Moral Hazard in Hierarchical International Agreements: Bilateral Swap Agreements, Reserve Accumulation, and the Private Sector

by

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Arts in the Department of
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ABSTRACT

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Abstract

There are various sources of moral hazard in IPE. In this paper, I contribute by examining whether bilateral swap agreements (BSAs) cause moral hazard in central banks and the private sector. Using an original dataset on BSAs signed by all countries from 2008 to 2020 and incorporating social network analysis, I find that BSAs lead to lower reserves-to-GDP ratios in central banks on the periphery of the BSA network, while the private banking sectors behave more cautiously to make up for this increased risk. This study answers the long-debated question of whether BSAs cause moral hazard and is in line with studies that find moral hazard in the IMF and other forms of financial cooperation. Policymakers in the creditor states, the IMF, and states protected by BSAs should be aware of the adverse effects of BSAs. Additionally, I find some suggestive evidence that states on the periphery of the BSA network may be more likely to have currency crises, while less likely to have banking crises. Finally, this study highlights an important source of moral hazard in IPE, and more broadly, in international cooperation: besides asymmetric dyadic relations, states' latent roles in the full interaction network may shape their different roles and cause moral hazard. Hierarchical structures can induce moral hazard even when interactions are symmetric.

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1. Introduction

BSAs are bilateral agreements signed between central banks that ensure the unconditional exchange of reserves, and they serve as an important and actively expanding layer of the global financial safety net (GFSN) (Denbee et al., 2016). Since the 2008 crisis, more than 60 countries have participated in BSAs, signing nearly 300 agreements. It is also an alternative source of liquidity for countries suffering from "IMF stigma" (Grimes, 2011). Despite BSAs being increasingly important for global financial safety, it is unclear whether BSAs have unintended effects: What is the effect of bilateral swap agreements (BSAs) on central banks and the private sector? In this paper, I examine whether BSAs lead to moral hazard. Existing studies have failed to find evidence for moral hazard in BSAs following the assumption that moral hazard in international relations exist only when dyadic relations are asymmetric. I argue that states' latent roles in the interconnected network constitute an important source of moral hazard, regardless of the relationship being symmetric or asymmetric in nature. States on the periphery of the network share less responsibilities for cooperation, and thus can have moral hazard. Additionally, such roles could be captured by states' centrality in the network. In the case of BSAs, do central banks on the periphery of the BSA network have lower reserves-to-GDP ratios, and do private sector commercial banks in these states respond similarly by having lower levels of buffer compared to risk?

BSAs may cause moral hazard, which can instead lead to higher risks. This is because compared with IMF lending, BSAs are signed without conditionalities. Moreover, many creditor states are signing BSAs to protect states that are important to them, and thus states can expect extensions of BSAs regardless of their behavior (McDowell, 2012; Broz, 2015; Liao & McDowell, 2015). This together makes central banks that share less responsibilities for overall liquidity provision tend to depend on other states and experience moral hazard, leading them to forgo self-insurance. BSAs can also affect the private financial sector. One possible effect is that the commercial banks also observe protection from BSA creditor states and thus take on higher risk. However, it is also possible that commercial banks become more cautious because the central banks are forgoing self-insurance. In this study, I focus on the effect of BSAs on both central banks and the private sector by examining variation in reserves-in-GDP ratio and banks' buffer compared to risk. In addition, I also look at whether BSAs have real consequences beyond altering banks' behavior, for instance, if they change states' probabilities of having crises.

Using an original dataset collected on BSAs signed by all countries from 2008 to 2020 and combining network analysis with regression, I find that BSAs lead to lower reserves-to-GDP ratios in central banks protected by BSAs, while the private banking sectors become more cautious. I identify states' latent roles as being creditor states or protected states in the BSA system using network centrality scores. States with lower

centrality scores are more likely to be protected states because they are less responsible for overall liquidity provision. Incorporating network measures in the regression analysis, I find that BSAs lead to moral hazard in central banks in peripheral states, while the private sector banks adjust by acting more cautiously. Specifically, central banks on the periphery of the BSA network have lower reserves-to-GDP ratios, indicating that they forgo self-insurance when they can draw liquidity from BSAs in crises. Meanwhile, private sector banks instead choose higher levels of buffer compared to risk when the state is protected by BSAs. To account for potential endogeneity, I also examine whether both effects on central banks and the private sector still exist when only considering BSAs lasting three years or longer. Additional analysis is also displayed in the Appendix, which will be discussed later.

This paper contributes to the literature in three broad ways. First, over the past few decades, IPE scholars have probed the question of whether international financial institutions and cooperation reduce financial crises. Many studies argue that participating in international financial safety cooperation instead induces moral hazard and increases risk-taking behavior (Meltzer, 2000; Dreher & Vaubel, 2004; Lipscy & Lee, 2019; Kuroda & Kawai 2004; Kawai 2010; Grimes 2011; Aklin & Kern, 2019). This is also in line with studies warning moral hazard caused by ODAs (Goldsmith, 2001). This study contributes to this stream of literature by proposing that while many states are shying away from the IMF and seeking liquidity provision from BSAs, the problem of

moral hazard still exists. Additionally, I provide a complete picture of the process by extending the scope of interest to the private sector.

Second, this study speaks to the line of research on the importance of structural factors in international finance and highlights the importance of structural factors in IPE since states on the periphery of a hierarchical cooperation system may experience moral hazard. After the 2008 crisis, Oatley et al. (2013) argue that instead of flat "interdependence", the international financial system has a hierarchical structure. Therefore, a crisis at the center of the financial transaction network, which is the US, can easily result in a global financial crisis. In contrast, crises in peripheral states have little impact on global financial safety. Bauerle Danzman et al. (2017) find that even capital cycles in the US can lead to financial fragility in international finance. Following Oatley et al. (2013), Winecoff (2015), Drezner (2015), and Farrell and Newman (2019) further point out that the hierarchical structure of international finance can increase the central state's power. Fichtner (2017) also explored whether the US has managed to maintain a dominant role in this hierarchical system. My study argues that not only does the structure of financial transactions affect economic and political outcomes, but the structure of international financial cooperation can also have important implications. Specifically, in a "center-periphery" coordination system, states on the periphery are protected from risk and thus may experience moral hazard and behave more recklessly.

Third, this paper suggests an important source of moral hazard in IPE and international cooperation, which is states' latent roles in the full interaction network. Previous research has studied moral hazard in asymmetric dyadic interactions where some states are being protected explicitly, including in foreign aid (Brautigam & Knack, 2004), environmental protection cooperation (Petrakis & Xepapadeas, 1996), humanitarian intervention (Kuperman, 2008a; Kuperman, 2008b; Rauchhaus, 2009), defensive alliances (Narang & Mehta 2019; Ryou-Ellison & Gold, 2020) and the IMF (Lipscy & Lee, 2019). I argue that only examining dyadic relations is insufficient to uncover moral hazard and that states' responsibilities in the full network can shape their roles. To account for such responsibilities, we must take higher-order effects into consideration. Therefore, moral hazard does not depend on asymmetric interactions between states. In fact, states on the periphery of a hierarchical coordination network can have moral hazard even when interactions are symmetric in nature. The argument on network roles as a source of moral hazard in international cooperation can be potentially extended beyond the scope of this study.

The findings also offer important guidance for policymakers. First, they help policymakers in the powerful states understand the possible adverse effects of taking up too much responsibility in maintaining global financial safety. Creditor states have used BSAs as a policy tool to advance their own interests. The US provided BSAs during the 2008 financial crisis to prevent spillover effects from states that have close financial

connections to it (McDowell, 2012). Broz (2015) also finds that the US provides swaps to states that are important for US commercial banks. Besides the US, China also signed BSAs to protect trade and investment stability of states that are closely connected to it (Liao & McDowell, 2015). However, this study suggests that using BSAs to protect these states can instead lead central banks in those states to forgo self-insurance. Therefore, creditor states should sign BSAs with more careful consideration and attach possible conditionalities even if this may make some states shy away. Second, for the IMF, this study suggests that future IMF reforms should better balance between attaching conditionalities and making IMF lending attractive for member states. Many states have turned to BSAs because they find the conditionalities of IMF lending too unbearable. Therefore, while IMF conditionalities are imposed for long-term reform purposes, keeping conditionalities at an acceptable level should lead to better incentives compared with having states sign unconditional BSAs. Finally, for central banks in the protected states, this study suggests that the commercial banks are behaving more cautiously to make up for the central bank's reckless behavior. This can indicate over-cautiousness and undermine market efficiency. Thus, although BSAs ensure liquidity in crises, forgoing self-insurance is not without consequences for central banks. The result on financial crisis also suggests that peripheral states may be more likely to have currency crises, while they may be less likely to have banking crises. This is consistent with findings on moral hazard because currency crises are more likely to happen when

central banks have lower levels of reserves, and banking crises are more likely to happen when private banks take on higher risks. However, I do note that this result should be taken with caution. Nevertheless, peripheral states forgoing self-insurance and relying on central states can make the entire network more vulnerable to shocks.

This paper proceeds as follows: I first discuss moral hazard in BSAs and how networks shape states' latent roles to derive the hypotheses. In the following section, I introduce the data and methods used to test the hypotheses. Then I present the results of the models, which examine the effect of BSAs on central banks and the private sector, respectively, and discuss how the results support my arguments. I also suggest that states on the periphery of the BSA network may be more likely to have currency crises, while less likely to have banking crises. The last section concludes with a discussion of limitations of the study and opportunities for future research.

2. Theory

2.1 Moral Hazard and International Cooperation

Moral hazard refers to the possibility that when agents are protected from certain risks and dangers, they are instead more likely to take reckless behaviors and induce higher risks than before (Kuperman, 2008a). Studies have considered moral hazard as one of the most important factors leading to the failure of international institutions and cooperation. On the one hand, moral hazard makes international cooperation fail to achieve its original goals since a higher risk is in fact induced although certain arrangements initially aimed to decrease risk; on the other hand, when facing moral hazard, states become more reluctant to engage in deep cooperation due to fear of getting "entrapped" (Snyder, 1984). The literature has documented various contexts in which moral hazard plays a role in international relations. Studies on foreign aid suggest that aid recipients will be more reluctant to reform because the government bears little responsibility for development outcomes (Goldsmith, 2001; Brautigam & Knack, 2004; Knack, 2004). In international environmental cooperation, Petrakis and Xepapadeas (1996) argue that states are subject to moral hazard, making them emit even more. Kuperman (2008a), Kuperman (2008b), and Rauchhaus (2009) also find that humanitarian intervention can instead foster rebellion by guaranteeing to protect civilians from genocide. Since the intervention is often too late to stop genocides, this instead makes genocides happen more frequently. Defensive alliances also suffer from

moral hazard. In defensive agreements between nuclear and non-nuclear states, nuclear umbrellas can lead non-nuclear states to take more risky behavior and experience more conflicts (Narang & Mehta 2019; Ryou-Ellison & Gold, 2020).

Similarly, in international finance, studies on the IMF argue that although the IMF has seemingly "hard" conditionalities, states will be reluctant to take reforms ex-ante if they hold the expectation of receiving IMF lending in crises (Meltzer, 2000; Dreher & Vaubel, 2004). Building on this literature, Lipscy and Lee (2019) further add that this effect is heterogeneous among lenders, with states having greater political influence in the IMF more reliant on IMF lending and thus taking riskier financial policies and experiencing more crises. Similarly, studies on regional financial arrangements also claim that moral hazard can be induced, reducing states' incentives to reform and take cautious policies (Kuroda and Kawai 2004; Kawai 2010; Grimes 2011). Aklin and Kern (2019) further find similar effects in the US's bilateral bailouts.

With the proliferation of BSAs, there is also a growing concern that BSAs, similar to the IMF and regional financial arrangements, might lead to moral hazard (Aizenman et al., 2010; Denbee et al., 2016; Vaughn, 2019). BSAs cause moral hazard for similar reasons as the IMF, while the effect can be more salient. Since BSAs guarantee liquidity swapping, states that are less responsible for the overall liquidity provision are relative recipients of liquidity in the system and are thus protected from liquidity shortages. While IMF lending is accompanied by conditionalities and future lending can be cut off

if the recipient behaves badly, BSAs do not have any conditionalities attached. When states can receive unconditional liquidity through BSAs, they have lower incentives to accumulate reserves for self-insurance purposes. However, while studies and policy reports suggest possible moral hazard in BSAs, there has not been a thorough empirical study on this topic.

One study that has touched upon this question is Aizenman et al. (2010). Aizenman et al. (2010) analyzed 24 swap lines and argued that BSAs do not necessarily cause moral hazard, as states that signed BSAs with the US Federal Reserve, ECB, and the People's Bank of China did not reduce reserves significantly. Aizenman et al. (2010) explained this result with the highly selective process of the Fed in signing swaps, while it is also warned that moral hazard may still make states less willing to accumulate precautionary reserves as swap agreements deepen. However, evidence provided by Aizenman et al. (2010) does not ease concerns on BSAs causing moral hazard, and the debate continues (Denbee et al., 2016; Vaughn, 2019). First, this is because of its limited time scope, which failed to take the proliferation of BSAs after 2009 into account. Before 2009, 24 countries were included in BSAs, and only eight were included in Aizenman et al. (2010)'s dataset. In this paper, I expand the scope of the study to include all swap agreements signed after 2008, adding up to nearly 300 agreements and more than 450 country-year dyads by 2020. This should add to the validity and generalizability of the results. Second, to examine how BSAs affect banks' behavior, we must test the

hypotheses on long-duration BSAs. The theoretical claim is that BSAs cause moral hazard because states are guaranteed liquidity and bear no costs for increasing risk through dropping reserves. If this mechanism is at work, then we should observe long-duration BSAs causing moral hazard. There are two reasons for this: First, for BSAs signed for a few months or one to two years, the protected states will not forgo self-insurance because BSAs will expire soon, and they will then need to deal with the risk alone. In contrast, long-duration BSAs ensure long-term protection, and states can have incentives to behave recklessly. Second, states signing short-duration BSAs also worry that if they misbehave in the current period, their partner states will not renew the agreements when they expire. How short-term BSAs relate to banks' behavior, however, is not clear. On the one hand, moral hazard is not likely to be induced in peripheral states as discussed above; on the other hand, short-term BSAs are often signed when states are in crises, and this may lead to reverse causality. Considering central bank reserves, the former may indicate unchanged reserves in peripheral states, while the latter indicates lower reserves on the periphery and is hard to differentiate from moral hazard. Thus, I differentiate short and long-duration BSAs to not only achieve a more accurate estimate of the effect but also to ensure that the underlying theoretical claim is correct.

Third, the analyses of moral hazard in international relations are mostly focused on state actors. Following Lipscy and Lee (2019), I examine the effect of BSAs on central

banks. However, to fully uncover the effect of financial arrangements, it is necessary to also consider their effect on the private sector. It is possible that the private sector also experiences moral hazard, which will amplify the total risk induced by BSAs. Contrarily, the private sector may make up for the central banks' reckless behavior, which decreases total risk. It is also possible that the private sector is not affected.

2.2 Network Centrality and Moral Hazard

Centrality is a network measure that captures the relative importance of a node in the network. Common types of network centrality include degree centrality, closeness centrality, betweenness centrality, and eigenvector centrality. In international relations, network centrality measures the importance of individual states in different interactions and has been shown to match important theories and generate novel hypotheses in several ways (Hafner-Burton et al., 2009). First, states with high centrality in networks have a greater influence on other states, even if such influence is exerted unconsciously (Danzman et al., 2017; Oatley et al., 2013). Second, network centrality could be a source of social power, and states with high centrality can leverage this power to set agendas or coerce and marginalize other states (Beckfield, 2003; Beckfield, 2008; Carpenter, 2011; Winecoff, 2020). Third, states at the center of the network may also face greater constraints. According to Hafner-Burton, Kahler, and Montgomery, "access may impose

constraints on autonomy as well as offer opportunities for influence."[1] In this paper, I base the source of moral hazard in hierarchical international agreements on this third mechanism.

Previous studies on moral hazard in international relations are based on explicit asymmetry in certain relations and connections. As mentioned earlier, IMF lending is given to a recipient state, and nuclear umbrellas shield states without nuclear weapons. I argue that besides such explicit asymmetry in dyadic relations, states' different latent roles in the larger interconnected network can induce moral hazard as well. In the BSA network, a state's role as a creditor state or protected state cannot be identified without considering interconnection and higher-order effects. This is because states' liquidity provision responsibilities are not restricted to their direct BSA partners. Instead, states' role of lender-of-last-resort can be indirectly connected through their common BSA partner or even a partner's partner, etc.

To better illustrate this point, consider the following example: Before 2008, Iceland had just experienced a rapid expansion of banks and had high financial risks. In 2009, Iceland was severely affected by the global financial crisis, and countries that had high exposure to Iceland's financial system worried about contagion. Therefore, Denmark and Sweden maintained swap lines with Iceland in 2009, "*in order to contribute*

[1] See Hafner-Burton et al. (2009).

towards safeguarding the macroeconomic and financial stability of …Iceland,…"[2] In this case, Sweden and Denmark served as Iceland's foreign lender-of-last-resort. However, such responsibilities were also passed on to the US, which did not have a BSA with Iceland but was indirectly connected with it. The US had BSAs with both Sweden and Denmark in 2009. As the financial risk in Iceland was extremely high, Sweden and Denmark could suffer from reserves loss, and investors may start panicking as well. This can lead the US, which serves as a lender-of-last-resort for Sweden and Denmark, to sense greater liquidity provision pressure. Although the US was not directly connected to Iceland, its indirect connections through Sweden and Denmark could increase its liquidity provision responsibilities. In fact, such direct and indirect connections transferring responsibilities can extend to the full BSA network, so only considering direct BSAs states have signed is insufficient. Therefore, higher-order effects must be taken into consideration when analyzing moral hazard in international relations. States' latent roles as relative creditor or protected states are determined by their position in the global BSA network. The more that a state is directly or indirectly connected with other states through BSAs, the greater responsibility it shares in providing liquidity. This latent role in networks indicates an important source of moral hazard in international interactions besides the one based on asymmetry in relationships.

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[2] https://www.riksbank.se/globalassets/media/rapporter/riksbanksstudie/engelska/2020/the-riksbanks-measures-during-the-global-financial-crisis-2007-2010.pdf

Overlooking higher-order effects and such latent roles in the full network explains why previous studies had difficulty in identifying moral hazard in BSAs. While moral hazard could be found in asymmetric interactions even if we only look at dyadic relations, since asymmetry in dyadic relations itself constitutes a source of moral hazard, it is less likely in symmetric interactions. Indeed, previous studies on BSAs had to make arbitrary differentiations between states' creditor and protected roles. Aizenman et al. (2010) differentiate between liquidity providers and recipients by considering the US, ECB, and China as liquidity providers and Argentina, Brazil, Hong Kong, Hungary, Indonesia, Korea, Mexico, and Poland as recipients. Similarly, Vaughn (2019) considered all states signing BSAs with the US, Japan, and China as possible to have moral hazard. However, such differentiation can be problematic because BSAs are symmetric in nature. For example, Korea had swapped with both China and Malaysia in 2016. While its BSA with China might make it a protected state, it is more likely to be a creditor state in its BSA with Malaysia. Moreover, as discussed above, states' responsibilities for liquidity provision and maintaining financial safety extend beyond direct BSA connections to indirect ones. Therefore, analyzing moral hazard in BSAs by looking at dyadic connections not only produces an incomplete picture but can also be misleading. In fact, states signing BSAs are interconnected, and their susceptibility to moral hazard cannot be identified without considering higher-order effects and states' roles in the full network.

I conceptualize such roles as states' network closeness centrality, which measures how closely a node is connected with all other nodes in the network. A state with high closeness centrality is closely connected with other states in the BSA network. I argue that such states are more responsible for liquidity provision and, even more broadly, the financial safety of the whole system. Figure 1 is a plot of the BSA network in 2009, and the sizes of vertices are adjusted according to their centrality. Again, consider the example of Iceland, Denmark, Sweden, and the US mentioned above. The closeness centrality scores of the four states are 12*10-3, 16*10-3, 16*10-3, and 23*10-3, respectively. Being directly or indirectly connected to more states, the US is apparently a larger node with higher centrality than Denmark and Sweden, and Iceland is the smallest.

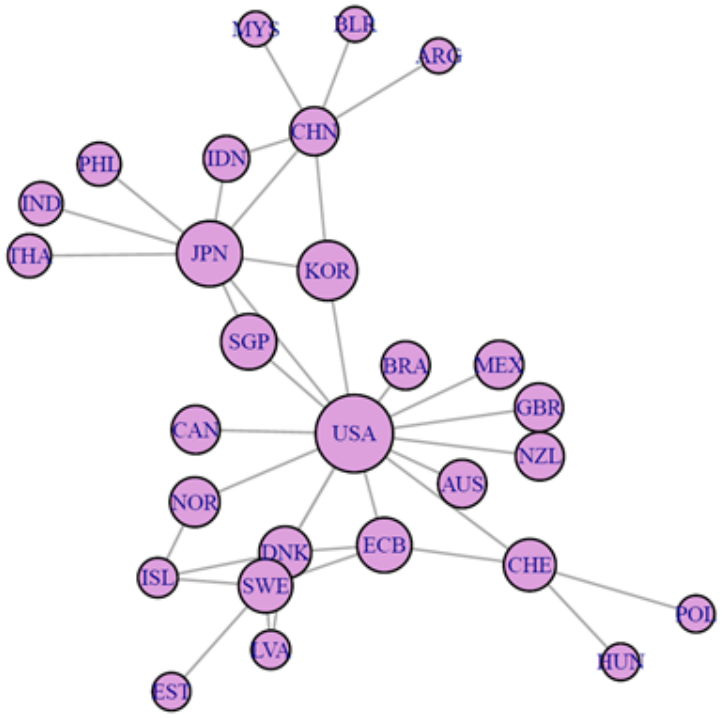

Figure 1: BSA Network in 2009

Specifically, states at the center of the BSA network share greater responsibilities for two reasons. First, central states have greater responsibilities in providing liquidity. A state drawing liquidity through swap lines due to a financial crisis can lead to a drop of reserves in its BSA network neighbors, which increases the liquidity provision pressure of those neighbor states' neighbors. In addition, such liquidity loss is not likely to be covered in a short time since states in crises often cannot repay timely, and they may even default as BSAs do not have conditionalities (Vaughn, 2019). Such a drop in reserves can be salient enough to generate pressures on third parties even when the creditor state has plenty of reserves. For instance, China had a BSA with Russia in 2014 when the latter was in a crisis, which led people to worry about whether China would suffer a huge loss.[3] As active BSA signatories, "*legislators in the United States, and even public commentators in China, have expressed concerns about the level of risk their respective central banks are taking in extending swap lines to certain nations.*"[4] Therefore, states at the center of the BSA network have greater pressure and responsibility to provide liquidity for the system, as it would be more directly caught responsible and affected when a random state in the network gets into crises. In contrast, a state on the periphery that is less connected with other states would be less responsible for liquidity provision when a crisis happens in other states.

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[3] See Yuan Xiong (Chinese Academy of Social Sciences)'s article on Tsinghua Financial Review. http://www.thfr.com.cn/m.php?p=10594

[4] See CFR: Central Bank Currency Swaps Tracker. https://www.cfr.org/article/central-bank-currency-swaps-tracker

Second, the responsibility of the central state extends beyond actual liquidity provision. As the international financial market expands, the cost for investors to collect information has increased rapidly. This leads investors to use aggregated information that is inferred from other markets' investor behavior or even mimic the behavior of investors in similar or related markets, which is called "herding" (Calvo & Mendoza, 1998; Calvo & Mendoza, 2000; Cipriani & Guarino, 2008). Herding is an important source of crises contagion, as investors in different markets follow each other's behavior. Since foreign reserves is the fundamental resource states use to deal with financial crises because states can stabilize their currency through repeatedly purchasing and selling their own currencies in the international currency market (Higgins and Klitgaard, 2004), states that are connected through BSAs either directly or indirectly are connected in their capability of dealing with crises. Therefore, it is highly possible that investors consider states connected through BSAs as closely related in terms of financial risk. For example, during the 2008 financial crisis, a swap line with the US helped calm South Korea's market and restored investors' confidence. In this case, it is not the actual amount of liquidity swapped that connects the two countries but the ability to deal with crises. The latter is important because it can translate into connected financial risk through investors' beliefs. According to Lee Seong-tae, the governor of the Bank of Korea, "*Fear had sparked excessive selling of the won. I hope the swap deal will stabilize not only the foreign exchange rates but also the entire financial markets.*" Indeed, it was "*a move that sent its*

battered stock market and currency up sharply on belief that the country's liquidity crisis may at last be easing."[5] Therefore, the BSA network is also a network of market calmness and investors' confidence. For states at the center of the BSA network, being more closely connected with all other states in the network, its market information is also more closely connected with other signatories. This makes the center states share greater responsibility in facilitating market calmness and sending signals to investors because they are more directly affected when other markets are unstable.

An alternative argument I should mention here is that crises can contagion through fundamental-based links. Kaminsky and Reinhart (2000) and others argue that contagion can arise from countries being linked by common bank lenders. This could lead to a counterargument that states at the periphery feel more at risk since crises are passed on through central nodes. However, this is not likely to be the case in the BSA network because BSAs are inactivated most of the time. Therefore, BSAs should be considered as precautious measures generating responsibilities and pressures instead of actual fundamental linkages.

States' positions in networks indicate that they play different roles in certain interactions (Hafner-Burton et al., 2009). As discussed above, states more closely connected with all other states through both direct and indirect BSAs have a greater

[5] S.Korea seals $30 billion swap deal with Fed, markets surge https://www.reuters.com/article/us-financial-korea-idUSTRE49T2CP20081030

responsibility of liquidity provision and boosting investor confidence. In contrast, states on the periphery of the BSA network are less connected with other states, and thus crisis or market instability in other signatories matter less for them, making periphery states less responsible. States' different positions in the BSA network determine their responsibilities in maintaining financial safety, and such responsibilities further shape their roles in the network. Specifically, states at the center of the BSA network play the role of creditor states that provide protection, while states on the periphery are protected states. The divide in states' roles further induces moral hazard. For the periphery states, sharing lower responsibilities and being protected from risk can lessen central banks' self-protection incentives and lead them to forgo self-insurance.

However, based on the network literature arguing that central nodes can draw more resources from the network (Colman, 1990), it could also be argued that states at the center of the BSA network should have moral hazard. This is because central states have greater access to liquidity in the network, and therefore should feel protected and behave recklessly. However, this is not likely to be true. In cases where states at the center of networks can access more resources like information-gathering networks (Hafner-Burton et al., 2009), states gain more with more connections with certainty. On the contrary, states do not need too many BSAs to deal with crises and having one or two lender-of-last-resorts is usually sufficient. This can be inferred from two facts: First, most countries only sign BSAs with only 1-2 countries with powerful central banks like

the US or China instead of signing as many BSAs as possible. Second, BSAs are usually not drawn to their caps. Therefore, a state more closely connected with all other states in the network does not necessarily mean that it is more "protected". A state's position in the network should thus be more related with responsibilities rather than resources.

As for the private sector banks, previous studies have argued that their risk-taking behavior is connected with the signals sent from the central bank. This is because the central bank acts as a lender-of-last-resort for private banks within a state, and thus private banks' behavior will depend on how much protection the central bank is able to provide. For instance, if the central bank dedicates itself to stabilizing the exchange rate, then private sector banks may feel more secure and take on higher risks (Burnside et al., 2001; Dooley, 2000). However, when considering the effect of BSAs, the behavior of private banks is still uncertain. Banks in peripheral states may behave more cautiously because they observe the central banks acting more recklessly. Since the central bank is their lender-of-last-resort, the private banks may turn to increase self-protection. It is also possible that they take on higher risks because BSAs guarantee liquidity provision, and thus banks feel more secure regardless of the central bank's behavior. Finally, it may be the case that private sector banks remain unaffected after the interaction of the two different effects.

Therefore, I expect moral hazard caused by BSAs in central banks on the periphery, while the effect on the private sector is unsure. To distinguish the effect of

moral hazard from reverse causality caused by states being protected because they are likely to have crises in the first place, I also expect both effects to exist when only considering long-duration BSAs because short-duration BSAs are usually signed with crises in sight. Additionally, for both central banks and the private sector, the effect caused by states' network roles should exist after taking the effect of dyadic BSA connections into account.

Hypothesis 1: *In a comparison of central banks in states with long-duration BSAs, those on the periphery of the BSA network will be more likely to have lower reserves-to-GDP ratios.*

Hypothesis 2 (horse-racing): *In a comparison of private sector banks in states with long-duration BSAs, those on the periphery of the BSA network are likely to have higher/lower/same levels of buffer against risk.*

Since I argue that being on the periphery of the BSA network can lead to moral hazard, a closely related question is: Do BSAs only lead to changes in banks' behavior, or do they also have substantive economic consequences such as causing more frequent financial crises on the periphery? There are three major types of financial crisis, including currency crisis, banking crisis, and sovereign debt crisis. Following Lipscy and Lee (2019), I only consider currency crisis and banking crisis here, as sovereign debt crisis is less relevant.

As for central banks, since I predict those on the periphery to have lower reserves-to-GDP ratios and forgo self-insurance, this can lead these countries to be more likely to experience currency crises for two reasons (Li & Rajan, 2005). First, with lower levels of reserves, central banks have a weaker ability to defend their currency (Higgins & Klitgaard, 2004). As a drastic drop in currency rate is the definition of currency crises (Reinhart & Rogoff, 2009), and peripheral countries with lower reserves-to-GDP ratios will find it harder to stabilize their currency rates, they are more likely to experience currency crises. Second, high reserves can signal to investors that a speculative attack would be less likely to succeed, which helps prevent currency crises. A line of research is focused on how high reserves may even offset weak fundamentals in preventing a crisis. For instance, Tornell (1999) finds that investors did not target countries with either high levels of reserves or strong fundamentals in the Tequila and Asian crises. Therefore, since I predict that countries on the periphery of the BSA network are likely to have lower reserves, they are also more likely to experience currency crises.

For the private sector banks, banking crises happen when there is a widespread bank run (Reinhart & Rogoff, 2009). While the effect of BSAs on private sector banks is not certain yet, we can predict the peripheral countries' relative likelihood of having banking crises in different scenarios. Since the Z-score is a measurement of bank stability, a high Z-score would indicate a lower possibility of widespread bank insolvency, and thus a banking crisis is less likely to happen (Caprio & Klingebiel, 1996). Therefore, if

banks in periphery states turn out to be more cautious and have higher Z-scores, these countries would be less likely to have banking crises. On the contrary, if they become less cautious, a banking crisis is more likely to happen. Still, currency crises and banking crises are closely related. A cautious central bank may reduce the risk of bank runs because investors' confidence is restored, while bank insolvency can also relate to other types of crises. However, the effects discussed here are the most direct and dominant ones.

***Hypothesis 3**: In a comparison of states with long-duration BSAs, those on the periphery of the BSA network will be more likely to experience currency crises.*

***Hypothesis 4**: In a comparison of states with long-duration BSAs, those on the periphery of the BSA network will be more/less/similarly likely to experience banking crises.*

3. Data and Methods

3.1 Dependent Variables

To test hypotheses 1 and 2, two dependent variables are included in the model to capture the effect of BSAs on central banks and the private sector banks, respectively. The first dependent variable is reserves-to-GDP ratio, which is used to measure whether central banks forgo self-insurance. Previous literature measures central bank moral hazard caused by the IMF either by using government budget deficit and rate of monetary expansion or by using the reserves-to-GDP ratio (Dreher & Vaubel, 2004; Lipscy & Lee, 2019). Here, I use reserves-to-GDP ratio following the reasoning of Lane & Phillips (2000) and the recent operationalization of Lipscy and Lee (2019). This is because reserves are the central banks' most important tool to help deal with financial crises. Specifically, central banks stabilize their currency with reserves through repeatedly purchasing and selling their own currencies in the international currency market (Higgins and Klitgaard, 2004). Similar to the case where central banks act as the lender-of-last-resort for domestic financial intermediaries can lead the latter to hold fewer liquid assets, foreign central banks acting as the lender-of-last-resort can also lead protected central banks to drop reserves (Lane & Phillips, 2000). The data for reserves

and GDP are both from the World Bank's WDI database,[1] and the dependent variable ***reserves-to-GDP ratio*** is calculated as the proportion of reserves to GDP.

The second dependent variable is ***z-score***, which is used to measure the level of risk private sector banks take. Bank Z-score is calculated as:

$$z - score = \frac{ROA + \frac{equity}{assets}}{sd(ROA)}$$

Here, *ROA* is the return on assets, and the *equity/assets* ratio captures the proportion of assets owned by the bank (in contrast to liabilities). Thus, the numerator captures the bank's aggregate buffer against risk. The denominator is the standard error of ROA, which stands for the bank's risk. Consider an example: In this data set, a Z-score in the 25th percentile, which is around 7, indicates that the bank's capitalization and returns are seven times of its volatility of returns. In comparison, a Z-score in the 75th percentile, which is around 18, means that the bank's capitalization and returns are 18 times of its volatility of returns. With the same level of capitalization and returns, the former bank is willing to take on more than two times the risk that the latter bank is willing to take. Therefore, all else equal, banks with lower Z-scores are less cautious.

Z-score is widely used in the empirical finance literature as a measure of a bank's risk-taking behavior, and it is found to be highly associated with the possibility of bank failure (De Nicoló et al., 2006; Lepetit & Strobel, 2013; Hadad et al., 2011). For instance, in

[1] See https://databank.worldbank.org/source/world-development-indicators

Hadad et al. (2011), Z-score is used to measure bank insolvency risk. Similarly, time-varying Z-score measures are used to capture banks' probability of insolvency in G20 countries in Lepetit and Strobel (2013). In addition, although the calculation of Z-score is relatively simple, it is as informative as other complex measures (Chiaramonte & Poli, 2015). Building on this literature, this paper uses Z-score to operationalize private banks' risk-taking behavior. Since the unit of analysis in this study is country-year, I use aggregate Z-score of commercial banks on the country level, which is from the World Bank's Global Financial Development Database.[2]

To test hypotheses 3 and 4 on whether BSAs lead peripheral states to have financial crises, I use two dependent variables: ***currency crisis*** and ***banking crisis***. The currency crisis data is from the BFFS Project,[3] which documents the widely used data collected by Carmen Reinhart and others. The data on banking crisis is from the World Bank's Global Financial Development Database. Both variables are dichotomous variables indicating whether a certain type of crisis had happened in a given year.

3.2 Independent Variable

The independent variable in this study is a state's position in the BSA network. The data on BSAs is an original dataset collected from official documents of central banks and major media releases, covering all swap agreements signed from 2008 to 2020.

[2] See https://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database
[3] See https://www.hbs.edu/behavioral-finance-and-financial-stability/data/Pages/global.aspx

The data on BSAs signed by China is from Chen and Pang (2020), and the rest is collected by the author. To account for states' latent roles in the BSA network, I use network centrality to measure states' relative liquidity provision responsibility. In other words, I measure how directly other states can swap liquidity with a state.

Closeness centrality is calculated as:

$$Centrality = \frac{1}{average\ path\ length}$$

Here, *path length* is how many swap lines a state needs to pass to get to another state in the network.

Having a lower centrality indicates longer average paths so that a state is less connected with all other states. Thus, states with low centrality play a less important role in liquidity provision in the network. Through calculating centrality, states' roles as protected states are no longer identified dichotomously as 0 or 1 in asymmetric agreements such as aid and nuclear umbrellas. In contrast, states' roles are labeled on a continuous scale, with higher centrality implying that the state is at the center of the global BSA network and shares greater liquidity provision responsibilities, while states with lower centrality are protected states that are located on the periphery and depend on the center for liquidity provision. As shown in Figure 2, the distribution of centrality

scores is skewed.[4] Thus, I use the natural log of centrality scores as the independent variable to get an approximately normal distribution, which is denoted as ***log(centrality)***.

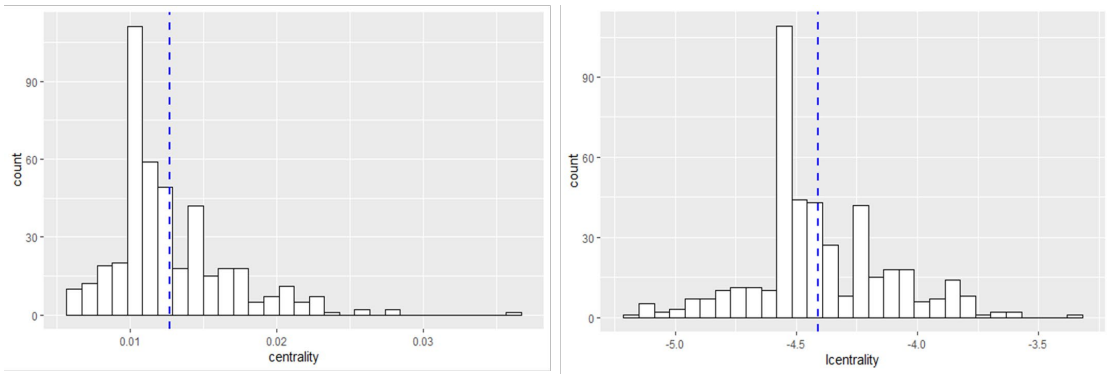

Figure 2: Histogram of Centrality Scores (left) and Logged Centrality Scores (right)

3.3 Dyadic Effect Variable

In order to estimate the effect of states' network roles on either moral hazard or financial crisis, it is necessary to exclude possible dyadic effects. Accounting for dyadic effects is important because the network role effect argued in this study is a higher-order effect, and we could be mistaking integrated dyadic effects as a network effect if they are not controlled in the analysis. Here, the dyadic effect of BSAs on states refers to the effect of its direct BSA partners. In other words, it only considers the BSAs a country actually has signed and ignores indirect connections. Since moral hazard is generated by states relying on BSAs to acquire liquidity and thus forgoing self-insurance, a dyadic argument could be made as: the more reserves a state's BSA partners have relative to itself, the

[4] The blue dashed lines in the two plots are the mean of the x-axis variables.

more likely its central bank will have moral hazard. On the contrary, if a state has relatively more reserves compared to its neighbors, then it is less likely to behave recklessly. Put into network terms, it means that the more reserves a node's network neighbors have relative to itself, the more likely the central bank will have moral hazard. Arguments on private banking sectors and financial crises can be made in similar ways.

Therefore, to measure the relative reserves a state's network neighbors have relative to itself, I construct a dyadic effect term ***nbratio***. It is calculated by first detecting all of a state node's network neighbors in a year, then adding up all reserves the neighbors had and dividing it by the reserves the state itself had. Since the data is also skewed, ***log(nbratio)*** is used in the analysis. Suppose state *i* has *q* neighbors, denoted by *j*. Then the dyadic effect of BSAs on *i* is calculated as:

$$\log\,(nbratio)_i = \log\,(\frac{\sum_{j=1}^{q} reserves_j}{reserves_i})$$

3.4 Control Variables

In addition, I control possible confounders in both models that are correlated with both the dependent and independent variables to reduce bias. First, GDP and GDP per capita are controlled because it is possible that developed countries are likely to share more responsibilities in the BSA network and have higher reserves and less risky banks at the same time. For the same reasons as the independent variable, GDP and GDP per capita are logged and appear as ***log(GDP)*** and ***log(GDP per capita)*** in the

model. Second, states with better macroeconomic foundations are likely to be liquidity providers and have higher reserves and less risky banks. Following previous literature, I use ***GDP growth***, which is the annual GDP growth rate, to operationalize this confounding factor (Demirgüç-Kunt & Detragiache, 2005; Kauko, 2012). Third, ***peg*** is a dichotomous variable that indicates the exchange rate regime. It equals 1 if the country has a pegged exchange rate, and 0 otherwise. Following Lipscy and Lee (2019), I also control ***log(export)*** and ***log(import)*** as they are correlated with both bank behavior and signing BSAs (Liao &McDowell, 2015). These two control variables are only used in testing hypotheses 1 and 2, as trade is more related to bank behavior rather than crises. Finally, ***crisis_1997*** is a dichotomous variable indicating whether the country is a major crisis country in the 1997 Asian financial crisis. Following Radelet et al. (1998), I identify Indonesia, Korea, Malaysia, the Philippines, and Thailand as the major crisis countries, while other countries are coded as 0. ***crisis_1997*** is controlled in models involving reserves, since countries that experienced the 1997 crisis often choose to maintain higher levels of reserves after 1997, while they are also more active in signing BSAs due to "IMF stigma".

Here, data on GDP, GDP per capita, GDP growth, export, and import are collected from the World Bank's WDI database. Data on the exchange rate regime is

from the Shambaugh exchange rate classification dataset,[5] which is not only used in economics studies but also widely used in the IPE literature (Copelovitch & Pevehouse, 2013; Leblang, 2010). Descriptive statistics of all the variables included in the two models can be found in Table 1 and Table 2. One problem in the control variables that can be observed from Table 1 is that the number of observations will decrease sharply when including ***peg*** in the central bank model. This is because there is missing data in ***peg***, and it is updated only to 2018. I deal with this problem by running separate regressions on the data with and without ***peg*** in the following section.

Table 1: Descriptive Statistics of Variables in the Central Bank Model

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
reserves-to-GDP ratio	433	0.224	0.203	0.002	0.107	0.263	1.440
log(nbratio)	433	3.625	2.030	-3.926	2.225	4.806	11.518
log(centrality)	433	-4.409	0.287	-5.165	-4.575	-4.248	-3.332
year	433	2,014.818	3.591	2,008	2,012	2,018	2,020
longterm	433	0.801	0.399	0	1	1	1
log(GDP)	433	26.554	1.926	21.286	25.696	27.875	30.696
log(GDP per capita)	433	9.514	1.236	6.693	8.429	10.717	11.482
GDP growth	433	2.299	3.969	-15.908	1.060	4.652	17.291
peg	348	0.198	0.399	0.000	0.000	0.000	1.000
log(export)	424	25.481	1.810	20.281	24.490	26.820	28.636
log(import)	424	25.514	1.716	20.819	24.622	26.723	28.769
crisis_1997	433	0.136	0.343	0	0	0	1

[5] See https://iiep.gwu.edu/jay-c-shambaugh/data/ and Shambaugh (2004).

Table 2: Descriptive Statistics of Variables in the Private Sector Banks Model

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
z-score	312	13.325	7.632	0.918	6.852	17.977	44.362
log(nbratio)	310	3.519	2.011	-3.926	2.171	4.787	9.241
log(centrality)	312	-4.342	0.292	-5.165	-4.543	-4.159	-3.332
year	312	2,013.157	2.848	2,008	2,011	2,016	2,017
longterm	312	0.763	0.426	0	1	1	1
log(GDP)	312	26.586	1.923	21.286	25.682	27.918	30.604
log(GDP per capita)	312	9.543	1.248	6.693	8.530	10.758	11.482
GDP growth	312	2.895	3.699	-14.629	1.313	4.972	17.291
peg	306	0.193	0.395	0.000	0.000	0.000	1.000
log(export)	306	25.520	1.809	20.281	24.507	26.823	28.532
log(import)	306	25.552	1.711	20.819	24.620	26.745	28.697

There are some differences in the descriptive statistics of the independent variable and control variables in the two models because data on reserves-to-GDP ratio is available from 2008 to 2020 while data for bank Z-score is only available from 2008 to 2017.

3.5 Method

The method used to test ***Hypothesis 1-2*** is OLS regression because both dependent variables are continuous. To test if the proposed effect still exists when considering only long-duration BSAs, I separate country-year observations into two groups: If an observation is in group **Long**, then all the country's BSAs active in this year

have durations of three years or longer. Otherwise, the observation is in group **Short**.[6] This is a conservative approach as discussed below. Put simply: it roots out the possibility of reverse causality brought by short duration BSAs, and only retains the possible moral hazard effect caused by long duration BSAs. I run models both in the complete dataset and in the **Long** sub-sample.

This is necessary because there is a threat of possible reverse causality in the central bank model. Countries may share fewer liquidity provision responsibilities because they are already in a crisis or have a high probability of experiencing crises. Since such BSAs signed during crises are usually short-duration agreements while long-duration BSAs are usually signed for precautionary reasons, long-duration BSAs should suffer less from reverse causality. For example, a typical 3-year long-duration BSA signed between the Bank of Korea and the Reserve Bank of Australia in 2014 mentioned that "*This agreement is designed to promote bilateral trade for the economic development of the two countries. In particular, the agreement will ensure that trade between the two countries can continue to be settled in local currency even in times of financial stress. The agreement can also be used for other, mutually agreed purposes.*"[7] In contrast, a typical 6-month short-duration BSA signed between the US and Singapore in 2008 was signed because "*In response to the heightened stress associated with the global financial turmoil, which has broadened to emerging*

[6] This separation is not arbitrary. In the total 290 BSAs signed, 113 of them have a 3-year cap which is "standard".

[7] http://www.bok.or.kr/eng/bbs/E0000634/view.do?nttId=197280&menuNo=400069

market economies, the Federal Reserve has authorized the establishment of temporary liquidity swap facilities with the central banks of these four large and systemically important economies."[8]

Another example is the bilateral agreements signed between the US, Canada, Japan, ECB, UK, and Switzerland. The six countries signed short-duration BSAs during the 2008 crisis and renewed them several times. After the crisis, those agreements were transformed into standing long-duration BSAs to prevent future crises. Besides dealing with this endogeneity problem, running the model on long-duration BSAs also provides a more accurate estimation of the causal effect since only long-duration BSAs are likely to cause moral hazard.

As mentioned above, I also run the regression both including and excluding ***peg*** in the central bank model to both take advantage of a larger N and take the confounding effect of the currency rate regime into account.

To test ***Hypothesis 3*** and ***Hypothesis 4***, I use logit regression since the dependent variables are dichotomous.

[8] https://www.federalreserve.gov/newsevents/pressreleases/monetary20081029b.htm

4. Results and Discussion

4.1 BSAs and Moral Hazard

As noted above, I test my hypotheses on two dependent variables to identify the effect of BSAs on the central banks and the private sector. The first model tests ***Hypothesis 1***, which focuses on the effect of BSAs on central banks. I expect a lower reserves-to-GDP ratio in states with lower ***log(centrality)*** in the BSA network when considering only long-duration BSAs. The results of the first model are displayed in Table 3.

Table 3: Bilateral Swap Agreements and Reserves-to-GDP Ratio[9]

	Dependent variable:				
	reserves-to-GDP ratio				
	All	All	All	Long	Long
	(1)	(2)	(3)	(4)	(5)
log(nbratio)	-0.017***	-0.080***	-0.077***	-0.084***	-0.087***
	(0.002)	(0.008)	(0.009)	(0.008)	(0.011)
log(centrality)	0.019	0.479***	0.417***	0.521***	0.464***
	(0.033)	(0.063)	(0.053)	(0.062)	(0.064)
log(GDP)		-0.246***	-0.245***	-0.207***	-0.214***
		(0.010)	(0.009)	(0.011)	(0.012)
log(GDP per capita)		0.011	0.011	0.029***	0.027**
		(0.012)	(0.014)	(0.009)	(0.012)

[9] All models use year-fixed/random effects based on the result of Hausman test with robust and clustered standard errors. Country-fixed/random effects are not included because many countries have only signed BSAs in less than 3 years, and this violates the common view that each group should have 5 or more observations (see http://web.pdx.edu/~newsomj/mlrclass/ho_sample%20size.pdf for more references).

GDP growth		0.005	0.006**	0.004	0.006*
		(0.003)	(0.002)	(0.003)	(0.003)
peg			-0.014		-0.046***
			(0.013)		(0.009)
log(export)		0.002	0.016	-0.049	-0.030
		(0.051)	(0.057)	(0.040)	(0.049)
log(import)		0.173***	0.161***	0.173***	0.159***
		(0.040)	(0.045)	(0.037)	(0.044)
crisis_1997		0.029**	0.028**	0.052***	0.038***
		(0.012)	(0.013)	(0.010)	(0.013)
Constant	0.371**				
	(0.151)				
Observations	433	424	341	338	268
Note:				*p<0.1; **p<0.05; ***p<0.01	

Models (1), (2), and (3) are analyses of the full dataset. Model (1) does not include any control variables, model (2) includes all control variables except ***peg***, since including ***peg*** leads to fewer observations. Model (3) is the full model with all control variables. The coefficients on ***log(nbratio)*** demonstrate the dyadic effect of BSAs on central banks. The negative and significant dyadic effect indicates that the more reserves a state's direct BSA partners have compared to itself, the lower the state's reserves-to-GDP ratio is. This is consistent with our expectations. Having taken this dyadic effect into account, the model tests the relationship between network centrality and central bank behavior. ***Hypothesis 1*** suggests that states on the periphery of the BSA network should have lower reserves-to-GDP ratios. This is because they forgo self-insurance when they are

relative liquidity recipients in the BSA network. The coefficients on ***log (centrality)*** in Models (2) and (3) are consistently positive and significant when control variables are added.

As noted earlier, I run the model in a dataset with only long-duration BSAs to substantiate my argument. Models (4) and (5) in Table 3 evaluate ***Hypothesis 1*** in the dataset that includes only long-duration BSAs. The coefficients on ***log (centrality)*** in Models (4) and (5) are both positive and statistically significant on the 0.05 level. In Model (5), it can be interpreted that reducing a state's centrality in the BSA network to its half leads to a 23.2-point decrease in its central bank's reserves-to-GDP ratio. Given that states' centrality scores in the BSA network range from 0.006 to 0.036, this hypothetical change is reasonable. Therefore, states on the periphery of the BSA network tend to have lower reserves-to-GDP ratios, and this effect exists in states with only long-duration BSAs. Furthermore, compared to Models (2) and (3), the effect is even stronger when considering only long-duration BSAs. This result supports ***Hypothesis 1*** and further shows that reverse causality is not driving the results. Thus, BSAs lead to moral hazard in central banks.

The confidence intervals of coefficients in Model (5) are visualized in Figure A.1 in the Appendix. Therefore, my results confirm the untested concern in the existing literature that BSAs can cause moral hazard (Aizenman et al., 2010; Denbee et al., 2016; Vaughn, 2019). Also, previous studies might be biased due to limited time scope,

arbitrary identification of protected states, and the failure to differentiate long and short-duration BSAs.

To further account for possible endogeneity as mentioned above, it should also be noted that network centrality is largely exogenous. This is because centrality scores are determined not only by a state itself but also by the connections of all other states in the network. One possible way that a state can control its centrality score is through deciding the number BSAs it signs since signing more BSAs leads to higher centrality. I provide a supplementary model controlling network degree (the number of BSAs a state has) in the Appendix, and the results consistently support my hypothesis.

I further test ***Hypothesis 2*** to examine the effect of BSAs on the private sector banks' risk-taking behavior. According to ***Hypothesis 2***, the effect of BSAs on the private sector is unknown, and there could be positive, negative, or null effects depending on the mechanism at work. If the empirical results show that private sector banks in states protected by BSAs pursue higher risk, then it indicates that the private sector experiences moral hazard similar to central banks. If they instead become more cautious, it suggests that the private sector observes the risky behavior of central banks and makes up for this increased risk. It is also possible that the private sector is not responding to this change. As noted above, I use bank Z-score to measure the risk-taking behavior of private sector banks, and a higher Z-score indicates more cautious behavior. The result of this model is displayed in Table 4.

Table 4: Bilateral Swap Agreements and Bank Z-score[10]

	Dependent variable:			
	z-score			
	All	All	Long	Long
	(1)	(2)	(3)	(4)
log(nbratio)	-0.822***	-0.357*	-0.715***	-0.149
	(0.131)	(0.213)	(0.146)	(0.261)
log(centrality)	4.031	-2.343***	-0.111	-3.738***
	(2.972)	(0.656)	(1.670)	(0.803)
log(GDP)		-0.472*		-0.853**
		(0.255)		(0.360)
log(GDP per capita)		1.550***		1.441***
		(0.310)		(0.278)
GDP growth		0.452***		0.505***
		(0.094)		(0.111)
peg		3.829***		4.233***
		(1.131)		(1.286)
log(export)		-13.685***		-12.209***
		(1.512)		(1.649)
log(import)		15.411***		14.460***
		(1.709)		(2.092)
Constant		-44.549***		-53.988***
		(9.447)		(13.756)
Observations	310	300	236	226
Note:				*p<0.1; **p<0.05; ***p<0.01

[10] Similar to the models on central banks, all models use year-fixed/random effects based on the result of Hausman test with robust and clustered standard errors.

Models (1) and (2) in Table 4 evaluate the effect of BSAs on the private sector banks in the full BSA dataset. Since the number of missing values in ***peg*** is much smaller than in the central bank model, I do not include a separate model that excludes ***peg***. The coefficient on ***log (centrality)*** in Models (2) and (4) are consistently negative and statistically significant when confounders are controlled. However, Models (1) and (2) on the full sample cannot differentiate countries that are protected and share fewer responsibilities because they are likely to have crises in the first place. In Model (4), I test ***Hypothesis 2*** on only long-duration BSAs, and the coefficient on ***log (centrality)*** remains negative and statistically significant. When a state's centrality score in the BSA network reduces to its half, its aggregate bank Z-score increases 1.869. Therefore, the results suggest a restatement of ***Hypothesis 2*** in the following way:

In a comparison of private sector banks in states with long-duration BSAs, those on the periphery of the BSA network are likely to have higher levels of buffer against risk.

Specifically, private sector banks in states protected by BSAs are likely to be more cautious, and they have higher buffer-to-risk ratios. This can be explained by the private sector observing central banks' risk-taking behavior and thus deciding to act more cautiously, which is consistent with the literature on how private sector banks base their risk-taking behavior on the central bank's behavior (Burnside et al., 2001; Dooley, 2000). The results here complicate the debate on moral hazard in BSAs and other forms of international financial cooperation in the literature. While BSAs lead to moral hazard in

central banks, the increased financial risk is to some extent made up by the private sector. Future studies should elaborate on how the balancing mechanism works in this specific context. Therefore, previous studies on this question that only discuss central banks are insufficient (Aizenman et al., 2010; Denbee et al., 2016; Vaughn, 2019).

Similar to the model on central banks, I visualize the confidence intervals of coefficients in Model (4) in Figure A.2 in the Appendix.

4.2 BSAs and Financial Crisis

To test the effect of BSAs on financial crisis, two models are employed. The first model's dependent variable is ***currency crisis***, and the second model's dependent variable is ***banking crisis***. The results are shown in Table 5.

Table 5: Bilateral Swap Agreements and Financial Crisis[11]

	Dependent variable:			
	currency crisis	currency crisis	banking crisis	banking crisis
	(1)	(2)	(3)	(4)
log(nbratio)	-0.088	0.018	0.201	-1.095***
	(0.142)	(0.277)	(0.193)	(0.319)
log(centrality)	-1.602	-1.969	0.201	3.166*
	(2.103)	(1.883)	(1.629)	(1.811)
log(GDP)	0.707	0.413	-0.079	-1.772***
	(0.145)	(0.326)	(0.226)	(0.575)
log(GDP per capita)	-0.189	-0.325*	0.300	-0.415
	(0.216)	(0.168)	(0.303)	(0.408)

[11] Similar to the models on central banks and private sector banks, all models use year-fixed/random effects based on the result of Hausman test with robust and clustered standard errors.

GDP growth	-0.193**	-0.108*	-0.343***	-0.408***
	(0.080)	(0.065)	(0.085)	(0.122)
peg	-15.889***	-17.383***	-0.343	-1.678**
	(0.660)	(0.853)	(0.085)	(0.709)
crisis_1997	-1.683***	-2.349***		
	(0.629)	(1.314)		
Observations	158	108	277	210
Note:			*p<0.1; **p<0.05; ***p<0.01	

Models (1) and (3) consider the full sample, while Models (2) and (4) only includes long-duration BSAs. In addition, Models (1) and (2) are on currency crisis, while Models (3) and (4) are on banking crisis. As shown in Model (2), having controlled dyadic effects, the coefficient on ***log(centrality)*** is negative. This suggests that states on the periphery of the BSA network are more likely to have currency crises, which provides some support for ***Hypothesis 3*** and is consistent with the implication of ***Hypothesis 1***. However, the coefficient is not statistically significant. Similarly, the coefficient on ***log(centrality)*** in Model (4) is positive and marginally significant on the 0.1 level. This suggests a restatement of ***Hypothesis 4*** as: *In a comparison of states, those on the periphery of the BSA network will be less likely to experience banking crises.* This is in line with the results on moral hazard and the private banks.

However, the findings on financial crisis here should be taken with caution. In Models (2) and (4), the sign of ***log(centrality)***'s coefficients are consistent with what was found in the full sample, but they are not significant on the 0.05 level. This may result

from a large amount of missing data on financial crisis. For example, in Model (3), the model on currency crisis and long-duration BSAs, among 346 observations, 217 observations had their data on currency crisis missing. This is both due to the data only being updated to 2016, and only 28 countries in the long-duration sample having data on currency crisis. Therefore, the findings on financial crisis show some support for ***Hypothesis 3*** and a restatement of ***Hypothesis 4*** consistent with the findings on moral hazard, but the coefficients are not significant, and they should be taken with caution. However, even if BSAs do not lead to more crises, hierarchy in the BSA network is still harmful for two reasons.

First, as the peripheral private sector banks become more cautious than usual, financial resources are stored as buffers against risk and are no longer efficiently distributed. This can do harm to the peripheral countries' growth. Second, even if we haven't seen peripheral countries experience frequent crises, an uneven distribution of cautiousness can make the system highly vulnerable. States are no longer protecting themselves, and thus the financial safety of the entire system is dependent on central states' liquidity provision. Therefore, when central states get into financial turmoil, it would soon spread across the network and cause a widespread financial crisis.

5. Conclusion

In this paper, I present an empirical study combining network analysis with regression to answer this question: What is the effect of bilateral swap agreements (BSAs) on central banks and the private sector? Using an original dataset on BSAs signed from 2008 to 2020, I find that being protected by BSAs leads central banks in these states to forgo self-insurance, while the private sector banks respond by having higher levels of buffer compared to risk. Specifically, central banks on the periphery of the BSA network tend to have lower reserves-to-GDP ratios, while the private sectors have higher bank Z-scores. This suggests that BSAs cause moral hazard in the central banks, while the private sector makes up for this increased risk by acting more cautiously. Additionally, there is some suggestive evidence for the implications of the moral hazard arguments: Peripheral states might be more likely to have currency crises and less likely to have a banking crisis, while this effect is not statistically significant. This is in line with findings regarding moral hazard, but the results should be taken with caution due to missing data and mixed results.

My findings speak to previous research on the IMF and regional financial arrangements leading to moral hazard (Meltzer, 2000; Dreher & Vaubel, 2004; Lipscy & Lee, 2019; Kuroda & Kawai, 2004; Kawai, 2010; Grimes, 2011). By analyzing BSAs, which is a rapidly expanding layer of the global financial safety net, I find that BSAs also lead to moral hazard. This not only provides empirical evidence for untested arguments on

BSAs in recent studies (Aizenman et al., 2010; Denbee et al., 2016; Vaughn, 2019) but also broadens the question by evaluating the effect of BSAs on both central banks and the private sectors. Furthermore, my study suggests that beyond hierarchy in financial transactions (Oatley et al., 2013; Bauerle Danzman et al., 2017), hierarchy in international financial cooperation can be hazardous as well. More importantly, this offers insights for the broader international relations literature: It is insufficient to analyze dyadic effects to identify moral hazard in international interactions. States' latent roles in the full interaction network can shape their responsibilities, and this can be a potential source of moral hazard. Therefore, moral hazard does not rely on asymmetric interactions between states and can be induced even in seemingly symmetric bilateral interactions in a "center-periphery" coordination system, where the states on the periphery are protected from risk.

There are two main limitations of this study. First, as noted earlier, there is possible reverse causality in the central bank model, and I have dealt with this problem by differentiating between long-duration and short-duration agreements. Since the proposed effects still exist when considering only long-duration BSAs, I can be more confident that it is centrality in the BSA network leading to reserves-to-GDP ratio instead of the opposite. I also present an analysis in the appendix to rule out the possibility that the number of BSAs states sign is driving the results. The second limitation of my study is that it is only covering states that have signed BSAs since 2008.

Although BSAs have covered more than 60 countries, more than half of the countries in the world have not signed BSAs and are thus not included in this study. This is the result of a trade-off between articulating within-BSA network interactions and including all states in the analysis. The network measures used here place states on a scale of how much responsibility they share within the BSA network, which provides better identification of states' roles in BSAs compared to previous literature but naturally excludes states outside the network.

Future research can compare states with centrality scores lower than a certain threshold and states without a BSA to evaluate the effect of BSAs on risk-taking behavior in a larger number of countries. This should complement my current study on within-BSA network interactions. In addition, the results on BSAs and financial crisis only provide some clues for understanding their relations. Future studies with more complete and updated data on financial crisis could examine the related arguments more carefully. Finally, the argument that latent network roles as a source of moral hazard is not limited to studying BSAs and can be extended in future IPE and international relations research.

The results of this study provide a warning to policymakers in BSA creditor states, the IMF, and states protected by BSAs. For BSA creditor states that have used BSAs to advance their self-interests, this study shows that the protected states are experiencing moral hazard, especially for the central banks. The results on financial

crisis also show that peripheral states are more likely to experience currency crises. Even if the results are taken with caution, hierarchy in the BSA network can be harmful for two reasons. First, as the private sector banks on the periphery become more cautious, the financial market is potentially distorted and becomes less efficient. Second, the global financial system is more vulnerable than before. This is because peripheral states forgo self-insurance and rely on the center for financial safety, so that financial instability at the center may soon lead to widespread crisis. Therefore, creditor states like the US and China should consider imposing conditionalities on BSA partner states. The IMF, on the other hand, should avoid imposing too stringent conditionalities, which would make states shy away from it and pursue unconditional BSAs instead. States protected by BSAs should also be aware that forgoing self-insurance is not without consequences: The private sector banks' behavior is being distorted.

Appendix A

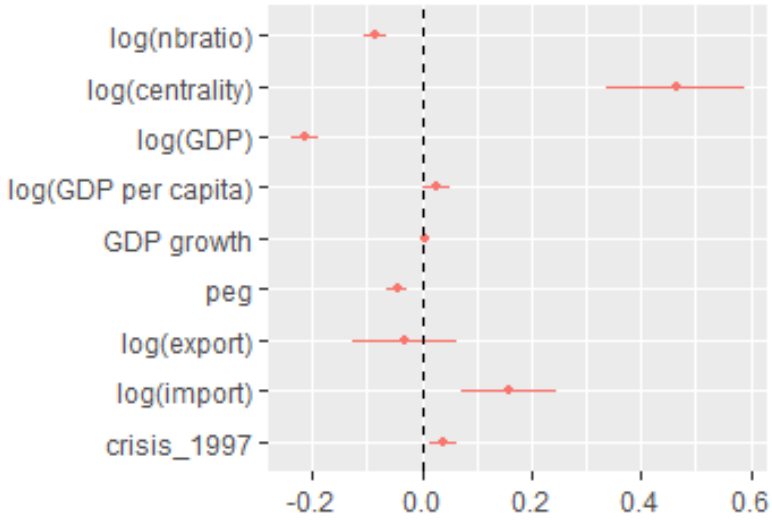

Figure A.1: Coefficients of the Reserves-to-GDP Ratio and Long-duration BSAs Model

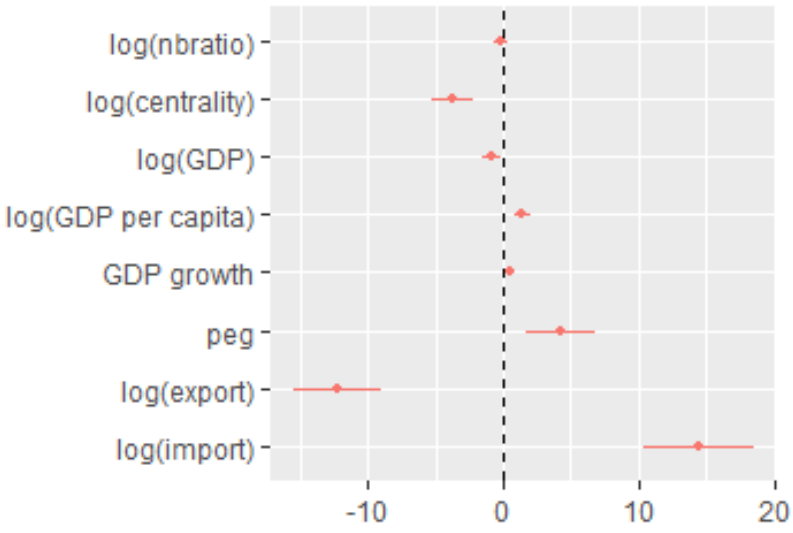

Figure A.2: Coefficients of the Z-score and Long-duration BSAs Model

Table A.1: Control Network Degree in the Central Bank Model[12]

	Dependent variable:			
	reserves-to-GDP ratio			
	All	All	Long	Long
	(1)	(2)	(3)	(4)
log(nbratio)	-0.084***	-0.078***	-0.096***	-0.096***
	(0.012)	(0.013)	(0.012)	(0.015)
log(centrality)	0.527***	0.431***	0.645***	0.554***
	(0.106)	(0.093)	(0.094)	(0.102)
log(GDP)	-0.245***	-0.244***	-0.204***	-0.211***
	(0.010)	(0.009)	(0.011)	(0.012)
log(GDP per capita)	0.012	0.011	0.032***	0.029**
	(0.013)	(0.014)	(0.010)	(0.013)
GDP growth	0.005*	0.006***	0.005*	0.006**
	(0.003)	(0.002)	(0.003)	(0.003)
peg		-0.013		-0.039***
		(0.013)		(0.007)
log(export)	-0.004	0.013	-0.066	-0.045
	(0.056)	(0.062)	(0.043)	(0.053)
log(import)	0.175***	0.162***	0.179***	0.166***
	(0.041)	(0.048)	(0.037)	(0.045)
crisis_1997	0.028**	0.027**	0.047***	0.036***
	(0.013)	(0.013)	(0.011)	(0.013)
number of BSAs	-0.003	-0.001	-0.006***	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Note:				*p<0.1; **p<0.05; ***p<0.01

[12] Similar to the previous models, all models use year-fixed/random effects based on the result of Hausman test with robust and clustered standard errors.

Table A.2: Removing China from Long-duration Central Bank and Private Sector Bank Models[13]

	Dependent variable:	
	reserves-to-GDP ratio	z-score
	(1)	(2)
log(nbratio)	-0.097***	0.145
	(0.017)	(0.234)
log(centrality)	0.538***	-6.165***
	(0.121)	(0.637)
log(GDP)	-0.217***	-1.365***
	(0.011)	(0.452)
log(GDP per capita)	0.018*	1.559***
	(0.010)	(0.281)
GDP growth	0.006**	0.434***
	(0.002)	(0.118)
peg	-0.055***	3.588**
	(0.011)	(1.611)
log(export)	-0.012	-12.427***
	(0.043)	(1.704)
log(import)	0.128***	15.269***
	(0.037)	(2.204)
crisis_1997	0.024**	
	(0.012)	
number of BSAs	0.014***	
	(0.004)	
Constant		-68.422***
		(11.827)

[13] Since China is the most active BSA signatory in recent years, and it also holds a high level of reserves, this analysis is to show that China alone is not driving the results. Removing China from the model does not change the findings.

Note:	*p<0.1; **p<0.05; ***p<0.01

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