DCAs on loans – or vice versa – involves only dyadic considerations. For example, if a dyad already enjoys a bilateral financial tie, then issue linkage or other dyad-level influences may encourage new defense ties. However, bilateral ties do not occur in a vacuum. A given financial or defense tie represents only a small part of a government's overall portfolio of foreign relations. Substantively, governments must consider not only the bilateral advantages of signing a DCA or making a loan, but also how that particular DCA or loan fits with their larger multilateral goals. Below, we elaborate on these bilateral and network interests, showing that they interact to yield unexpected outcomes.

Bilateral interests

Governments actively co-ordinate their economic and security policies. In the United States, this co-ordination occurs at multiple levels.[30] Within the National Security Council, for example, a committee oversees interagency co-operation on issues that intersect foreign security and financial policy. In addition, the Office of Military Affairs assigns liaison officers from each of the combatant commands to the State Department and the US Agency for International Development (USAID); in turn, State and USAID assign senior officials to the Pentagon. Further, the 2006 National Defense Authorization Act establishes a review process wherein the Departments of Defense and State jointly develop security and economic programs.[31] This sort of co-ordination is common across governments.[32] Empirically, such complementarity across issue areas is most evident at the bilateral level: governments deliberately co-ordinate security and financial policies with their partners. We first assess the bilateral influence of DCAs on loans, and then address the reverse situation.

How bilateral loans increase the probability of defense co-operation

Government-to-government loans increase the probability of bilateral defense co-operation through two mechanisms. First, bilateral loans are a type of *side payment*. According to Davis,

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[24]Cranmer and Desmarais 2016; Dorussen, Gartzke, and Westerwinter 2016.
[25]For example, see Davis 2004; Keshk, Pollins, and Reuveny 2004; Kim and Rousseau 2005.
[26]Bussmann 2010; Hegre, Oneal, and Russett 2010.
[27]Ward, Ahlquist, and Rozenas 2013.
[28]Warren 2010.
[29]For example, see Cranmer and Desmarais 2011; Haim 2016; Kinne 2013; Maoz 2010; Ward, Siverson, and Cao 2007; Warren 2016.
[30]Lawson and Epstein 2009.
[31]'FY 2009 Summary Justification', *Department of Defense*, p. 103.
[32]Katzenstein and Okawara 1993; Lampton 2001; Sandler and Hartley 2007.

'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'.[33] Side payments do not involve immediate returns but nonetheless aim to transform the preferences of recipients. As Kahler and Kastner explain, 'countries deploy economic links in the hopes that economic interdependence itself will, over time, change the target's foreign policy behavior'.[34] Side payments are commonly deployed for alliance building,[35] and this practice appears to extend to loans and defense agreements. For example, in 2003 a proposed $270m loan from the United Arab Emirates (UAE) to Oman loomed over bilateral discussions on defense relations between the two countries. As the UAE vacillated on whether to provide the loan, it conspicuously emphasized the 'need to have close co-operation and co-ordination' on security issues.[36] Similarly, the resolution of border security issues between Kuwait and Iraq in 2006 appears to have been tied to $440m in soft loans from the Kuwaiti Government.[37]

A second, closely related, mechanism is *issue linkage*, defined as the simultaneous discussion of two issues for joint settlement.[38] In bargaining, issue linkage creates new zones of agreement and increases opportunities for mutual gain.[39] As with side payments, economic linkages are commonly used to encourage defense co-operation.[40] A 2003 loan negotiation between the United States and Turkey offers an example. In its appeal for financial support from the United States, the Turkish government drew an explicit connection to security concerns:

> Turkey believes that we cannot divorce the security co-operation 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.[41]

The prospect of increased security co-operation appealed to the United States, which was preparing military action in neighboring Iraq. A subsequent draft term sheet directly incorporated security provisions, noting 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'.[42] Further, the Erdogan government's authorization for US troops was tied to 'a very sizable US package to include [an] $8.5 billion bridge loan'.[43] As if to dispel any uncertainty, a US official explicitly declared that 'military and economic co-operation have always been part of the loan package'.[44]

Diplomatic evidence shows that financial ties in fact often precede DCA negotiations. In a 2004 visit to India, Sri Lanka's president negotiated a $250m concessional loan as a precursor to signing an expansive DCA.[45] In 2007, Japan's prime minister 'announce[d] the provision of a 600 billion yen ($5 billion) loan' to facilitate the construction of a high-speed railway in India,

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[33]Davis 2008.

[34]Kahler and Kastner 2006.

[35]Long and Leeds 2006; Papayoanou 1999.

[36]US Embassy in the UAE, 'UAE, Oman Discuss Common Security Concerns, Development Assistance', 15 December 2003. Note that all cited diplomatic cables are available via *Wikileaks Public Library of US Diplomacy*.

[37]US Embassy in Kuwait, 'Scenesetter for Secretary of Defense Gates' Visit to Kuwait', 26 July 2007.

[38]Sebenius 1983.

[39]Davis 2004; Fearon 1998; Koremenos 2001.

[40]Davis 2008; Long and Leeds 2006.

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

[42]US Embassy in Turkey, 'Draft Term Sheet for Turkey Grant/Loan Facility', 8 February 2003.

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

[44]US Embassy in Turkey, 'Ankara Media Reaction Report', 28 August 2003.

[45]US Embassy in Sri Lanka, 'Sri Lankan President's Visit to India Yields Soft Loans, Stronger Language on Peace Process', 17 November 2004.
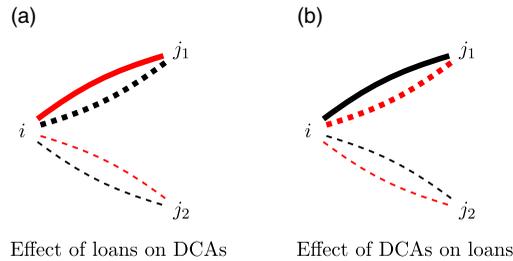
Figure 1. Anticipated bilateral effects.

Note: Node i is the focal state; j nodes are potential partners. Red lines are loans. Black lines are DCAs. Solid lines are current ties. Dashed lines are prospective ties; line thickness indicates probability of tie creation.

while subsequently opening a discussion on how 'India and Japan share the same intentions with regard to naval and other military co-operation'.[46] Combined, side payments and issue linkage should increase the probability that financial ties manifest defense ties. Figure 1(a) illustrates the anticipated relationship. In a hypothetical scenario in which i must choose between two potential DCA partners, the *ceteris paribus* probability of a tie is greater if i and j have a loan in place.[47]

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

How defense co-operation increases the probability of bilateral loans

In the reverse of Hypothesis 1, we also expect bilateral DCAs to increase the probability of bilateral loans. Governments have long used economic relationships to enhance the capacity of their allies and strengthen contributions to mutual defense. Gowa and Mansfield argue that the security externalities generated by free trade compel states to focus trade relations on allies rather than potential adversaries.[48] Empirical work generally confirms these predictions.[49] While DCAs do not involve alliance commitments, they nonetheless endeavor to improve defense capacity, such as weapons acquisition and procurement, pooling of research and development resources, officer exchanges and training programs, joint exercises, defense industry collaboration and overall military modernization.[50] Bilateral loans provide a way for interested governments to further enhance their defense capacity. 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.[51] On the demand side, the economic development spurred by loans generates domestic demand for greater security, incentivizing loan recipients to participate more deeply in security co-operation.

There is considerable evidence that governments use loans to strengthen their defense partners. In a 2014 speech on US–India co-operation, Secretary of Defense Chuck Hagel explicitly connected financial and military co-operation, arguing that '[i]ncreased investment towards defense industrial partnership with India is the way of going forward' and that 'a robust defense

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

[47]Importantly, we only consider the effect of *existing* DCAs and loans, not merely verbal commitments. As DCAs and loans are non-trivially costly, it is unlikely that states would sign DCAs or make loans in order to misrepresent their preferences and obtain outcomes closer to their respective ideal points. As we discuss below, high levels of aggregate DCA activity are in fact associated with *fewer* loans, and vice versa.

[48]Gowa and Mansfield 1993.

[49]Gowa and Mansfield 2004; Haim 2016; Long 2003; Mansfield and Bronson 1997; Morrow, Siverson and Tabares 1998; Poast 2012; Skalnes 2000.

[50]Kinne 2018.

[51]Joerding 1986; Ram 1995.

partnership and joint military capabilities' would be 'the cornerstone of [the] Indo-US relationship'.[52] Governments often tie defense co-operation specifically to loans. In 2010, in an 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 co-operation for national defense, science and technology, and collaboration in defence production', while China committed to 'provide 100 million US Dollars in preferential loans and 300 million US Dollars in preferential buyer's credit for projects of great importance to Pakistan'.[53]

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 co-operation encourages linkages to financial co-operation. For example, military co-operation between China and Russia enabled a massive $25 billion loan-for-oil deal in 2009. 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'.[54] In a similar example, in 2002 Russia tied security co-operation with Vietnam to financial incentives, linking agreements on law enforcement and border defense to a subsequent loan for constructing hydroelectric plants in Vietnam's central highlands.[55]

Both mechanisms − capacity improvements and issue linkages − increase the probability of bilateral loans. Figure 1(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.

Network interests

Side payments, issue linkage and defense capacity may connect loans and DCAs at the bilateral level, but they do not exhaust governments' strategic considerations. Governments must also consider how a given loan or DCA fits into their broader structural goals. At the network level, governments use DCAs to establish cohesive groups of like-minded defense collaborators, which are capable of working in concert to address shared security challenges and non-traditional threats. Scholars have long argued that defense agreements help establish affinity groups.[56] Particularly strong affinity groups may develop into security communities, in which members coalesce around a shared identity and common interests.[57] While DCAs do not yield the distinctive modular structure often seen in alliance networks,[58] they nonetheless evince a strong tendency toward cohesion and in-group collaboration. For example, Secretary of Defense Ashton Carter argued that overlapping webs of bilateral defense commitments engender an 'inclusive and principled security network', 'open to all that seek to preserve and strengthen the rules and norms that have undergirded regional stability'.[59] Diplomatic language surrounding DCAs similarly reflects the notion of shared interests and political alignment. In 2010, after Brazil signed an expansive DCA with the United States, one Brazilian analyst argued that 'Brazil is aligning itself strategically with the United States, like the European nations have done with NATO'.[60]

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[52]'Hagel Supports India's Larger Footprint in Region', *New Indian Express*, 9 August 2014.
[53]'Pakistan, China resolve to consolidate strategic ties', *Frontier Post*, 20 December 2010.
[54]US Embassy in China, 'China/Russia: Strange Bedfellows Or Strategic Partners?' 28 April 2009.
[55]US Embassy in Vietnam, 'Vietnam-Russia: Strong but "pragmatic" relationship', 8 November 2002.
[56]Bueno de Mesquita 1975; Signorino and Ritter 1999.
[57]Adler and Barnett 1998.
[58]For example, see Maoz 2010.
[59]Carter 2017.
[60]'Why Brazil Signed a Military Agreement with the US', *The Christian Science Monitor*, 13 April 2010.

The incentive to form cohesive groups of like-minded collaborators lies in the potential for these groups to better respond to novel security threats. For example, after signing a DCA with Australia in 2006, a Philippines defense official observed: '[i]t's like a basketball game. We need to practise with other players from other teams to learn new skills and techniques to raise the level of our game'.[61] Secretary of Defense Leon Panetta similarly argued that 'networks of co-operation' help to 'ensure collective capability and capacity for securing common interests'.[62] And Secretary Carter's principled security network 'allows countries to take co-ordinated action in response to humanitarian crises and natural disasters, address common challenges such as terrorism, and ensure the security of and equal access to the commons'.[63]

These structural incentives do not imply that defense co-operation is harmonious or devoid of co-operation problems. Powerful governments often take the lead in assembling groups of collaborators, and these efforts may involve explicit efforts to incentivize co-operation for others (or, alternatively, disincentivize non-cooperation). Indeed, as revealed by the above discussion of bilateral interests, loans can function as material rewards for defense partners. Yet even when spearheaded by self-interested major powers, security communities promote extensive co-operation among the participants themselves, and this emphasis on group cohesion contrasts sharply with the more explicitly hierarchical logic of bilateral lending (discussed below). In turn, group cohesion and defense policy co-ordination generate synergy effects that increase the overall effectiveness of security actions.

The network-level incentives in bilateral lending are distinctly different than in DCAs. Bilateral loans are intimately connected to power, as they provide creditors with the capacity to control, influence and coerce others.[64] Creditors may gain power directly by attaching political conditions to monetary resources.[65] Further, creditors may exert indirect influence by moving into more central positions in the global lending network. Within a network, power 'accrues to those who operate from core positions, since those positions provide opportunities for influence'.[66]

Positions of authority provide creditors with political benefits, such as favorable policies in debtor countries.[67] The British Secretary of State for Business, Energy, and Industrial Strategy noted that bilateral lending 'creates influence and leverage'.[68] For example, the Chinese Government uses loans to dissuade recipients from acknowledging Taiwan politically.[69] Loan recipients may also cast favorable votes in the United Nations.[70] Conversely, an absence of loans diminishes political influence. For example, the *Financial Times* recently opined that increased Chinese lending activity 'is likely to deepen unease in US business and foreign policy circles about diminishing US influence'. Loans also provide economic benefits. China's recently announced 'One Belt, One Road' policy offers bilateral loans to foreign governments for infrastructure projects. These projects, in turn, 'help support China's weakening economy', as 'the majority of foreign construction projects will […] be undertaken by Chinese companies'.[71]

The contrast between the network interests of DCAs versus loans is readily apparent in the structures of the networks themselves. In the top row of Figure 2, the embedded histograms show each network's degree distribution, where 'degree' refers to a node's number of ties, and

[61]'Philippines, Australia agree on new security pact', Reuters News, 27 November 2006.
[62]Panetta 2012, 2.
[63]Carter 2016.
[64]Blau 1964; Bunte 2018a.
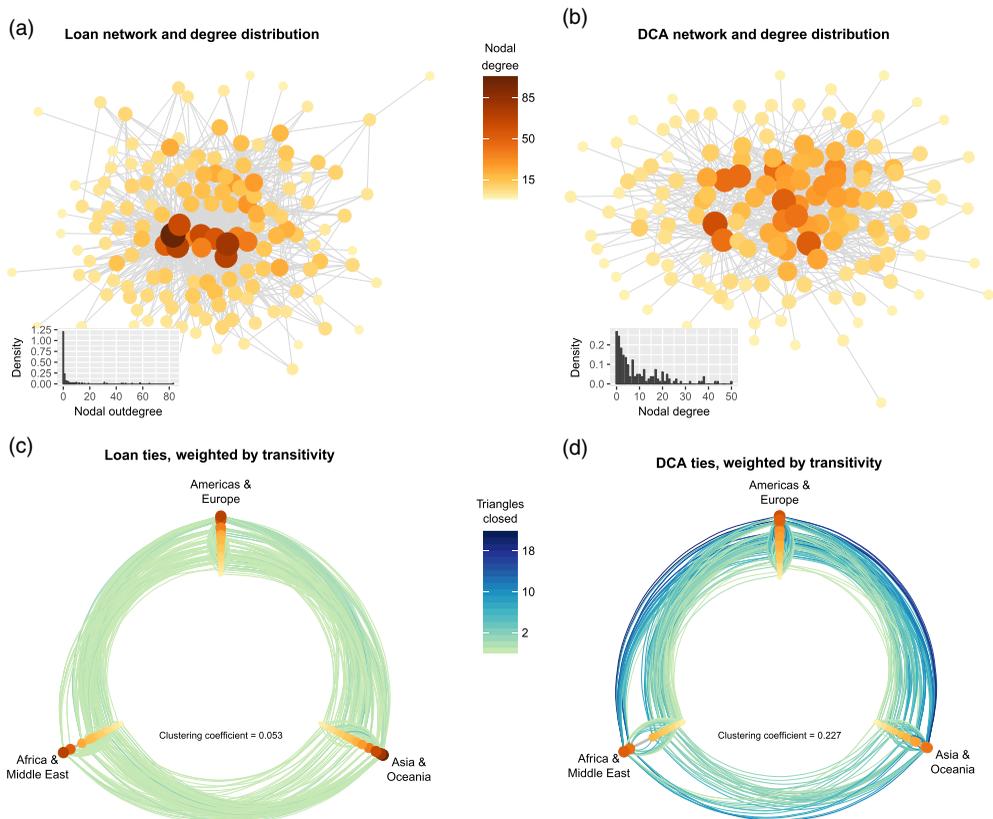[65]Cohen 2006.
[66]Winecoff 2015, 499.
[67]Lake 2009.
[68]'Sajid Javid to Lead High-Level Export Push to Iran', *Financial Times*, 9 March 2016.
[69]Rich 2010.
[70]Wang 1999.
[71]'China Backs Up Silk Road Ambitions with $62bn Capital Injection', *Financial Times*, 20 April 2015.

Figure 2. Topologies of the DCA and loan networks.
Note: Plots (a) and (b) illustrate loan network and DCA network, respectively; embedded plots are degree distributions. Plots (c) and (d) are hive plots of loan and DCA networks, with edge color determined by number of triangles closed.

the distribution indicates the frequency of these degrees. Figure 2a shows that a core of highly active creditors, or 'hubs', dominates the loan network. The degree distribution of this network is highly skewed, with few high-degree nodes and many low-degree nodes. The DCA network in Figure 2b, in contrast, is relatively flatter and lacks a clear core, with a smoother degree distribution, which is consistent with a network that is less hierarchical and more clustered.

The second row of Figure 2 uses hive plots to illustrate transitivity in the two networks. Transitivity, colloquialized as 'the friend of my friend is my friend', is typically measured by the number of 'triangles' in the network, defined as $\{ijk\}$ triplets of fully connected nodes, such as △. Transitivity is the smallest-scale representation of group cohesion. High levels of transitivity indicate that actors generally form ties to partners of partners and coalesce around clusters of collaborators. In Figures 2c and 2d, edge color corresponds to the number of triangles closed by each particular edge. The loan network shows little transitivity; the network-level clustering coefficient, which measures transitivity on a scale from 0–1, equals 0.05, which indicates that few closed triangles exist. The DCA network, in contrast, reveals an abundance of closed triangles and a substantially larger clustering coefficient.

Overall, the loan network tends toward a hub-and-spoke topography that is dominated by a handful of central actors, with few interactions among peripheral nodes. These features are emblematic of a *hierarchical* structure. In contrast, the DCA network's flatter topography and higher incidence of closed triangles reflects a network oriented more toward group connectivity

and 'small world' dynamics.[72] These distinct topologies reflect the macro-level incentives behind loans and DCAs; in the former case, governments use bilateral ties to establish hierarchical positions of authority, while in the latter case they use bilateral ties to establish cohesive affinity groups. Further, while many loans overlap with DCAs (and vice versa), as predicted by Hypotheses 1 and 2, there are clear divergences between the two networks. Over 80 per cent of loans go to countries that are not DCA partners, and nearly 80 per cent of defense partners do not have a lending relationship. These patterns suggest that the logic of bilateral incentives is limited, and that we must consider more complex cross-network influences.

How the structure of the DCA network affects bilateral lending

We first consider how the structure of the DCA network influences bilateral lending. A key question is whether DCA ties affect a creditor's ability to hierarchically impose its favored policies on debtors. *Ceteris paribus*, we anticipate that the more active a country is within the DCA network, the less susceptible it is to external influence. Because DCAs allow governments to build groups of defense collaborators, they reflect pre-existing commitments to specific partners, typically involving co-ordinated policies across a wide range of security, defense and military issue areas. These commitments in turn limit policy flexibility. Consequently, creditors' bilateral loans purchase relatively less influence over policy decisions when recipients are deeply embedded in the DCA network. We thus anticipate that the creditor's ability to exercise political leverage is inversely proportional to the debtor's *degree centrality* in the DCA network – that is, the debtor's number of signed DCAs. Figure 3a illustrates this empirical expectation, where a creditor i is more likely to lend to a government with few DCAs (j_2) than to one with many DCAs (j_1).

This expectation is consistent with the long-standing observation that powerful countries, such as net creditors, prefer partners they can easily influence.[73] For example, in the mid-2000s Japanese officials observed that Indonesia lacked extensive bilateral ties, 'in contrast to other ASEAN members, […] which seem to be falling under China's orb of influence'. Subsequently, Japan offered the Indonesian Government multiple loans, totaling 120.5 billion yen.[74] A similar logic motivates the US partnership with Thailand, which, like Indonesia in the mid-2000s, has signed very few DCAs. Loans to Thailand help maintain US influence, warding off 'increasing competition in this regard from China'.[75] In the view of US diplomats, these loans 'preserve political and economic security in the region and maintain a leading US role'. This logic yields a straightforward hypothesis:

Hypothesis 3: Creditor governments avoid loan partners that are highly active in the DCA network.

Some features of the DCA network *increase*, rather than decrease, the probability of new loans. Hypothesis 2 argued that governments use loans to directly improve their partners' defense capacity. This bilateral logic readily extends to the multilateral context. Consider DCA partners i and k, as illustrated in Figure 3b. By co-ordinating their lending policies and making loans to the same j_1 debtor, i and k are able to simultaneously improve the capacity of an agreed-upon partner while reducing the odds of inadvertently propping up a rogue government or potential challenger. Indeed, precisely because bilateral loans improve military capacity, DCA partners should generally avoid making loans to disparate debtors. Instead, lending activities should converge on the debtors that best allow defense partners to achieve their broader goal of addressing non-traditional security threats. Put differently, a bilateral interest in improving the

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[72]Watts and Strogatz 1998.
[73]Keohane 1969.
[74]US Embassy in Japan, 'Japan Placing Importance On Ties To Indonesia', 11 May 2009.
[75]US Embassy in Thailand, 'Foreign Minister Kasit's Visit to Washington', 20 April 2009.
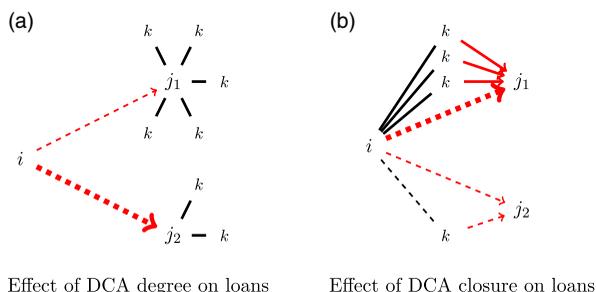
Figure 3. Anticipated effects of DCA network structure.
Note: Node *i* is the focal state; *j* nodes are potential partners; *k* nodes are third parties. Red lines are loans. Black lines are DCAs. Solid lines are current ties. Dashed lines are prospective ties; line thickness indicates probability of tie creation.

capacity of debtors percolates up to and reinforces the network-level interest in co-ordinating policies among clubs of like-minded defense partners. Figure 3b illustrates the empirical manifestation of this tendency, denoted 'DCA closure', where the presence of multiple *ik* DCAs entrains *i* and *k*'s respective loan ties and incentivizes a tie to j_1 over j_2. The more of *i*'s DCA partners that make loans to j_1, the more likely *i* is to do the same.

The historical record contains abundant examples of defense partners co-ordinating their lending activity on common debtors, such as efforts by the United States and Japan in the 1980s to boost South Korea's defense capacity. The United States and Japan are DCA partners, and the United States has a history of lending to South Korea. In 1983, Japan's prime minister signed a $4 billion loan to South Korea, deliberately co-ordinating with American lending activity. Tellingly, in a statement that reinforces the network-level motivations behind co-ordinated lending, North Korea condemned the move as a 'ruse to strengthen a "triangular" alliance between Japan, South Korea and the United States'.[76] We anticipate that, in an effort to co-ordinate security policies and improve the capacity of strategically valuable targets, defense partners mirror one another's bilateral lending activities.

Hypothesis 4:   Creditors lend to the same debtors as their defense partners.

How the structure of the loan network affects DCAs

The previous subsection analyzed how the structure of the DCA network shapes the likelihood of new loans. Here, we consider the influence of the loan network structure on DCAs. Note that these reverse influences do not necessarily mirror the influence of DCAs on loans, as the two networks differ sharply both in their topologies and in the network-level incentives to form ties. Instead, we simply ask how structural features of the loan network might affect states' ability to achieve their goals in the DCA network, either positively or negatively.

We first consider the effect of degree centrality in the loan network on the creation of new DCAs, as illustrated in Figure 4a. We anticipate that highly active creditors threaten governments' ability to form cohesive defense partnerships for two reasons. First, because active creditors worry that collusion among their debtors may prevent them from unilaterally exercising their policy interests, they work to impose hierarchical authority structures on subordinates, where peripheral nodes co-operate little among themselves. This asymmetric influence directly conflicts with DCA partners' emphasis on group cohesion and policy co-ordination, which explicitly requires co-operation among otherwise peripheral nodes. By relying on exercises of asymmetric authority in the loan network, active creditors' hierarchical interests conflict with the more group-oriented interests of defense partnerships. This tension implies that governments

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[76]'South Korean President to Make First Visit to Japan in 39 Years', *Washington Post*, 3 September 1984.
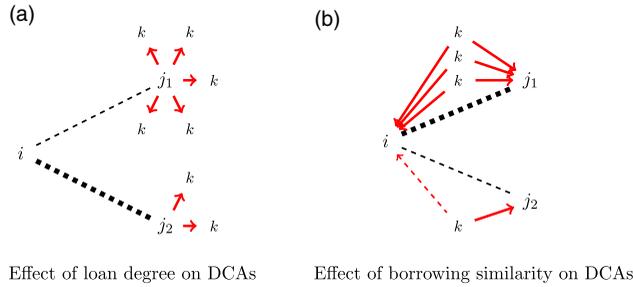
Figure 4. Anticipated effects of loan network structure.
Note: Node *i* is the focal state; *j* nodes are potential partners; *k* nodes are third parties. Red lines are loans. Black lines are DCAs. Solid lines are current ties. Dashed lines are prospective ties; line thickness indicates probability of tie creation.

that most ardently pursue the macro-level incentives of the loan network may find themselves unable to participate deeply in the DCA network.

Secondly, DCAs typically involve sensitive activities – such as joint exercises, information sharing and defense industry collaboration – that depend on mutual trust and compatible preferences. A government that strongly adheres to its unilateral interests presents a trust dilemma. For example, the United States is frequently frustrated by the financial activities of such long-time allies as Saudi Arabia, Turkey and Egypt. Indeed, those activities sometimes directly militate against US security interests. A key concern, then, in forming defense relationships with highly active creditors is that those creditors, at the extreme, may use their extensive financial ties – intentionally or not – to enhance the capacity of one's own adversaries. Forming defense partnerships that might indirectly benefit one's adversaries is, at best, politically imprudent; at worst, it poses a security threat.[77]

Overall, the disparate, hierarchical interests of active creditors are incompatible with – and potentially pose direct threats to – governments' structural goal of using DCAs to improve policy co-ordination among clubs of likeminded defense partners. We thus anticipate that as a *j* potential debtor's lending activity increases, *i* becomes increasingly concerned about *j*'s appropriateness as a defense partner. As illustrated in Figure 4a, this tendency effectively increases the probability of *i* signing a DCA with j_2 over j_1, *ceteris paribus*:

Hypothesis 5: Governments avoid signing DCAs with states that are highly active in the loan network.

Other characteristics of the loan network promise to *increase* the likelihood of new DCAs. When considering defense partners, governments must first ask whether those partners share their foreign policy goals and strategic interests. The similarity of governments' borrowing portfolios may be helpful in this regard. Figure 4b illustrates an influential structure in the loan network, where *i* and j_1 are both debtors of common third-party creditors, *k*. We anticipate that as *i* and a given *j* grow increasingly similar in their borrowing portfolios (by borrowing from the same creditors) they become increasingly likely to sign a bilateral DCA. As noted earlier, creditors attempt to exert authority over debtors' policies, typically by attaching conditions to loans.[78] These conditions may be political in nature, or they may involve economic requirements. For example, Western governments expect concessions on liberalization of trade and investment policy,[79] while China requires loan recipients to hire Chinese companies.

Importantly, the types of conditions attached to loans – and the subsequent policy concessions granted by debtors – differ systematically across creditors.[80] A borrowing portfolio that includes

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[77]Cf. Hufbauer, Schott, and Elliott 1990; Skalnes 2000.
[78]Bueno de Mesquita and Smith 2007.
[79]Bueno de Mesquita and Smith 2009.
[80]Bunte 2018b.

Brazil and China, for example, will entail different conditions and concessions than one that includes the United States and Germany. Policy co-ordination among defense partners is more difficult if those governments have conflicting security commitments. If, say, government i formally recognizes Taiwan while j does not, co-ordinating a joint ij security policy on Chinese island building or territorial claims in the South China Sea will necessarily be more difficult. A borrowing portfolio reveals not just the concessions a government has already made, but also its general bargaining position and preferences over types of political negotiations and demands more generally. This logic further extends to economic conditions. The greater the overlap in i and j's portfolios, the more similar the economic policy concessions they are likely to have made, which in turn encourages the sort of direct economic ties – such as trade and investment – that engender defense co-operation.

This similarity in borrowing may go so far as to encourage political defiance against common third-party creditors. That is, while creditors favor hierarchical authority and disfavor colla-boration among peripheral nodes, debtors are not idle bystanders. They recognize creditors' interest in hierarchy, and they may prefer greater autonomy. Defense agreements provide a valuable means of protecting one's policy interests against external influence. Governments in structurally similar positions offer the greatest potential for defense collaboration, as they are likely to share an interest in using defense ties as a bulwark against a potentially meddlesome creditor. In the 1990s, for example, numerous South American governments proposed political integration as a way of projecting 'a single voice vis-á-vis the United States'. For Bolivarian governments in particular, integration became 'an element to promote 'autonomy' and to 'transform the region into a political player not subordinated to the unipolarism that the United States represents'.[81] Diplomatic evidence shows extensive discussions on this topic. At a 2011 summit, defense ministers from Argentina and Brazil advocated a 'security commu-nity' among South American governments, 'ready to repel possible threats outside the subcontinent'.[82]

Hypothesis 6:   Countries with similar borrowing portfolios are more likely to sign DCAs.

Data and Research Design

We analyze loan and DCA data for the 1990–2010 period. The online appendix provides extensive information on data collection. We operationalize each longitudinal network as a $T = 21$ stack of matrices, where an $y_{ij,t} = 1$ entry in a given $\mathbf{y}_t$ loan network indicates the presence of a loan tie, and an $x_{ij,t} = 1$ entry in a given $\mathbf{x}_t$ DCA network indicates the presence of a DCA tie. Note that the DCA network is symmetric ($x_{ij,t} = x_{ji,t}$), while the loan network is asymmetric ($y_{ij,t} \neq y_{ji,t}$).

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. We thus cannot simply treat one network as an exogenous covariate in a traditional regression model. Secondly, 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.[83] Similarly, the creation of DCAs among some states incentivizes DCA creation among others.[84] These dependencies violate the basic assumption, common to most regression models, of independent and identically distributed data. Any such dependencies must be properly modeled in order to obtain unbiased estimates of cross-network effects.

[81]Briceno Ruiz 2010.

[82]'Brazil / Argentina / Mil / Tech - Defense Ministers meet and discuss cooperation', *The Global Intelligence Files*, 30 August 2011.

[83]Bunte and Kinne 2017.

[84]Kinne 2018.

We model the coevolutionary dynamics of loan and DCA networks using a modified stochastic actor-oriented model (SAOM) of network evolution,[85] which has been fruitfully applied to other areas of international relations.[86] 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 the observed networks as closely as possible. A standard SAOM relies on a single nodal utility function, $f_i(\mathbf{x})$, which is assumed to apply identically to all nodes in network $\mathbf{x}$. By 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 coevolving networks, we consider an additional network, $\mathbf{y}$, with a separate corresponding utility function. We thus simultaneously 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.[87]

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. *DCA Bilateral* measures the tendency for i to make loans to current DCA partners, which tests Hypothesis 2. *DCA Degree$_j$* captures the influence of a potential loan partner's position in the DCA network on i's probability of making a loan, which tests Hypothesis 3. A negative parameter estimate here indicates that as j's DCA ties increase, it becomes less attractive as a debtor. *DCA Closure* incorporates i and j's mutual ties to relevant k third parties, which tests Hypothesis 4. A positive estimate here 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 $f_i^X(\mathbf{x}, \mathbf{y})$ function, where DCA ties are the dependent variable of interest, we similarly include cross-network effects. *Loan Bilateral* measures the tendency for i to sign DCAs with its current loan partners, which tests Hypothesis 1. *Loan Outdegree$_j$* operationalizes states' overall lending activity in the loan network, which tests Hypothesis 5. Finally, *Loan Similarity* measures the similarity of i and j's respective borrowing portfolios, which tests Hypothesis 6. The online appendix provides additional details on the SAOM and gives formal definitions for each of the network effects.

We also model endogenous influences *within* each of the respective DCA and loan networks. Both the loan and DCA equations include an endogenous transitivity term, which accounts for governments' tendency to make loans or sign DCAs with 'friends of friends'. In keeping with the logic of network interests, we expect a negative parameter estimate for transitivity in the loan network and a positive estimate in the DCA network.[88] The DCA equation further includes a degree term, while the loan equation includes indegree and outdegree terms, all three of which control for the relative activity of nodes. Finally, the DCA equation includes an 'isolates' term, which accounts for the relative sparsity of the DCA network.[89] These various endogenous terms improve inference by ensuring that estimated cross-network effects and covariates are not epiphenomenal to endogenous network dynamics.

In addition, we include a battery of control variables. In the DCA equation, we control for (1) *Military Factors*, which include military power, shared terrorist or interstate threats, NATO membership, membership in non-NATO alliances, and partnerships between NATO and Partnership-for-Peace governments; (2) *Political Factors*, which include regime type, affinity of voting in the UN General Assembly (UNGA), former colonial ties and geographic distance; and (3) *Economic Factors*, which include per capita gross domestic product (GDP), bilateral trade and complementary arms industries.

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[85]Snijders 2005.

[86]For example, see Chyzh 2016; Kinne 2013; Kinne 2016; Warren 2010; Warren 2016.

[87]Snijders, Lomi, and Torlo 2013.

[88]Bunte and Kinne 2017; Kinne 2018.

[89]The loan equation also includes a reciprocity term, which is fixed at an arbitrarily low value to reflect the lack of reciprocal ties in the loan network.

In the loan equation, we control for (1) the *Creditor's Motivation to Lend*, which includes the creditor's per capita GDP, current account and propensity to contribute to multilateral institutions; (2) the *Debtor's Motivation to Borrow*, which includes the debtor's per capita GDP, current account, propensity to borrow from multilateral institutions and propensity to borrow from private lenders; (3) the *Economic Attractiveness of Debtors*, which includes the debtor's credit rating, oil reserves and exposure to investment by private foreign banks, as well as indicators of debt, banking, and/or currency crises and measures of bilateral creditor–debtor imports and exports; and (4) the *Political Attractiveness of Debtors*, which includes similarity in regime type, UNGA affinity, former colonial ties, geographic distance and military alliances. The online appendix summarizes each measure in detail, lists data sources, discusses empirical expectations and provides summary statistics.

Empirical Analysis

Figure 5 presents the main results of our analysis, with estimates for the DCA equation (that is, with DCAs as the dependent network variable) in the left panel and estimates for the loan equation in the right panel. Dots are rescaled point estimates and lines are standardized 95 per cent confidence intervals. We note first that the endogenous network statistics, shown in the bottom rows of each forest plot, are consistent with our assumptions about the unique macro-level interests that define each network. In the DCA network, *Transitivity* exerts a significantly positive effect, confirming a tendency toward closure and 'friend of a friend' relations in DCA partnerships. In contrast, *Transitivity* in the loan network is significantly negative, while degree effects are positive and extremely strong; together, these estimates indicate that tie formation in the loan network depends heavily on highly active hubs, with an aversion to transitive closure.

Hypotheses 1 and 2 anticipate a reciprocal relationship between DCAs and loans at the bilateral level. The estimates for *DCA Bilateral* in the right panel and *Loan Bilateral* in the left
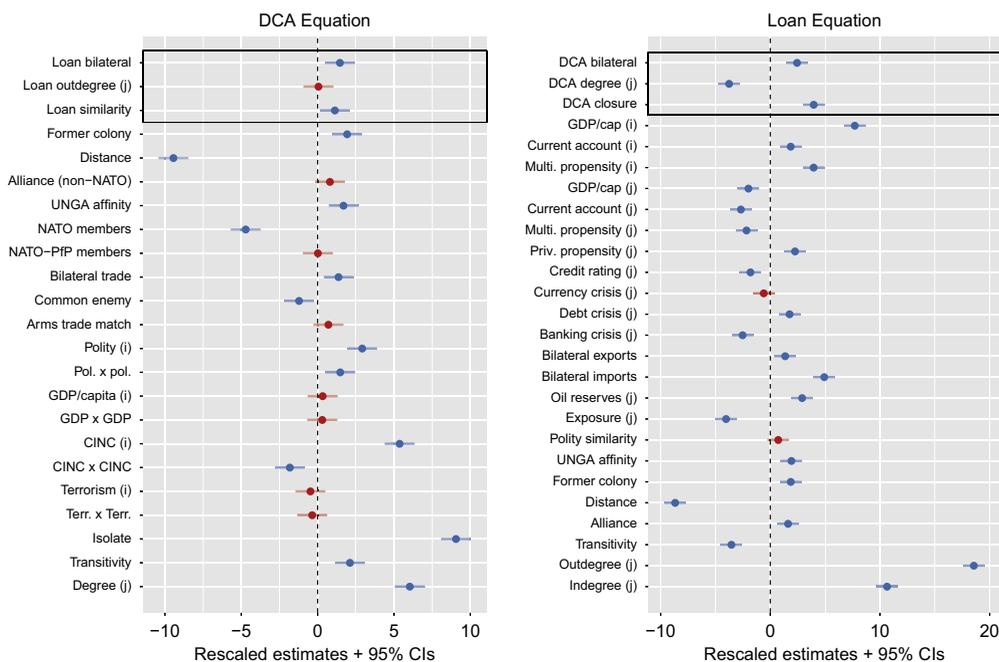
Figure 5. Stochastic actor-oriented model of DCA-loan coevolution, 1990–2010.
Note: dots are rescaled parameter estimates. Lines are standardized 95 per cent confidence intervals. Estimates in blue are statistically significant at the 5 per cent level. All convergence diagnostics < 0.1. See the online appendix for raw estimates and further diagnostics.

panel are both positive and statistically significant, which supports both dyad-level hypotheses. Substantively, a bilateral loan increases the probability of a bilateral DCA by about 33 per cent.[90] Reconsider the hypothetical scenario in Figure 1a. All else equal, i is about 33 per cent more likely to form a DCA with j_1 over j_2. Note that this effect is over three times as strong as the effect of (non-NATO) defense pacts, which increase the probability of a DCA by just under 10 per cent. The reverse effect is even stronger. A bilateral DCA increases the probability of a bilateral loan by over 77 per cent, all else equal. This effect is greater than the effect of former colonial ties and over twice 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 cross-network structural influences. The estimate for *DCA Degree (j)*, in the right panel, is negative and highly significant, which supports Hypothesis 3's contention that creditors avoid lending to governments that occupy central positions in the DCA network. Substantively, a potential debtor with one DCA membership is about 16 per cent less likely to be selected as a loan partner than a potential debtor that has no DCA ties. This effect compounds as the number of nodal ties increases. For example, in the hypothetical illustration in Figure 3a, node j_1 has five DCA ties while node j_2 has only two. All else equal, i is about 40 per cent less likely to lend to j_1 than to j_2. As expected, governments prefer not to lend to debtors that are highly active in the DCA network, likely due to the inherent difficulty of exercising hierarchical influence over such countries.

We also find strong support for Hypothesis 4, as reflected by the positive and significant estimate for *DCA Closure* in the right panel. 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 20 per cent more likely, all else equal, to extend a loan to j than if either the ik DCA or the kj loan is not present. Because a given i may have many third-party DCA partners, the substantive impact of this effect can grow quite large. For example, if three of i's DCA partners extend loans to j, i is nearly 80 per cent more likely to follow suit (that is, compared to a j that receives no loans from i's DCA partners). As hypothesized, DCA partners co-ordinate their foreign security policies in order to better achieve their network interests.

Turning to the DCA network as the dependent variable, the parameter estimate for *Loan Outdegree*, shown in the left panel of Figure 5, is indistinguishable from zero. Thus we find no support for Hypothesis 5. However, the estimate for *Loan Similarity* is positive and significant. To understand the substantive significance of this result, reconsider Figure 4b. In that hypothetical, the borrowing portfolios of i and j_1 perfectly overlap, while the portfolios of i and j_2 are exclusive. Based on the parameter estimate for *Loan Similarity*, i is nearly 40 per cent more likely to form a DCA with j_1 than j_2, *ceteris paribus*. This result supports Hypothesis 6's argument that debtors glean information about one another's suitability as defense partners from their financial ties to third parties. The more similar i and j are in their borrowing portfolios, the more likely they are to share an interest in using formal agreements to co-ordinate their security policies.

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 model's results justify its complexity? To assess the value-added of the SAOM, we employ Kinne's out-of-sample prediction technique, 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.[91] We reserve the year 2010 as the validation set, and we use the prior 1990–2009 period as the training set. Thus we predict

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[90]Note that SAOM parameters are similar to log odds ratios and can be interpreted accordingly. See Ripley, Snijders, and Preciado (2012). The interpretations here are based on the non-rescaled estimates, available in the online appendix.

[91]Kinne 2013.
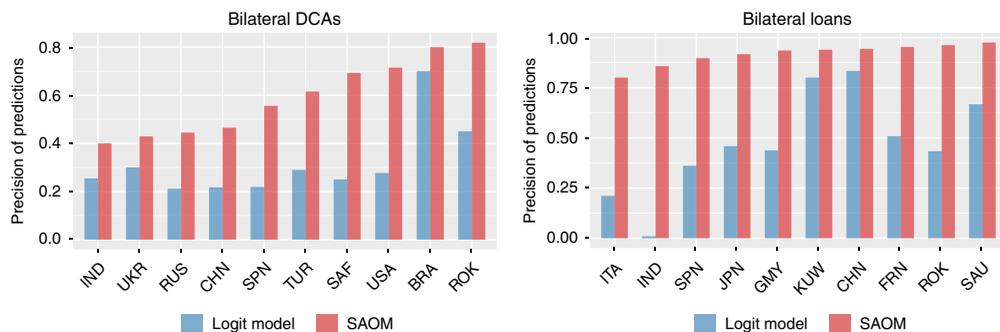
Figure 6. Out-of-sample predictions for individual countries, 2010.
Note: Out-of-sample prediction of each country's total 2010 DCA or loan ties, using 1990–2009 as the training set.

loans and DCAs in 2010 using estimates drawn from prior years. As suggested by Dorussen, Gartzke and Westerwinter, we compare these results to predictions generated by two separately estimated logit models (that is, with DCAs and bilateral loans as dependent variables).[92] The logit models include the same exogenous covariates as the respective SAOM equations, as well as an AR1 autocorrelation term, but without endgeonous network terms or higher-order cross-network terms. The goal is to compare the SAOM to the most common alternative modeling strategy.

We used the out-of-sample predictions to fit a series of receiver operating characteristic (ROC) and precision-recall (PR) curves, and we compared the area under the curve (AUC) for each model. For the DCA equation, we found that the standalone logit model yielded AUCs for the ROC and PR curves of 0.85 and 0.17, respectively, which increased to 0.97 and 0.76 in the coevolutionary SAOM. For the loan equation, the standalone logit model yielded AUCs for the ROC and PR curves of 0.95 and 0.29, respectively, which increased to 0.98 and 0.87 in the SAOM. We also compared the logit model and multi-equation SAOM to two separately estimated SAOMs, where the DCA and loan networks are assumed to evolve endogenously but not across networks. The single-equation SAOMs also improve goodness of fit dramatically over the logit model – though the coevolutionary SAOM yields a better fit. The online appendix provides the ROC and PR plots and a thorough discussion of the out-of-sample prediction technique.

To concretely illustrate the SAOM's dramatic improvement in fit over conventional regression models, we selected the ten most active countries in each of the DCA and loan networks, and we compared the logit model's and coevolutionary SAOM's predictions for each country's respective DCA and loan portfolios. Given that both networks are relatively sparse, and that predicting zero values in these networks is much easier than predicting positive events, we use positive predicted value (PPV) as our key metric, which is simply the ratio of the model's true positive predictions to its total positive predictions. Figure 6 illustrates the results. A PPV of one indicates that all of the model's positive predictions are correct (that is, there are no false positives). The PPVs for the SAOM's bilateral loan predictions are extremely high, while the logit model's precision is generally quite low. For example, the SAOM predicts South Korea's 2010 loans with nearly 100 per cent precision, while the logit model's PPV is less than 45 per cent. The SAOM's PPVs for the DCA network are less impressive, but in each case the SAOM nonetheless more accurately predicts bilateral defense co-operation than does the logit model – in some cases, such as South Africa and the United States, by dramatic margins. The superior fit of the SAOM is due to a combination of factors, including the simultaneous modeling of DCAs and loans at the bilateral level, the simultaneous modeling of DCAs and loans at the cross-network level, and the inclusion of endogenous network influences.

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[92]Dorussen, Gartzke, and Westerwinter 2016.

Conclusion

The case of Kyrgyzstan, with which we opened this article, readily illustrates bilateral linkages. Russia provided loans to Kyrgyzstan and successfully maintained a defense relationship, while the United States withheld loans and found its defense relationship severed. But this case also raises the interesting question of why the US Government, which almost certainly recognizes the allure of bilateral issue linkages, failed to deliver even a single loan to Kyrgyzstan. Examining higher-order cross-network effects allows us to answer that question. Kyrgyzstan is quite active in the DCA network, having signed multiple agreements with Russia, Ukraine, Belarus, Turkey, China, India and many of its central Asian neighbors. Between 2000 and 2010, Kyrgyzstan signed over seventy DCAs. Further, relatively few of the United States' own DCA partners lend to Kyrgyzstan. While the Kyrgyz Government did receive loans from Japan and South Korea (both long-time US defense partners), its primary creditors, by far, were Russia and China, having received multiple loans from both countries. Together, these factors pose a structural challenge for the United States. Kyrgyzstan's high number of defense ties mean that it is less susceptible to the sort of asymmetric political influence that loans provide. Indeed, diplomatic evidence shows that US interests in Kyrgyzstan were routinely at odds with the Kyrgyz Government's commitments to its other defense partners.[93] At the same time, few US defense partners have singled Kyrgyzstan out for financial attention, which means there is little pressure for policy co-ordination from similarly positioned third parties. Overall, despite an obvious bilateral need for defense co-operation (prompted, in this case, by the war in Afghanistan), the bilateral logics succumb to macro-level network interests.

The relationship between defense co-operation and economic co-operation remains a critical area of inquiry. The rise of new lenders, such as China and India, poses a formidable challenge to traditional creditors and represents a potential shift in the global financial architecture. Similarly, states face increasingly intimidating security challenges, including trafficking, cyberwar and transnational terrorism. Our analysis provides insights into complementary dynamics across issue areas. Although we address only defense co-operation agreements and bilateral loans, these two types of relations are particularly representative of governments' foreign economic and security policies. DCAs are now the most numerous form of defense co-operation, and bilateral loans offer a highly strategic avenue for connecting financial relations to political influence. At the same time, DCAs and loans pose few level-of-analysis problems. They are both strictly intergovernmental, which avoids complications of non-state actors, domestic politics and preference aggregation.

The simplest conclusion of this analysis is that 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 each other are non-trivial. Indeed, in some cases the cross-network influences are larger in magnitude than such traditional influences as geography, colonialism and military alliances. Nonetheless, the relationship between defense and financial ties remains complex. States must consider not only the pay-offs of bilateral ties, but also how those ties fit into their larger multilateral goals. In some cases, sufficiently strong structural interests doom the formation of new ties, even when bilateral incentives are strong. 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, and network theorists have long argued that interests must be defined broadly. Furthermore, the relationship between loans and DCAs almost certainly impacts other issue areas, such as trade, investment or militarized conflict. Ultimately, loans and DCAs are two layers in a global multiplex network structure. Theorizing and modeling this highly complex structure, despite substantial challenges, remains an essential avenue for future research.

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[93]For example, US Embassy in Kyrgyzstan, 'Kyrgyzstan, Manas Air Base, and the SCO Summit: Food for Thought', 11 May 2007.

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