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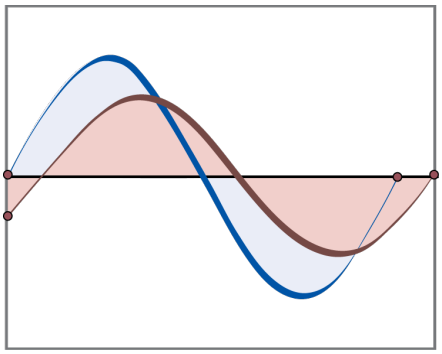

Domestic Banking Industry Network Analysis: The Sovereign-Bank Nexus

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The importance of sovereign-bank linkages has been a major topic of discussion among academics and regulators. While interdependencies can play a supportive role in the smooth functioning of the financial system and the wider economy, imperfections in the relationship have fostered an embrace which has, on occasion, led to a systemic risk event. This paper examines the potential fault lines of the relationship with a review of direct and indirect channels by which sovereign risk may spill over into the banking sector (or vice versa) and reverberate throughout the financial system. The assessment builds on a 2020 study of the domestic inter-bank network by appending public sector exposures extracted from the balance sheets of local commercial banks and non-bank financial institutions. The sovereign-bank nexus is modelled using static network analysis, which produces network diagrams, heat maps and inferential statistics for examination. Results show that deep connections exist between the state and a few key players in the banking system, owing to the strong home bias in sovereign debt holdings. Bilateral claims between the sovereign and one indigenous bank were particularly prominent. The findings highlight the need for a formalised macroprudential framework to mitigate systemic risks from financial interconnectedness.

JEL Classification Numbers: D85, G21, H63

Keywords: interconnectedness; contagion; network analysis; sovereign-bank linkages; systemic risk; financial stability

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1.0 Introduction

Deep connections between the state and the banking sector have been known to exist. The main factors driving these connections are limited investment opportunities and the preferential treatment of sovereign exposures. Mutualistic but sometimes toxic is the common theme across the literature that best describes this nexus, especially the home bias[1] dimension. On the positive side, the nexus has played a major role in shoring up bank liquidity, facilitating fiscal support, deepening capital markets and facilitating policy transmission. Despite these merits, financial market imperfections have fostered binding constraints, which occasionally culminated in systemic distress.[2] Consequently, credit, liquidity, solvency and reputational risks are also a feature of the nexus. During good times, the positives far outweigh the negative attributes of the nexus. Still, recent events such as the novel coronavirus (COVID-19) have required state support, exposing the potential vulnerabilities associated with these ties, urging the need to explore these dynamics.

Several tools have emerged to manage sovereign-bank connections. Risk-based supervision has become the main resource for regulators to meet financial stability objectives. Knowing the financial ties and the depth of interconnections within subsets of the macro-financial system is crucial for managing the financial system. As it stands, the mobilisation of financial resources (particularly within a small, open economy) is largely influenced by the state (as manager of the economy) and banks (as critical intermediaries). Thus, these economic agents are the main sources of funding for each other, as well as corporates and consumers. On that basis, assessing the sovereign-bank nexus is of systemic importance.

Understanding this network as a whole and the role of the financial ties between the sectors can help identify central linkages (and potential contagion paths) supporting current and future prudential and fiscal policy actions. This method is not new to Trinidad and Tobago – the local banking system network was developed and assessed using a similar framework in 2020.[3] The results showed that the local banking network was somewhat interconnected, with a small subset of commercial banks and one non-bank financial institution (non-bank) acting as central nodes in the system. Local network analysis studies are still developing due to the lack of granular data needed for this type of exercise. Hence, this paper expands and enhances the existing inter-bank network analysis. Using public sector exposures captured on local banks' balance sheets, this paper leverages network theory to offer a nexus-measuring framework that depicts and quantifies the depth of the linkages between the banking sector and the public sector.

[1] Preferences for domestic sovereign holdings.

[2] The most infamous crises that showcased this toxic bond are the Great Depression (1930s), Global Financial Crisis (GFC) in 2008 and the European Debt Crisis in late 2009 and 2010 Díaz-Alejandro (1984), Kaminsky and Reinhart (1999), Reinhart and Rogoff (2010), Reinhart and Rogoff (2013), Acharya, Drechsler and Schnabl (2011), Laeven and Valencia (2008), Laeven and Valencia (2012), Laeven and Valencia (2018), Honohan (2010), Farhi and Tirole (2017) and Dell'Ariccia, et al. (2018).

[3] See Chapter 5 of the Central Bank of Trinidad and Tobago's Financial Stability Report 2019 (CBTT 2020).

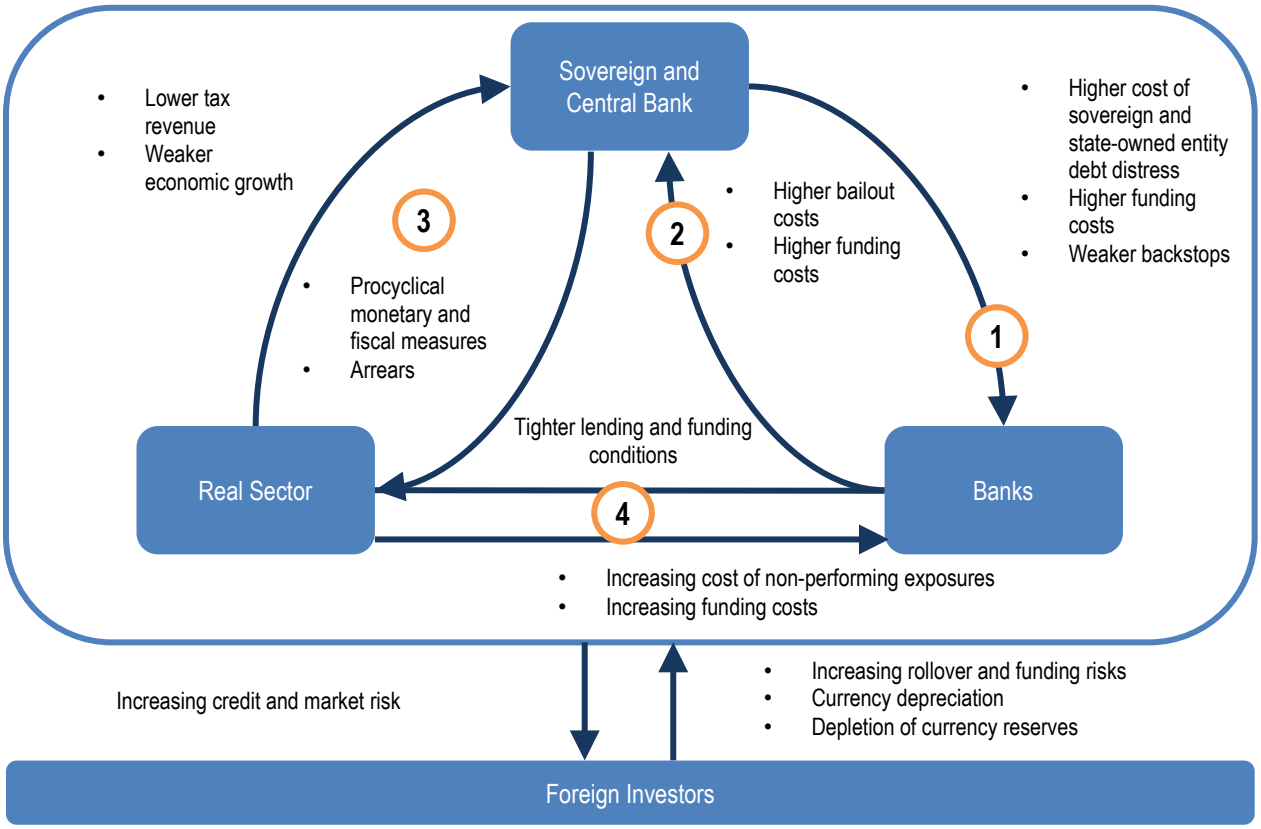
The paper is structured as follows: Section 2 outlines the intricacies of the sovereign-bank nexus. Section 3 collates and briefly describes the findings of connectedness measures that assessed the nexus. Sections 4 and 5 summarise the local sovereign-bank data providing context for the findings presented and discussed in Section 6. Key implications and recommendations of the study are offered in Section 7 before the paper concludes in Section 8.

2.0 The Sovereign-Bank Nexus

The dynamic interrelationship between the health of a sovereign and a banking sector, known as the sovereign-bank nexus, has influenced numerous streams of research in the financial stability arena. Direct and indirect connections or exposures between the parties create potential contagion paths by which sovereign risk may spill over into the banking sector (or vice versa) and reverberate throughout the financial system, often with a multiplier effect. The sovereign-bank nexus can incorporate cross-border relationships[4] but this study focuses exclusively on the interactions between a sovereign and its domestic banking sector. Feyen and Zuccardi (2019) described four distinct channels in a domestic context (**Figure 1**). These include two direct channels – banks' direct exposures to the sovereign (1) and government support to failing banks (2) – and two indirect channels – fiscal-real sector interactions (3) and banking-real sector interactions (4). The remainder of this section presents the background against which these channels may develop and the potential pathway for shock transmission throughout a financial system and the real economy.

[4] Including domestic bank to foreign sovereign; domestic bank to foreign bank, where the foreign bank is exposed to a foreign sovereign; or domestic bank to domestic sovereign, where the domestic sovereign is exposed to a foreign sovereign.

Figure 1: Direct and Indirect Channels of the Sovereign-Bank Nexus



Source: Feyen and Zuccardi (2019).
Note: The authors describe two direct channels of the nexus – banks' direct exposures to the sovereign (1) and government support to failing banks (2) – as well as two indirect channels of the nexus – fiscal-real sector interactions (3) and banking-real sector interactions (4).

Direct balance sheet linkages between the sovereign and domestic banks play a crucial role in the smooth functioning of the financial system and wider economy and can mutually benefit both parties. In both advanced and emerging markets and developing economies (EMDEs), banks are major lenders to the government and exhibit significant home bias in their sovereign bond portfolios (Deev and Hodula 2016, Andreeva and Vlassopoulos 2016). This preference is especially pronounced in regions with shallow capital markets and limited access to external financing, alongside attractive domestic sovereign yields (Asonuma, Bakhache and Hesse 2015). As primary dealers, banks are key actors in implementing and transmitting monetary policy; they can also be utilised as a vehicle for fiscal support during economic crises, as evidenced during the COVID-19 pandemic. At the same time, sovereign exposures have generally been regarded as risk-free, which has been encouraged by the application of zero risk-weights under prudential capital standards and the designation of home sovereign securities as high-quality liquid assets for calculating liquidity and funding ratios. Banks, therefore, capitalise on their holdings to increase investment income, boost liquidity and provide collateral to raise wholesale funding (CGFS 2011).

The deceptive notion of a risk-free sovereign has been widely disputed in the literature in the aftermath of crises (BIS 2013)[5] as researchers and policy makers acknowledged that deterioration in sovereign health has direct implications for the banking sector

[5] BIS (2013) presents a compilation of papers and summarises the proceedings of a sovereign risk seminar hosted by the BIS in 2013 and attended by senior central bankers, sovereign ratings analysts, fund managers and other market participants, sovereign legal specialists, risk managers at financial institutions and academics.

via claims on central government and state-owned enterprises. Sovereign distress may foreshadow debt-servicing difficulties, which translates to banks' asset impairment via large loan losses and sovereign bond devaluations.[6] Depleted capital reserves, due to higher provisioning, may impinge on banks' lending capacity, limiting economic expansion and further exacerbating sovereign vulnerabilities. Knock-on effects on bank profitability indicators could follow over time. Moreover, lower sovereign bond values and a deterioration in sovereign debt-servicing capacity may result in similar haircuts applied to the collateral used by banks to raise wholesale funding (Schich and Lindh 2012). Elevated liquidity pressures may be compounded by large deposit withdrawals – significant public sector deposits are characteristic of local banks in EMDEs, including the Caribbean (Ogawa, et al. 2013, Feyen and Zuccardi 2019). Effects are exaggerated when a credit rating downgrade has been triggered, or a debt restructuring exercise has been initialised. Specifically, sovereign downgrades may have repercussions on the ratings of local banks, especially state banks. Lower ratings further inflate wholesale funding costs and market access may be compromised (CGFS 2011).

Even without direct balance sheet exposures, bank and sovereign risk may be indirectly tied through explicit government guarantees and the implicit expectation of state support in crisis periods. Explicit guarantees such as deposit insurance schemes are an important line of protection for depositors when a bank fails, but characteristics differ globally where available. In a broad review of existing schemes as at 2013, Demirgüç-Kunt, Kane and Laeven (2014) found that the majority of schemes were pre-funded by member banks, though some received partial or complete government financing[7]. Furthermore, coverage limits varied by country but were typically capped (with few offering blanket guarantees). Central government backstops were often written into legislation if a funding shortfall were to be realised. Backstops could be financed via the scheme by issuing bonds or receiving loans guaranteed by the government, thereby increasing contingent liabilities and the overall stock of sovereign debt. The authors observed an increase in explicit guarantees on bank deposits, non-deposit liabilities and assets at the height of the GFC. Though most of these guarantees are no longer operative, there may be lingering beliefs that the government would intervene as it has done in the past (Schich and Lindh 2012) to prevent the failure of domestic banks such as systemically important or state-owned banks. Other government support in credit guarantee schemes are intended to reduce barriers to accessing finance for selected borrowers, such as small and medium enterprises. These guarantees provide third-party credit risk mitigation for banks by reducing direct exposure to lenders with limited collateral. Credit guarantee schemes have been crucial for alleviating firm distress by bridging liquidity gaps during crisis periods such as the COVID-19 pandemic (Brault and Signore 2020).

Explicit and implicit government guarantees provide a secondary channel by which sovereign-bank linkages may disrupt macroeconomic and financial stability. These guarantees artificially lower the cost of funding for banks, but introduce moral hazard and encourage excessive risk-taking, which may amplify bank vulnerabilities in crisis periods (Allen, et al. 2017, Leonello 2017). The effectiveness of the guarantee to stymie market panic is only as good as its credibility – concerns about a government's willingness and ability to fund the guarantee, especially in an uncertain economic environment with tight fiscal

[6] The impact on banks may be exacerbated by exposure to other loans which have collateral secured by sovereign assets.
[7] It is worth noting that most schemes are still "legally separate from the central bank, banking supervisory agency, or ministry of finance, even though they may be 'housed' within such institutions" (Demirgüç-Kunt, Kane and Laeven 2014).

space, can increase the likelihood of the guarantee being called, which could result in higher fiscal costs and increased taxpayer losses (ECB 2015). An increase in sovereign distress, whether or not it has been induced by a call on guarantees, reduces the perceived value of a guarantee by investors and challenges banks through direct exposures as discussed earlier. Governments and policy makers have introduced measures post-GFC designed to minimise the need for guarantees and protect taxpayer dollars ex post including, inter alia, the formalisation of crisis resolution frameworks and imposition of higher capital and reporting requirements on systemically important banks. With sufficient bank and fiscal buffers, it is envisaged that sovereign-bank linkages may work as an effective shock absorber (Feyen and Zuccardi 2019).

Bank and sovereign risk may also be indirectly linked through their distinct relationships with the real sector. During periods of difficulty, state responses to sovereign risk may lead to, inter alia, tax increases or lower spending to stabilise the fiscal accounts. Systemic risk may materialise if these actions lead to an economy-wide recession, which may hamper the income flows of the private sector, restricting tax revenues and further constraining the fiscal space (Dell'Ariccia, et al. 2018). In addition to being important creditors to the government, banks are major lenders to businesses and consumers. As such, the weakened debt-servicing capacity of the key economic agents may have a material impact on banking sector asset quality and profitability indicators. In a distress scenario – whether a distinct banking crisis or triggered by an economic recession – banks may choose to reduce lending to preserve capital, which may weigh on economic activity and fiscal balances. This may initiate a negative spiral of rising non-performing loans and further credit tightening that could deepen a recession (BCBS 2017). A banking crisis may also impact on banks' role as transmitters of monetary policy, limiting liquidity in sovereign bond markets (Feyen and Zuccardi 2019).

3.0 Literature Review

Understanding the theoretical underpinnings of sovereign-bank linkages and the propellants of a virtuous or vicious cycle have been key to the development of empirical studies which analyse these connections. This section highlights connectedness measures of the sovereign-bank nexus that have been applied internationally. It takes a broad perspective and includes the study of cross-border relationships.

In a comprehensive review of the International Monetary Fund's (IMF's) approach to interconnectedness and contagion analysis, Bricco and Xu (2019) discussed three distinct phases of assessment: the mapping of financial system exposures; the analysis or modelling of inter-bank, cross-sector and cross-border relationships; and policy discussions to address the findings of the earlier stages. For cross-sector assessments, the flow of funds data may be sourced from national authorities (if collected) and supplemented by more granular, supervisory data. Data limitations impede a complete analysis, but useful conclusions may be drawn with aggregate data in the first phase. For the second phase, the authors noted that the network-based Espinosa-Vega and Solé (2010) and CoMap (Contagion Mapping) models had greater application in Financial Sector Assessment Programs (FSAPs)[8] as they rely on exposure data, which may be more readily available than market data in low-income economies. Direct,

[8] An FSAP is a joint undertaking of the IMF and the World Bank which gauges the health of a country's financial sector and its contribution to economic growth and development. The assessment aims to help countries reduce the likelihood and severity of financial crises through

bilateral exposure data is typically accessed through the supervisor but may not be incorporated into routine data requirements. For advanced and emerging economies, the IMF may employ market-based approaches such as the CoVaR (Conditional Value-at-Risk), Diebold and Yilmaz (2014) and SRISK models to assess indirect connectedness using granular, high-frequency market data. More advanced techniques including the SyRIN (Systemic Risk and Interconnectedness) (Cortes, et al. 2018), Systemic CCA (Contingent Claims Analysis) (Jobst and Gray 2013) and the Global VAR (Vector Autoregression) (Dées, et al. 2007) models can analyse a mixed dataset (exposure and market data). All methods are suitable for assessing cross-sector linkages, though a perusal of the FSAP literature suggests that they were more often utilised for inter-bank analysis. To ensure the validity of results and minimise model error, the authors suggested using more than one model and applying robustness checks for each approach.

The identification of sovereign connections with the financial system has featured prominently in many FSAPs post the euro area debt crisis. In Italy and Spain – two of the more severely affected countries – mission teams reported banks' sizeable exposures through holdings of sovereign debt securities and contingent liabilities, which were reflected in the co-movement of bond spreads and bank equity indicators (IMF 2017, IMF 2020). The Italian review recommended implementing prudential policies to temper the sovereign-bank nexus by reducing domestic sovereign concentrations or increasing loss absorption capacity through accumulating a capital buffer that considers sovereign exposure risk. Similar recommendations have been made for Romania, where domestic sovereign exposures rose to the highest in the region since the onset of the debt crisis (IMF 2018). The Polish financial system was second to Romania in terms of the ratio of domestic government claims to banking sector assets at the end of 2017 – a possible repercussion of the introduction of a financial institution asset tax in 2016, which exempted government securities thereby encouraging banks to hold more government debt (IMF 2019). The nexus was compounded by the significant presence of state-owned banks in the country, which strengthened the correlation between the market valuation of credit risk in the sectors.

The link between the creditworthiness of a sovereign and its banking sector, particularly state-owned banks, is reflected in credit rating assessments. The methodology for Standard and Poor's Banking Industry Country Risk Assessment (BIRCA) scores two components – economic risk and industry risk. The indicators considered in determining a sovereign rating are also applied to the BIRCA. These are captured under the economic risk component and include measures of the stability and structure of a country's economy, its economic policy flexibility, actual or potential imbalances, and the credit risk of economic participants (mainly households and enterprises) (S&P Global Ratings 2020). The industry assessment serves as a starting point for an individual bank's stand-alone credit profile and issuer credit rating; it is complemented by bank-specific factors such as performance and the likelihood of external support from the government and parent group. Fitch Ratings' criteria apply a similar approach where the individual bank rating reflects its stand-alone profile, Government Support Rating (GSR) and Shareholder Support Rating. The GSR is a function of several key rating drivers, but assessment begins with the sovereign rating. The sovereign rating attracts a higher weight for markets without developed resolution frameworks and policy banks. Typically, the

the identification of financial sector vulnerabilities and the design of appropriate policy responses. https://www.imf.org/en/About/Factsheets/Sheets/2016/08/01/16/14/Financial-Sector-Assessment-Program

GSR for a domestic systemically important bank is close to the sovereign rating, which is correlated with the sovereign's broader financial flexibility (Fitch Ratings 2021).

Westphal (2015) applied quantitative analysis in the euro area by leveraging network theory to construct a map of sovereign debt (balance sheet) exposures between 123 banks and 27 European Union countries and Iceland as at December 2013. The network was found to be relatively dense due to the number of links between the nodes displayed on the network map. To study changes in the network over time, the dataset was narrowed to 57 banks, for which data was consistently collected for seven reporting dates between December 2010 and December 2013. Characteristics of this dataset, including exposure volumes, financial ratios and network statistics, were reported. The in-depth analysis confirmed the network's density, though there was a decline since December 2010 in the aftermath of the euro area debt crisis; banks increased the overall volume of investment portfolios but channelled funds to fewer sovereigns. By combining balance sheet and network characteristics, the author identified a core group of 15 highly connected banks which held close to 60 per cent of the total sovereign debt in the network. The systemic designation of the core set was reinforced by the financial support received over the sample period, including implicit and explicit government guarantees. Using regression analysis[9], the author confirmed the presence of counterparty risk between the core banks and sovereign debt issuers and its "significant and increasing" effect on sovereign credit default swap (CDS) spreads.

In the Caribbean, direct cross-border (bilateral) exposures between regional banks, insurers and sovereigns have been examined, supported by network analysis techniques. Canetti et al. (2017) reported that Trinidad and Tobago banks had the greatest share of claims on sovereigns as a per cent of total assets (around 6 per cent), followed by Guyana (around 5 per cent) at the end of 2013. However, most of the claims from Trinidad and Tobago banks were on global sovereigns (particularly the United States) in contrast to Guyanese banks' claims on sovereigns which were overwhelmingly regional. In addition to being minimal – none of the aggregate banking and insurance sectors within each country had greater than 5 per cent of assets exposed to a regional sovereign – banks' claims on regional sovereigns were concentrated in a few larger territories. Static network analysis of these exposures revealed that domestic sovereign-bank linkages were the most significant in the network for several countries (greater than regional inter-institutional claims), with the strongest connection observed in Trinidad and Tobago (CCMF 2016). Macro-financial shocks were also applied using the Espinosa-Vega and Solé (2010) model to assess system robustness and simulate spill-over effects (dynamic network analysis).

Financial linkages and the interdependence between sovereign and banking risk indicators have also been modelled using econometric measures of connectedness. Contingent claims analysis (CCA) (Merton 1973) has been frequently exploited to build risk-adjusted balance sheets using market and balance sheet information, from which aggregate risk indicators are derived (Gray, et al. 2013). Billio et al. (2013) proffer a novel approach to the measurement and analysis of the interactions between banks, insurers and sovereigns in 17 countries[10] using CCA-based expected loss ratios for major financial institutions and CDS

[9] This followed the work of Signori and Gençay (2007), which assessed counterparty risk in the US supplier-customer network of public companies.

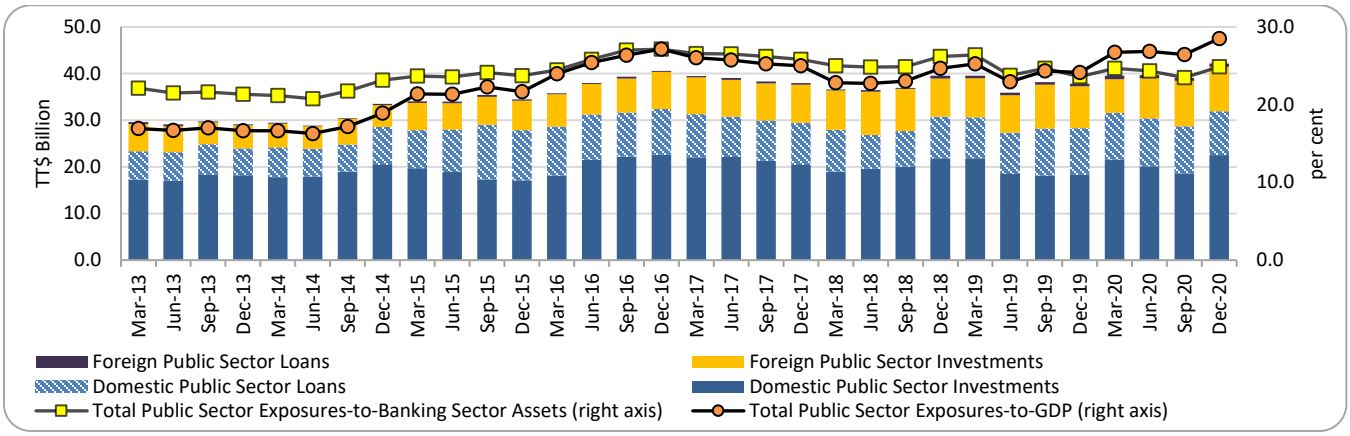
[10] Austria, Belgium, Germany, Spain, France, Greece, Ireland, Italy, Netherland, Portugal, Denmark, Sweden, UK, Norway, Switzerland, the US and Japan.

spreads as an indicator of sovereign risk. Network statistics were generated from pairwise linear Granger-causality tests to highlight statistically significant connections between the entities. Gómez-Puig, Singh and Sosvilla-Rivero (2018) also applied the CCA method to produce distance-to-default (DtD) credit risk indicators for sovereigns and country-level banking sectors in five euro area countries[11] from 2004 to 2013. Three alternative econometric models were then developed based on principal component analysis, pairwise Granger-causality tests and Diebold-Yilmaz's connectedness indices (2014) to quantify the magnitude and direction of the relationship between the sovereign and banking risk measures. All results pointed to considerable interconnectedness and strong co-movement between the indicators.

4.0 Stylised Facts[12]

On the surface, there is evidence of a local sovereign-bank nexus. On the banking side of the nexus, attractive incentives such as government guarantees and the special treatment of domestic sovereign exposures have created a home bias[13]. Compared to banks' foreign public sector exposures (which averaged 5 per cent of the sector's total asset portfolio over the period studied), banks' domestic sovereign holdings were more significant (averaging 19 per cent of assets) (**Figure 2**).

Figure 2: Banking Sector Public Sector Exposures



Source: Central Bank of Trinidad and Tobago and the Ministry of Finance of the Republic of Trinidad and Tobago.

A deeper inspection of the banking sector's sovereign investment portfolio showed a marked preference for shorter-term securities, that is, Treasury Bills (T-Bills), which are considered a more available and attractive option. Following T-Bills, another large component of banks' sovereign investments was domestic central government securities (**Figure 3**). Over the quarter ending December 2020, increases in holdings were mainly local – domestic T-Bills and central government securities increased

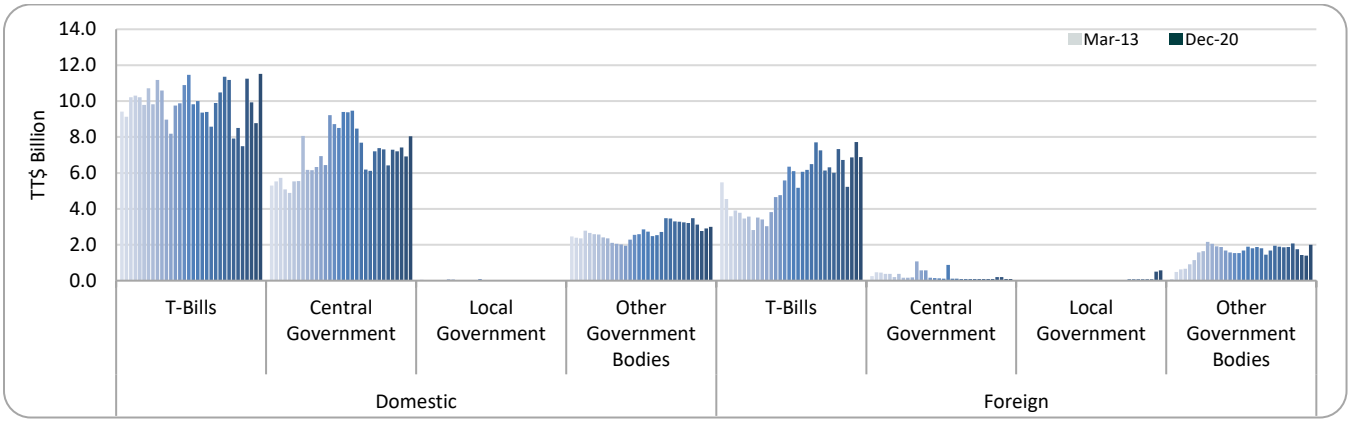
[11] Greece, Ireland, Italy, Portugal and Spain.

[12] For the purpose of this paper, public sector refers to central government, local government, state-owned other financial institutions and other government bodies, including state-owned non-financial enterprises, statutory boards and public utilities. Note also that in June 2021, as part of its overall Debt Reform Strategy, the Ministry of Finance in collaboration with its technical consultants, revised the debt measurement parameters to bring them into alignment with International Standards. However, the data presented in this chapter reflects statistics prior to the 2021 adjustment.

[13] Proxy for the home bias is measured by banks' holding of domestic sovereign debt relative to total assets (Acharya and Steffen 2013).

by 31.3 per cent and 16.3 per cent, respectively – a trend witnessed in other territories and noted in the literature during crisis periods.

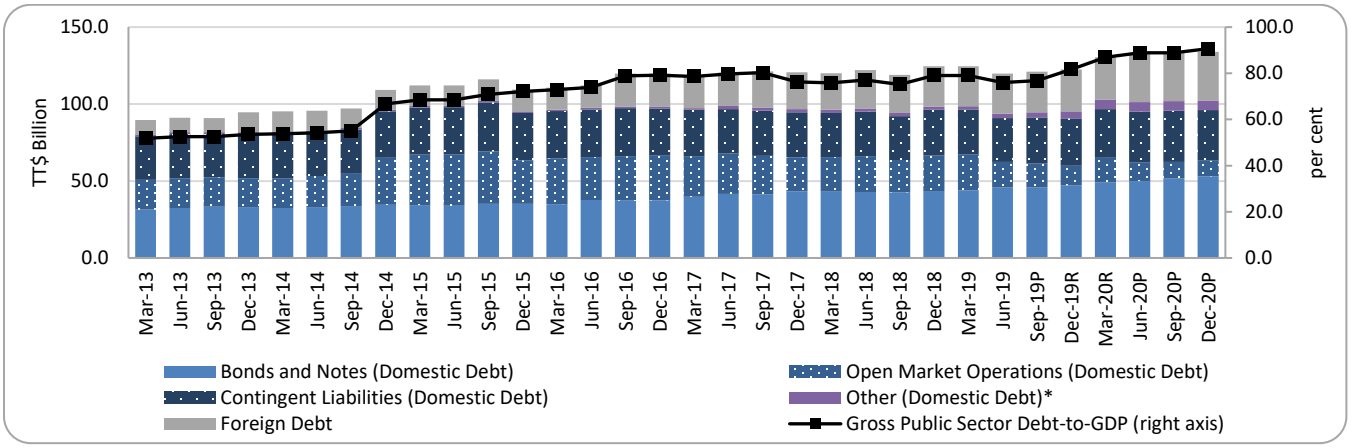
Figure 3: Banking Sector Public Sector Investments, March 2013 – December 2020



Source: Central Bank of Trinidad and Tobago and the Ministry of Finance of the Republic of Trinidad and Tobago.
Note: March 2013 (■) – December 2020 (■) represented from left to right.

On the sovereign side of the nexus, to finance endeavours such as past bailouts and current financial obligations, debt issuance has been a major recourse of the Government, with a preference for domestic debt over external debt. As a result, the public sector's debt portfolio composition is heavily concentrated in domestic bonds, notes and contingent liabilities (**Figure 4**). In 2020, state support to curb the economic effects of the pandemic negatively influenced debt levels[14]. Also of note are the Government's creditors. The local financial sector is bank-centric with a shallow capital market. As a result, commercial banks have been the major lender to the Government and, in recent years, have emerged as the state's primary domestic financier.

Figure 4: Public Sector (Domestic and Foreign) Debt Portfolio



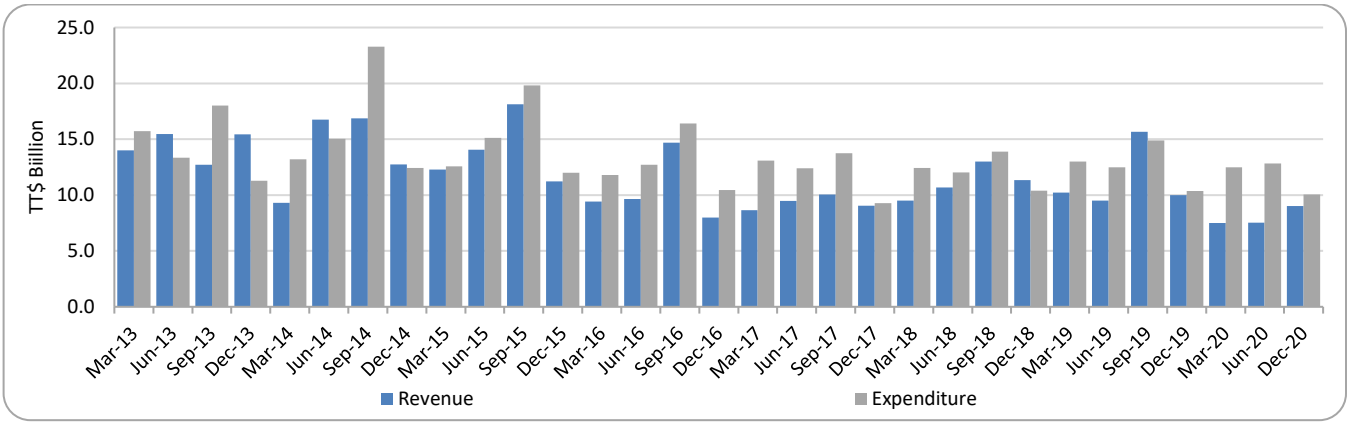
Source: Central Bank of Trinidad and Tobago and the Ministry of Finance of the Republic of Trinidad and Tobago.
Note: R and P indicate revised and provisional data, respectively. * Other (Debt Management Bills, Public Sector Arrears, Leases and Bolts).

A closer look at the country's fiscal operations from March 2013 to December 2020 showed signs of fiscal strain. Deteriorating revenue caused by constrained activity in the energy sector and fallouts from the COVID-19 pandemic restricted the state's

[14] According to the IMF Guidance on Debt Sustainability for emerging market economies, debt-to-GDP ratios exceeding 60 per cent are considered unsustainable.

fiscal space. Larger financing gaps could suggest growing fiscal risks, which could weaken the perceived safe-haven status of government paper (**Figure 5**).

Figure 5: Central Government Fiscal Operations



Source: Central Bank of Trinidad and Tobago and the Ministry of Finance of the Republic of Trinidad and Tobago.
Note: No provisional figures were available for September 2020. *Excludes debt issued for liquidity sterilisation purposes.

Virtuous and vicious attributes of the sovereign-bank nexus are also evident locally. Due to the pandemic, state backing for loans and banks' involvement in moratoriums for the regulatory treatment of payment deferrals or restructured loans featured as key aspects of local COVID-19 recovery efforts, showcasing the value of the public sector and banking sector ties (CBTT 2021).

5.0 Data and Methodology

5.1 Data

As part of the Financial Interconnectedness Project (Trinidad and Tobago), a data-gathering template was issued in September 2019 to collect claims related to inter-institutional and cross-border exposures for banks and insurers as at June 2019. The present study of the sovereign-bank nexus builds on an excerpt of this dataset – direct, bilateral asset exposures among the eight commercial banks and sixteen non-banks operating in Trinidad and Tobago – which was used to conduct inter-bank network analysis in June 2020[15]. The sovereign dimension is incorporated by appending domestic public sector exposures captured on each bank's balance sheet regulatory return or statement of condition (CB20)[16] as at December 2020. The unavailability of the sovereign balance sheet prevents essential data matching for the precise construction of a bilateral matrix of claims. Though one-sided, the CB20 is a suitable proxy for a proportion of direct sovereign exposures. The return captures investments in, and loans to, the domestic sovereign alongside public sector deposits in the banking sector. However, equity held by the sovereign in banks remains unavailable. **Table 1** describes the bilateral exposures that were captured in this study.

[15] See Chapter 5 of the Central Bank of Trinidad and Tobago's Financial Stability Report 2019 (CBTT 2020).
[16] CB20 – Balance Sheet

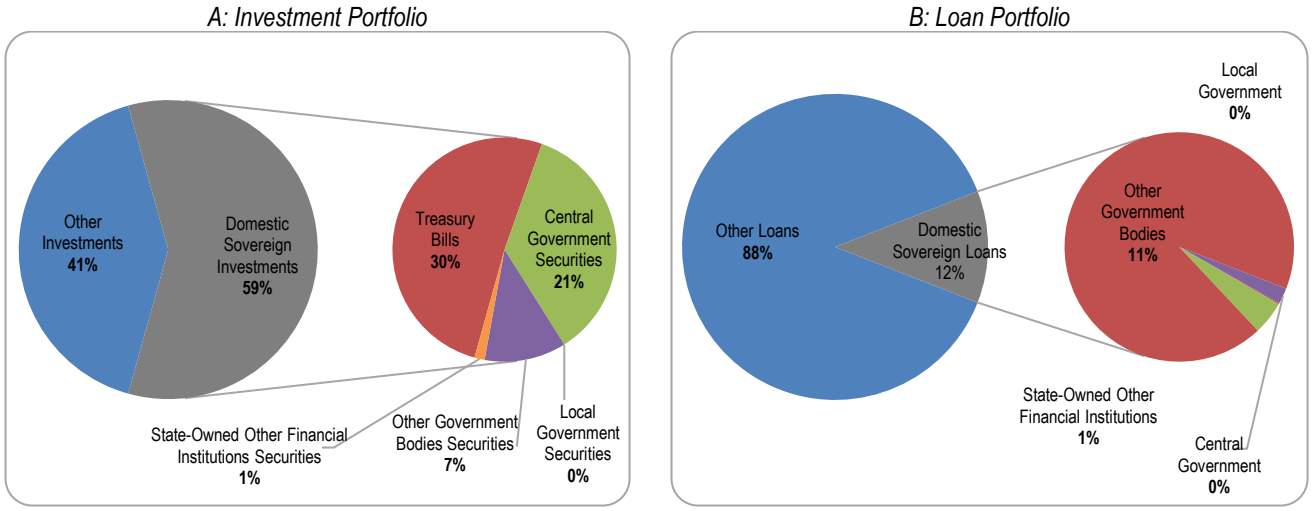
Table 1: Dataset Description - Bilateral Exposures

Term	Description
Debt Securities	Debt securities are negotiable instruments serving as evidence of a debt that units have obligations to settle by means of providing cash, a financial instrument, or some other item of economic value. They include bills, bonds, notes, negotiable certificates of deposit, commercial paper, debentures, asset-backed securities, and similar instruments normally traded in the financial markets.
Loans	Loans are financial assets that are (i) created when a creditor lends funds directly to a debtor, and (ii) evidenced by documents that are not negotiable.
Equity Securities	Equity comprises all instruments and records acknowledging claims on the residual value of a corporation or quasi-corporation after the claims of all creditors have been met. Equity is treated as a liability of the issuing institutional unit. Ownership of equity in legal entities is usually evidenced by shares, stocks, participations, depository receipts or similar documents.
Deposits	Deposits are standard, non-negotiable contracts open to the public at large that allow the placements of variable amounts of funds and the later withdrawal. They include all claims on the central bank, other depository corporations, government units, and, in some cases, other institutional units that are represented by evidence of deposit. The category of deposits comprises transferable deposits and other deposits.

Source: IMF (2014).

As outlined in Section 4, banks hold considerable exposure to the public sector on the asset side of the balance sheet. Investments (debt securities) in the local sovereign as at December 2020 amounted to $22.5 billion or 58.7 per cent of the total banking sector investment portfolio (**Figure 6, Panel A**). This consisted largely of treasury bills and central government securities. The loan portfolio was not as concentrated as only $9.4 billion or 11.8 per cent of total banking sector loans were issued to the public sector as at end-2020 (**Figure 6, Panel B**). Other government bodies, specifically state-owned non-financial enterprises, accounted for the lion's share of the exposure.

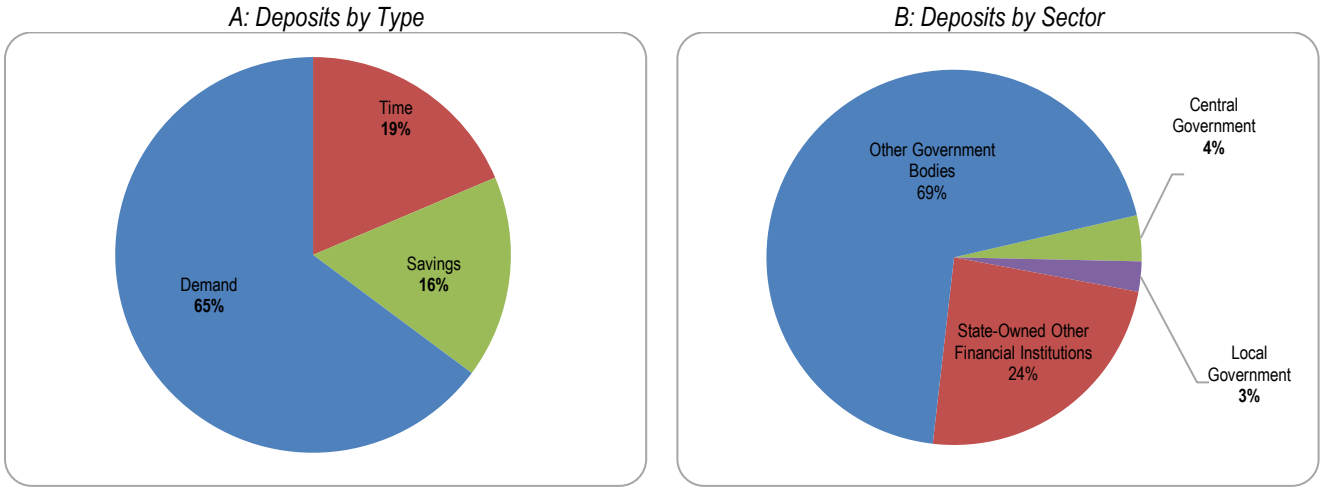
Figure 6: Banking Sector Assets, December 2020



Source: Central Bank of Trinidad and Tobago.

On the liabilities side of the aggregate bank balance sheet – a proxy for sovereign claims on banks – public sector deposits constituted $17.7 billion or 14.0 per cent of total deposits in the banking sector as at December 2020. This was equivalent to 12.3 per cent of total banking sector liabilities. Demand deposits led by type and accounted for 64.8 per cent of total public sector deposits (**Figure 7, Panel A**). Notably, among all deposit types, other government bodies contributed the majority (69.6 per cent) owing to state-owned non-financial enterprises followed by statutory boards (**Figure 7, Panel B**).

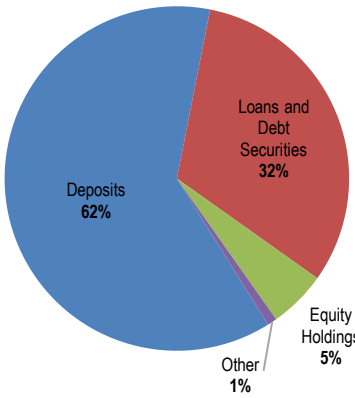
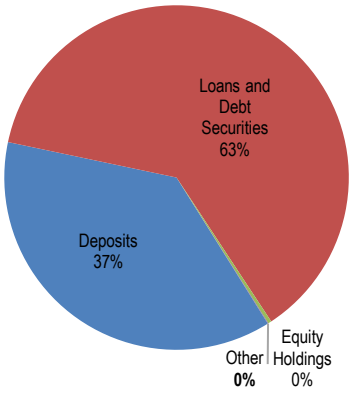
Figure 7: Public Sector Deposits in the Banking Sector, December 2020



Source: Central Bank of Trinidad and Tobago.

Given the significant exposure of the aggregate banking sector balance sheet to the public sector, total claims within the sovereign-bank network are magnified when compared to the inter-bank network only (**Figure 8**). Inter-bank claims amounted to $3.1 billion, 62.0 per cent of which were deposits. When sovereign exposures were added to the dataset, the size of total claims grew to $52.7 billion (247.1 per cent of total banking sector adjusted qualifying capital). The distribution by type was also skewed due to the inclusion of sovereign exposures; loans and debt securities dominated claims within the expanded network (62.4 per cent).

Figure 8: Inter-Bank Claims Compared to Sovereign-Bank Claims

	Inter-Bank Claims, June 2019	Sovereign-Bank Claims, Dec 2020*
Claims by type		
Total Claims (TT$Billion)	3.1	52.7
as a per cent of banking sector capital	14.1	247.1

Source: Central Bank of Trinidad and Tobago.
*Inter-bank claims and sovereign-bank claims as at June 2019 and Dec 2020, respectively.

5.1 Methodology

Financial networks can be analysed using a static or dynamic approach. Static network analysis depicts the financial network architecture (interconnections and concentrations), identifies and quantifies core structural properties, and shows the network's evolution over time (Bennani, et al. 2014). The dynamic approach relies on simulation studies that capture the cumulative effects of exogenous shocks, identify systemic linkages and vulnerable nodes[17], and tracks contagion from one node to another (IMF 2009).

Using static analysis, network diagrams, heat maps and inferential statistics were generated to model the local sovereign-bank nexus. Statistical properties of the network give credence to observations drawn from the network map and allow for quantifying systemic risks. This mirrors the methodology described in the first instalment of this paper[18] – an excerpt of which is presented in the Annex.

6.0 Results and Discussion

The introduction of the domestic sovereign as a node in the local banking industry network is presented via selected graphs and descriptive statistics. For comparative purposes, the results are juxtaposed with the output for inter-bank claims only, discussed in Chapter 5 of the Central Bank of Trinidad and Tobago's Financial Stability Report 2019 (CBTT 2020).

The sovereign-bank network map (**Figure 9, Panel B**) illustrates the direct, bilateral asset exposures among institutions, and between institutions and the sovereign. The network map is accompanied by heat maps of weighted and unweighted linkages (**Figure 10, Panel B**). Taken together, Figures 9 and 10 highlighted that sovereign linkages were well-distributed across institutions. There was a noticeable increase in the number of paths in the network map for sovereign-bank claims compared to paths for inter-bank claims only (**Figure 9, Panel A**). The respective heat maps for unweighted linkages (**Figure 10**) supported this assertion as a greater proportion of cells were populated (yellow). A closer look at the underlying data revealed that two-thirds of institutions in the banking sector had claims on the sovereign in the form of loans and investments. In contrast, the public sector had claims on less than half of the banks. All eight institutions with no direct bilateral exposures to the sovereign were non-banks.

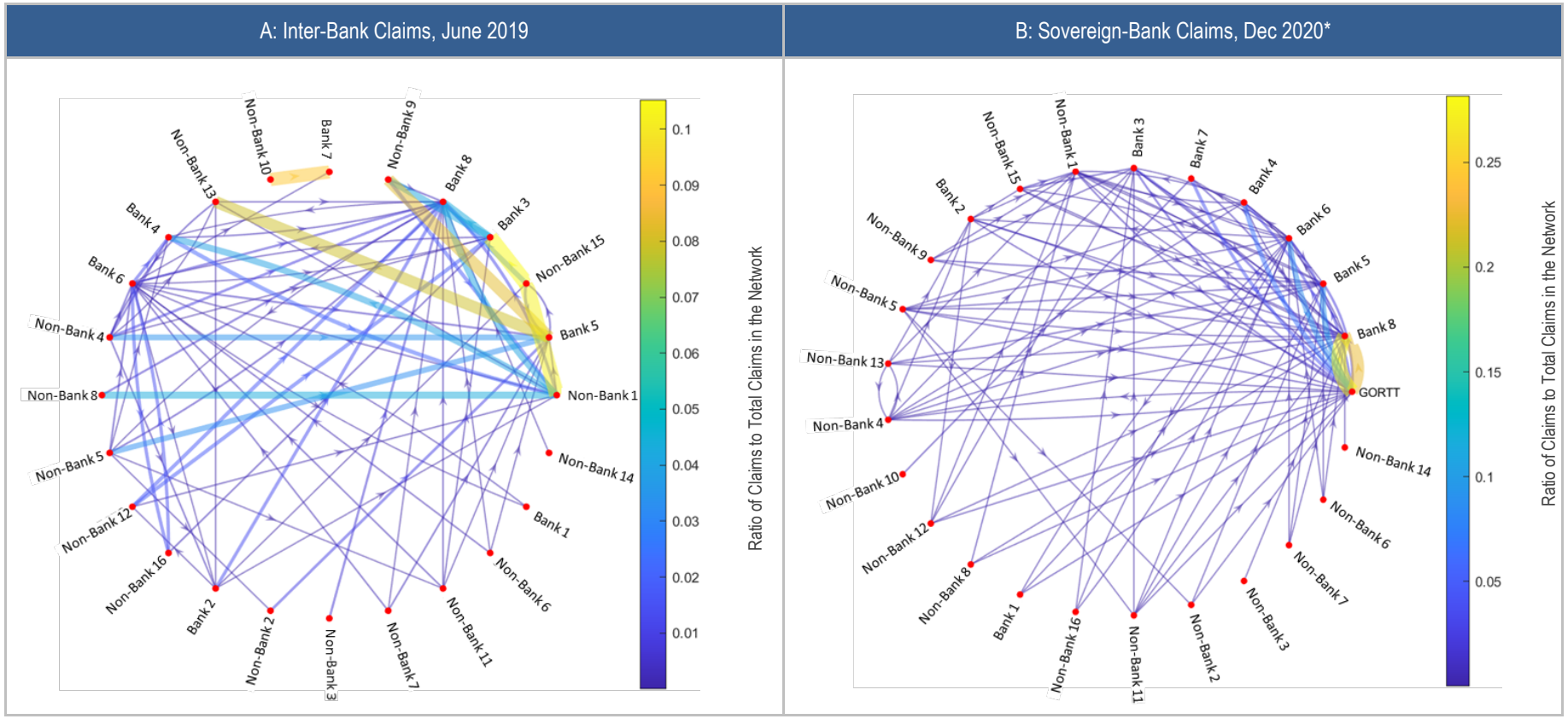
Nevertheless, significant sovereign exposures were clustered among a subset of commercial banks. In particular, the sovereign connection with an indigenous bank, Bank 8, dominated the network – aggregate, bilateral claims between the nodes amounted to just over 50 per cent of total claims. Specifically, Bank 8's unilateral claims on the public sector totalled $14.8 billion (28.1 per cent of total claims in the network), around 70 per cent of which were attributable to investments in central government securities, treasury bills and other government bodies. Two foreign-owned banks (Bank 5 and Bank 6) and another indigenous bank (Bank 4) also had claims on the sovereign, which were material in the context of the entire network (over 5 per cent). The four banks accounted for close to 90 per cent of claims on the sovereign, equivalent to 19.3 per cent of their assets and 186.2 per cent of their capital. This suggests that a shock to the sovereign may have a significant, direct impact on the subset and the sector at

[17] Where a node can represent an entity such as a financial institution, group or sector.
[18] See Chapter 5 of the Central Bank of Trinidad and Tobago's Financial Stability Report 2019 (CBTT 2020).

large, owing to the size of the institutions and their linkages with other nodes. The inter-bank analysis showed that Bank 8 and Bank 6 had the greatest number of connections with other banks, though the value of claims on these institutions was moderate compared to the rest of the network (CBTT 2020). The inter-bank analysis also drew attention to the significance of one non-bank (Non-Bank 1). Though its weight in the sovereign-bank network appears scaled-down in comparison to commercial bank exposures, it still ranked as the most important non-bank (as indicated by the ordering of institutions in the graph and heat maps).

Notably, most public sector claims on banks (around 90 per cent) were to the same subset of institutions, with a particular bias to Bank 8. Deposits at Bank 8 of $11.8 billion accounted for almost 70 per cent of total public sector claims on banks and 22.4 per cent of total claims in the network. This represented 30.4 per cent of Bank 8's assets and approximately 276.6 per cent of its capital base.

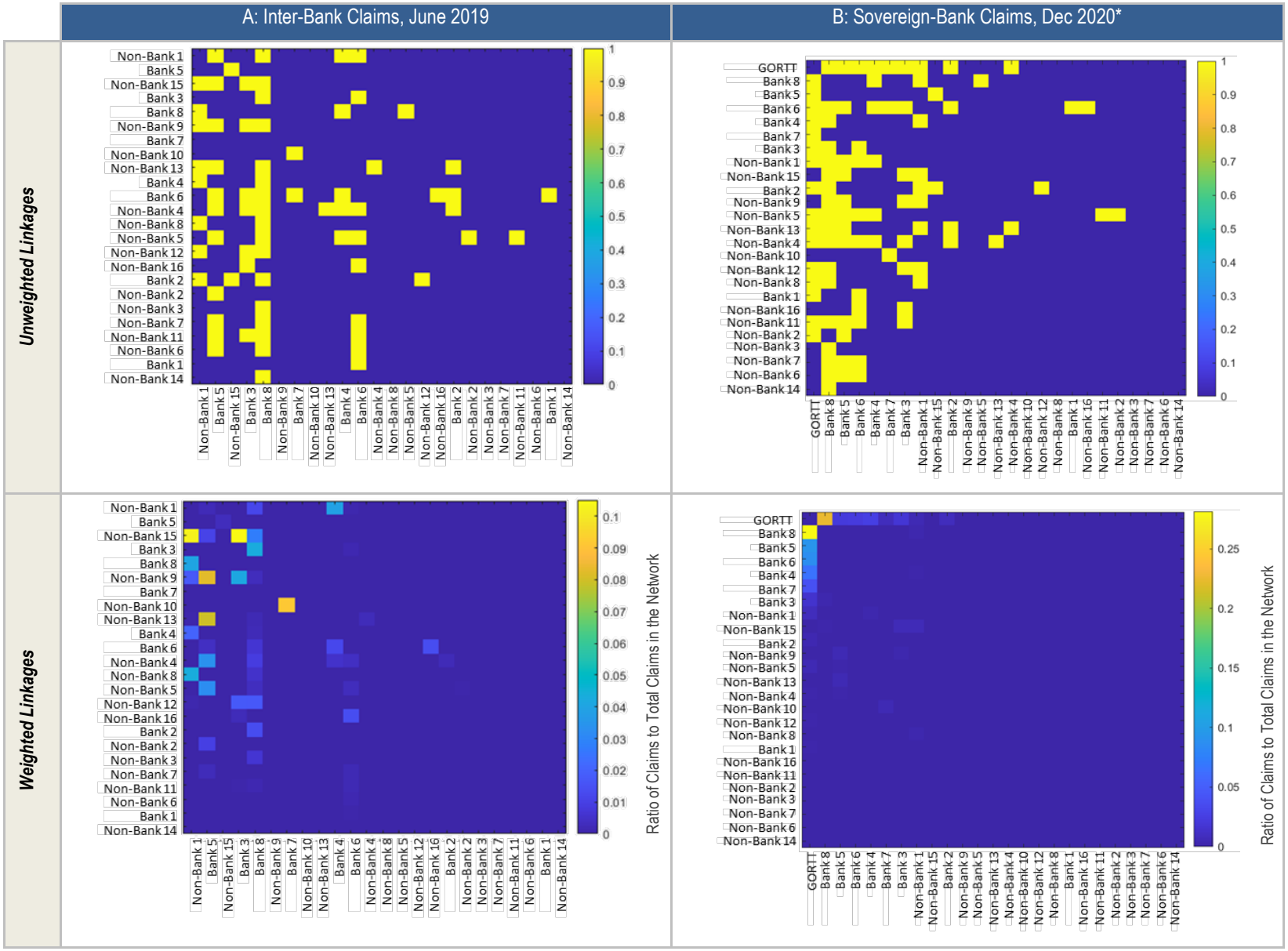
Figure 9: Ordered Network of Sovereign-Bank Bilateral Asset Exposures



Source: Central Bank of Trinidad and Tobago.

Note: Each institution is represented by a node on the map (●) and each link or exposure between nodes is represented by a line. The network map is weighted and directed. That is, the colour and width of the line indicate the relative magnitude of the exposure within the network, while the direction of the arrow indicates the flow of funds. A node has a claim on another node to which the arrow is pointed. *Inter-bank claims and sovereign-bank claims as at June 2019 and Dec 2020, respectively.

Figure 10: **Heat Maps of Sovereign-Bank Bilateral Asset Exposures**



Source: Central Bank of Trinidad and Tobago.

Note: Heat maps of Unweighted Linkages indicate the existence of a relationship (value of 1); Heat maps of Weighted Linkages indicate the presence and relative importance of a relationship within the network. Institutions on the y axis have claims on those on the x axis. *Inter-bank claims and sovereign-bank claims as at June 2019 and Dec 2020, respectively.

Table 2: **Major Statistical Properties of the Inter-Bank and Sovereign-Bank Networks**[19]

Measure	Description	Interpretation	Inter-Bank Network	Sovereign-Bank Network
Density	The overall level of connectivity in the network	Higher values indicate higher network connectivity	13.04%	16.17%
Diameter	The longest path that it will take for contagion to pass through the network	Lower values indicate higher network connectivity	6	5
Distance	The speed of transmission or flow of contagion throughout the network	Lower values indicate higher network connectivity	2.34	2.23
Degree*	The connectivity of nodes in the network	Higher values indicate higher network connectivity	3.00 (2.51)	3.88 (3.29)
Strength*	The intensity of connections in the network	Higher values indicate higher network connectivity	0.042 (0.05)	0.040 (0.10)
Reciprocity	The likelihood of 'bi-directional' relations between nodes in the network	Higher values indicate higher network connectivity	25.00%	37.11%
Clustering Co-efficient	The size of counterparty risk of a node	Higher values indicate higher network connectivity	4.55%	11.11%

Source: Roukny, Georg and Battiston (2014), León (2015).
* Values in brackets represent the standard deviation of the respective score.

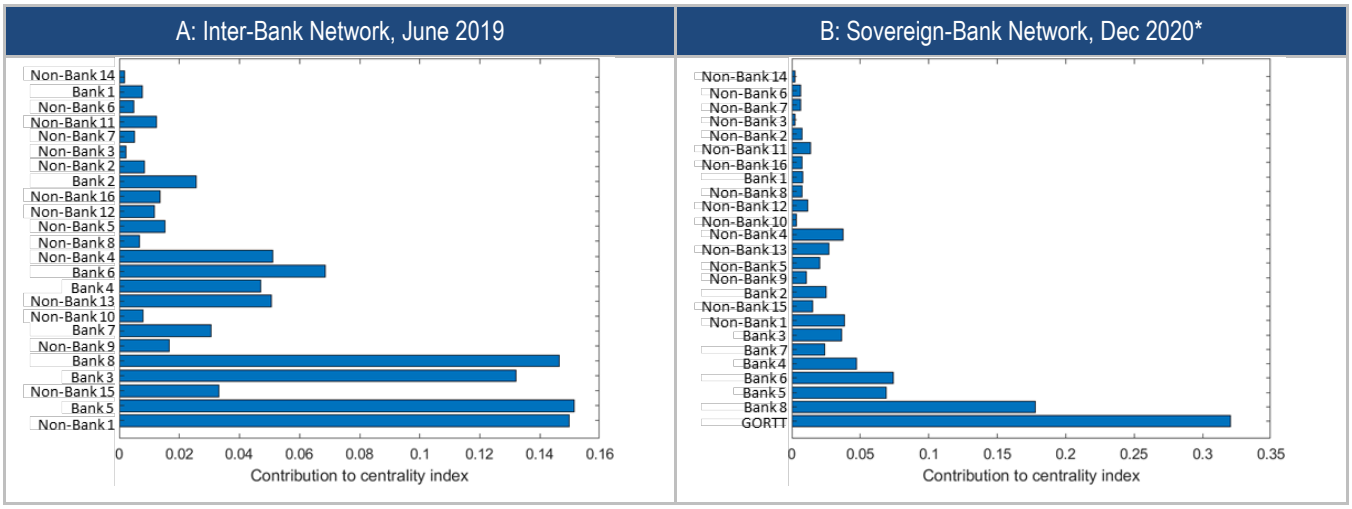
Network statistics suggested that the inclusion of the sovereign node strengthened core contagion paths within the network, though overall connectivity remained low to moderate (**Table 2**). The sovereign-bank network was incomplete as only 16 per cent of potential connections were realised (density), slightly higher than 13 per cent of connections in the inter-bank network. A lower diameter score implied that a shock may be transmitted throughout the entire sovereign-bank network through fewer connections (five connections) than in the inter-bank network (six connections). Moreover, the speed of transmission was expected to be marginally faster due to the shorter minimum distance between nodes – on average, there were at least 2.2 connections between any two nodes in the sovereign-bank network, compared to a minimum of 2.3 connections in the inter-bank network.

The addition of the sovereign node and its linkages with two-thirds of banks had an unsurprising impact on mean node-level statistics. The average number of connections per node (degree) increased from 3.00 in the inter-bank network to 3.88 in the sovereign-bank network. Nevertheless, the average intensity or strength of the connections per node remained low. While the sovereign and the four major banks registered individual strength scores that were well-above the remaining nodes (due to the large value of claims between them), average node strength was suppressed by the greater number of small sovereign-bank exposures that were added to the network. The network structure also exhibited moderate reciprocity, implying that many two-way linkages existed between counterparties. Similarly, moderate transitivity was observed – the clustering coefficient was just over 10 per cent – suggesting a fair number of interconnected sub-groups or clusters in the network, which could magnify counterparty risk.

[19] See Annex for the computation of each of the measures.

Centrality results concurred with the structural properties observed within the network as the sovereign node contributed significantly to the centrality index[20], followed by Bank 8 (**Figure 11, Panel B**). Bank 8 was considered core to both the sovereign-bank network and the independent inter-bank network, underscoring its importance in the domestic financial system. In contrast, the role of other core entities in the inter-bank network such as Bank 5, Non-Bank 1 and Bank 3, appeared minimised with the inclusion of sovereign exposures. This was likely due to the strength component of the centrality index, as intensity of the banks' linkages with the sovereign was minimal in relation to the entire network.

Figure 11: **Contribution to Centrality Index**



Source: Central Bank of Trinidad and Tobago.
*Inter-bank claims and sovereign-bank claims as at June 2019 and Dec 2020, respectively.

7.0 Implications

This study adds to the body of work on domestic financial sector interconnectedness. Matched against traditional descriptive statistics, the results confirmed that deep connections exist between a handful of banks and the domestic sovereign, which may give credence to a bank's designation as systemically important. This reinforces internal and external policy advice from agencies such as the IMF to develop and formalise a macroprudential framework comprising appropriate tools to enhance risk-based supervision. Implications for regulation, policies and current and future work using network theory can be deduced from the findings.

Estimating the cost of crises is essential. Local risk assessment frameworks have not overlooked the two-way nature of these connections, although special treatment still applies. Since 2017, the sovereign-bank nexus has featured in the Central Bank of Trinidad and Tobago's analysis of local vulnerabilities and risks, presented in its annual financial stability reports. Tracing the domestic implications for financial stability if the doom loop is triggered has revealed that the risks posed by high sovereign concentrations in the financial system are generally rated as moderate to high. Local stress tests also assess these

[20] The centrality index employs Principal Component Analysis to aggregate different centrality metrics including degree, strength, distance, pagerank, hub centrality and authority centrality (León, Machado and Murcia 2015).

concentrations (that is, large exposures[21]). Results from the stress testing exercises have shown that a shock to domestic commercial banks' GORTT exposures[22] typically causes banks' capital adequacy ratios to fall below the 10 per cent regulatory minimum. As at December 2020, the ratios of five out of seven[23] banks fell below the industry's prudential benchmark. Notably, these banks accounted for 89.2 per cent of assets in the sector. Moreover, a study by Thomas and Garcia-Singh (2019) calculated and assessed the domestic sovereign subsidy and SRISK indicators[24], created by discounting sovereign exposures, for local commercial banks. The indicators showed that the absence of sovereign-related guideposts obscures risks, giving a false sense of security. Despite these observations, the risk profile, namely of banks does not reflect this vulnerability. Consequently, all three analytical pieces coupled with the findings of this study support the need for continuous monitoring of the risk absorption capacity for banks and, tangentially, the development and integration of a government medium-term fiscal strategy.

Effective risk mitigation strategies therefore require apt risk identification frameworks. Currently, the structure of risk assessment frameworks has contributed to the depth of interconnections between banks and the state. Thus, the validity of bank liquidity and capital adequacy indicators are largely dependent on the integrity of risk quantification and the suitability of contingency buffers. Hence, perceptions that government paper carries little to no default risk could (and has for some countries) compromise macro-financial stability objectives by discounting the costs of these connections. Having a full understanding of the dynamics of the local sovereign-bank network therefore reduces information asymmetries that could lead to market failures.

Whether the crises are bank-led or sovereign-induced, the main catalyst for instability in the nexus is counterparty risk. To encourage de-risking of portfolios exposed to sovereign/bank risks requires adjustments to the asset and liability frameworks of sovereigns and banks. Studies on the matter emphasise the importance of capital and liquidity controls, concentration limits and fiscal governance strategies.[25] For banks, regulators have direct influence over the asset and liability management frameworks of the industry. Locally, efforts to strengthen the prudential framework are likely to improve banks' resilience, leading to better management of the nexus.[26] Among the prudential solutions proposed to manage the nexus, adding risk-weights are contestable given that they could be pro-cyclical – in good times sovereign ratings are favourable, demanding lower buffers, but during hard times when funding needs are high, demands for higher buffers will be difficult to maintain if sovereign ratings deteriorate. Dell'Ariccia et al. (2018) offer a time-invariant (through-the-cycle) risk-weight for domestic sovereign exposures. According to the authors, this solution reduces the regulatory incentive to hold large amounts of sovereign exposures and avoids the pro-cyclicality drawbacks. Another contributor to counterparty risk in networks is concentration risks. Concentration limits have

[21] In the Financial Institutions Act, 2018 of Trinidad and Tobago, large exposures refer to the aggregate of all credit exposures to a person or a borrower group, which amounts to 25 per cent or more of the capital base or assigned capital of a licensee.
[22] This entails a 50 per cent credit shock to GORTT exposures, according to the CBTT stress testing exercise, for local commercial banks (which on average accounts for over 90 per cent of assets in the sector under study).
[23] One bank held no large exposures to the GORTT Group.
[24] The sovereign subsidy represents the gap in capital created from zero risk-weights. The SRISK (Systemic RISK) indicator measures a financial entity's capital shortfall conditional on severe financial system distress (Korte and Sascha 2013, Andritzky, et al. 2016, Brownlees and Engle 2011, Thomas and Garcia-Singh 2019).
[25] International Monetary Fund (2016); BCBS (2017); Dell'Ariccia, et al. (2018); and The World Bank (2021).
[26] These measures include Pillar 2 (capital for additional risks), leverage ratio, capital conservation buffer, higher loss absorbency requirements for domestic systemically important banks and the liquidity coverage ratio.

emerged as a more viable mitigant that can minimise both sectors' exposure to counterparty risks. Note, locally banks are allowed to hold sovereign exposures in excess of 25 per cent of their capital base. However, all large exposures (including sovereign exposures) are subjected to an overall limit of 800 per cent of their capital base. Nevertheless, the solution should address both sides. Managing concentrations on both ends of the spectrum can curb the depth of the connection between the sectors, limiting any possibility of crises and increasing the sectors' resilience.

Other recommendations to curb growing concentrations of sovereign exposures by banks are liquidity and leverage ratios as well as buffers on sovereign exposures directly. The leverage ratio supplements other risk-based capital measures but is not risk-based. Managing excessive leveraging limits the accumulation of risk associated with using sovereign exposures, perceived as 'risk-free'. The liquidity coverage ratio (LCR) safeguards against short-term market disruptions and demands. Unlike the traditional liquidity indicators used to measure performance, the LCR requires that specific guidelines are adhered to when selecting liquid assets to meet compliance benchmarks. Capital buffers that account for sovereign exposure risks alone are also a potential solution. This was the case in the euro area when a temporary sovereign capital buffer was set and released when market conditions improved (ESRB 2015).

On the bank side, the main downside to these approaches is the disharmonious application of capital controls and concentration limits across countries. As a result, stunting the home bias could reduce liquidity in domestic capital markets and encourage a move to foreign sovereign holdings, which can introduce foreign currency risks. Currently, both sectors are exposed to the US (banks via external securities and the state via foreign currency liabilities), but exposures are relatively low compared to local sovereign holdings. As with other diversification risks, this may spread default risks across countries (and sectors) if exposures are split. Further, applying capital charges in a domestic setting characterised by banks with high capital ratios could be less efficacious.

Network studies also promote efficient strategies for financing operations. Efforts to improve the local market structure, namely through diversification, have been a challenge. Unlike other market-based economies such as the US or Singapore, the local capital market predominantly trades government paper. Hence, state dominance in capital markets and the lack of private sector investment options drive the connections shown in the domestic nexus. The widespread use and adoption of network maps, statistics and simulation exercises in the public and private sector could catalyse the promotion of alternative sources of finance. Reverting to security market auctions[27] could reduce sovereign-bank ties. Stimulating local capital market activity and introducing competition brings diversity, spreading exposures across the financial system and discouraging concentration build-ups between the public and banking sectors. According to Bossone (2010), developed capital market activity (described as deep and efficient) offers several advantages for banks, such as improving borrower-risk profile assessments and better monitoring of bank investments. This applies similarly to other financial entities' risk profiles and internal assessments. Additionally, capital market data provides a real-time, high frequency series that allows for more forward-looking analyses that are known to be more efficient at assessing risk build-ups in the system. Such data could add to domestic interconnectedness studies and enhance

[27] Currently private placement transactions are used.

local stress tests, systemic importance identification and assessment frameworks, and early warning indicators (Arregui, et al. 2013). Though the findings of this study were insightful, the low levels of data granularity and frequency limited the analysis.

However, the tradeoffs of having a more robust tool to identify, assess and mitigate risks could have implications for funding and liquidity conditions within an economy. Adjustments to regulatory guidelines and limits – such as banks' concentration limits or public sector borrowing limits – could affect traditional sources of finance for both sectors. On the banking side, adjustments to limits, capital and liquidity could dissuade banks from holding sovereign paper, limiting the state's (and other economic agents') access to funding. Any deleveraging during difficult times when deep connections between the banking and public sector exist could worsen economic conditions. The Government is a key player in local banking and financial markets; thus tighter financial conditions could constrain the Government's allocative and entrepreneurial roles in the economy. Though this may be advisable and an inescapable short-term consequence of the Government transitioning to a more facilitative role, limiting activities such as bond issues and guarantees stifles collateral and investment channels. Most studies agree that caution is advised when addressing sovereign-bank ties, as decisions should consider micro- and macro-financial fallouts.

8.0 Conclusion and Recommendations

The analysis of direct, bilateral linkages between the domestic sovereign and local banking institutions underscored the significance of the sovereign-bank nexus in Trinidad and Tobago and corroborated the existence of a few systemically important institutions. Though overall connections were limited, introducing the sovereign into the inter-bank network created tighter linkages between the entities, which could facilitate faster shock transmission throughout the entire sector. The strength or intensity of connections within a subset of four institutions was noteworthy and owing largely to the strong home bias in sovereign debt holdings. Specifically, the sovereign connection with an indigenous bank, Bank 8, overwhelmed the network – aggregate, bilateral claims between the two nodes amounted to just over 50 per cent of total claims in the network. It should be noted that at least two of the four banks, including Bank 8, also ranked among the most important players in the independent, inter-bank network; the stability of the subset is, therefore, key to preserving system-wide stability.

Several potential solutions exist for limiting vicious aspects of the nexus. From a regulatory perspective, a macroprudential framework comprising the appropriate tools to enhance risk-based supervision is recommended. In particular, the introduction of specialised buffers under this framework to incorporate sovereign exposure risk could be considered. Additionally, interconnectedness studies and contagion analyses have emerged as a main feature of systemic risk assessment frameworks. The static analysis undertaken in this study may be enhanced by the application of macro-financial shocks through dynamic network analysis. Dynamic analyses include simulation exercises that highlight the strength of contagion paths from one node to another and the speed at which a shock may pass through the system for several rounds. Local network maps, statistics and simulation studies can enhance and complement risk models such as stress testing. Advantages of these approaches for local stress tests include the determination of risk factors, risk transmission sequencing and possible shock values over multiple periods. This is particularly important for crisis preparation and the supervision of entities, promoting financial stability and fiscal sustainability. Locally, this will be beneficial in determining the systemic importance of key market players and associated risk

mitigants, complementing traditional monitoring and performance indicators. In terms of fiscal management, determining key risk exposures could influence budgetary planning strategies. For both sectors, network studies showcase a high degree of accuracy when identifying vulnerable areas, especially when they converge. Knowing where commonalities lie can better guide asset allocation strategies and promote diversified exposures that may weaken the nexus. The consensus among academics and regulators is that the interlinkages should be monitored and managed, not stifled, to curb the harsh elements of the cycle while promoting the good.

9.0 References

Acharya, V, and S Steffen. 2013. The Greatest Carry Trade Ever? Understanding Eurozone Bank Risks. NBER Working Paper, NBER.

Acharya, Viral V., Itamar Drechsler, and Philipp Schnabl. 2011. A Pyrrhic Victory? - Bank Bailouts and Sovereign Credit Risk. Working Paper, National Bureau of Economic Research.

Allen, Franklin, Elena Carletti, Itay Goldstein, and Agnese Leonello. 2017. Government guarantees and financial stability. Working Paper, European Central Bank.

Alogoskoufis, Spyros, and Sam Langfield. 2018. Regulating the doom loop. Working Paper, European Systemic Risk Board. https://www.esrb.europa.eu/pub/pdf/wp/esrb.wp74.en.pdf.

Alter, Adrian, and Andreas Beyer. 2013. The Dynamics of Spillover Effects during the European Sovereign Debt Turmoil. Working Paper, European Central Bank.

Andreeva, Desislava C., and Thomas Vlassopoulos. 2016. Home bias in bank sovereign bond purchases and the bank-sovereign nexus. Working Paper, European Central Bank.

Andritzky, Jochen, Niklas Gadatsch, Tobias Körner, Alexander Schäfer, and Isabel Schnabel. 2016. "Removing Privileges for Banks' Sovereign Exposures – A Proposal." European Economy: Banks, Regulation and the Real Sector 139-152.

Arellano, Cristina, and Narayana R. Kocherlakota. 2008. Internal Debt Crises and Sovereign Defaults. Working Paper, National Bureau of Economic Research.

Arregui, Nicolas, Mohamed Norat, Antonio Pancorbo, and Jodi Scarlata. 2013. Addressing Interconnectedness: Concepts and Prudential Tools. Working Paper, International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2013/wp13199.pdf.

Asonuma, Tamon, Said Bakhache, and Heiko Hesse. 2015. Is Banks' Home Bias Good or Bad for Public Debt Sustainability? Working Paper, Washington DC: International Monetary Fund.

Bangwayo-Skeete, Prosper F., Michael Brei, Dorian M. Noel, and Justin Robinson. 2019. "Sovereign Risk Spill-Overs to Banking Sectors in Central America and the Caribbean." Conference Paper.

Bank for International Settlements. 1995. Financial structure and the monetary policy transmission mechanism. Bank for International Settlements. Accessed 2020. https://www.bis.org/publ/bisp00.pdf.

BCBS. 2017. The regulatory treatment of sovereign exposures. Discussion paper, Bank for International Settlements.

Bennani, Taryk, Morgan Després, Marine Dujardin, Thibaut Duprey, and Anna Kelber. 2014. "Macroprudential framework: Key questions applied to the French case." Bank of France. February. Accessed 2016. https://www.banque-france.fr/fileadmin/user_upload/banque_de_france/publications/OP9_Macroprudential-framework.pdf.

Billio, Monica, Dale Gray, Andrew W. Lo, Robert C. Merton, and Loriana Pelizzon. 2013. "Sovereign, Bank and Insurance Credit Spreads: Connectedness and System Networks."

BIS. 2013. "Sovereign risk: a world without risk-free assets?" BIS Papers No 72. Bank for International Settlements.

Bossone, Biagio. 2010. "Banks and capital markets: A two-way nexus." VOX EU CEPR. 12 December. Accessed August 25, 2021. https://voxeu.org/article/banks-and-capital-markets-two-way-nexus#fn.

Brault, Julien, and Simone Signore. 2020. Credit Guarantees in the COVID-19 crisis – Relevance and Economic Impact. Policy Note, SUERF: The European Money and Finance Forum. https://www.suerf.org/policynotes/14869/credit-guarantees-in-the-covid-19-crisis-relevance-and-economic-impact.

Bricco, Jana, and TengTeng Xu. 2019. Interconnectedness and Contagion Analysis: A Practical Framework. Working Paper, International Monetary Fund.

Brownlees, Christian, and Robert F Engle. 2011. Volatility, Correlation and Tails for Systemic Risk Measurement. Washington University.

Canetti, Elie, Kimberly Beaton, Qiaoe Chen, Fabio Di Vittorio, Udi Rosenhand, and Kalin Tintchev. 2017. "Financial Interconnectedness for the Caribbean: Challenges for Financial Stability." In Unleashing Growth and Strengthening Resilience in the Caribbean, by International Monetary Fund. International Monetary Fund.

CBTT. 2021. COVID-19 Response updates. Accessed August 27, 2021. https://www.central-bank.org.tt/core-functions/supervision/covid-19-response-updates.

CBTT. 2020. Financial Institutions (Capital Adequacy) Regulations. Regulation, Port of Spain: Central Bank of Trinidad and Tobago. https://www.central-bank.org.tt/sites/default/files/page-file-uploads/financial-institutions-capital-adequacy-regulations-2020_0.pdf.

CBTT. 2015. Financial Stability Report 2014. Annual, Port of Spain: Central Bank of Trinidad and Tobago. https://www.central-bank.org.tt/sites/default/files/reports/Financial%20Stability%20Report%202014.pdf.

CBTT. 2020. Financial Stability Report 2019. Central Bank of Trinidad and Tobago.

CBTT. 2021. Financial Stability Report 2020. Annual Report, Port of Spain: Central Bank of Trinidad and Tobago.

CCMF. 2016. Caribbean Regional Financial Stability Report 2015. Caribbean Centre for Money and Finance.

CGFS. 2011. The impact of sovereign credit risk on bank funding conditions. Committee on the Global Financial System, Bank for International Settlements.

Cortes, Fabio, Peter Lindner, Sheheryar Malik, and Miguel A. Segoviano. 2018. A Comprehensive Multi-Sector Tool for Analysis of Systemic Risk and Interconnectedness (SyRIN). Working Paper, International Monetary Fund.

Cruces, Juan J., and Christoph Trebesch. 2013. "Sovereign Defaults: The Price of Haircuts." American Economic Journal: Macroeconomics 3: 85–117.

Dées, Stéphane, Filippo di Mauro, M. Hashem Pesaran, and L.Vanessa Smith. 2007. "Exploring the international linkages of the euro area: a global VAR analysis." Journal of Applied Econometrics 22(1): 1-38.

Deev, Oleg, and Martin Hodula. 2016. "Sovereign default risk and state-owned bank fragility in emerging markets: evidence from China and Russia." Post-Communist Economies 28:2, 232-248.

Dell'Ariccia, Giovanni, Caio Ferreira, Nigel Jenkin, Luc Laeven, Alberto Martin, Camelia Minoiu, and Alex Popov. 2018. Managing the Sovereign-Bank Nexus. European Central Bank.

Demirgüç-Kunt, Asli, Edward Kane, and Luc Laeven. 2014. Deposit Insurance Database. Working Paper, International Monetary Fund.

Díaz-Alejandro, Carlos F. 1984. Good-bye Financial Repression, Hello Financial Crash. Working Paper, The Hellen Kellogg Institute for International Studies.

Diebold, Francis X., and Kamil Yilmaz. 2014. "On the Network Topology of Variance Decompositions: Measuring the Connectedness of Financial Firms." Journal of Econometrics 182 (1): 119-134.

ECB. 2015. The fiscal impact of financial sector support during the crisis. ECB Economic Bulletin, European Central Bank.

Espinosa-Vega, Marco A., and Juan Solé. 2010. Cross-Border Financial Surveillance: A Network Perspective. Working Paper, International Monetary Fund.

ESRB. 2015. ESRB report on the regulatory treatment of sovereign exposures. Report, European Systemic Risk Board.

Farhi, Emmanuel, and Jean Tirole. 2017. “Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops.” Review of Economic Studies 85(3): 1781-1823.

Feyen, Erik, and Igor Zuccardi. 2019. The Sovereign-Bank Nexus in EMDEs: What Is It, Is It Rising, and What Are the Policy Implications? Policy Research Working Paper, World Bank Group.

Fitch Ratings. 2021. Bank Rating Criteria: Master. FItch Ratings. https://www.fitchratings.com/research/banks/bank-rating-criteria-12-11-2021.

Fratzscher, Marcel. 2011. Capital Flows, Push versus Pull Factors and the Global Financial Crisis. Working Paper, National Bureau of Economic Research.

Garcia, Roman, Dimitri Lorenzani, Daniel Monteiro, Francesco Perticari, Bořek Vašíček, and Lukas Vogel. 2021. Financial Spillovers and Contagion Risks in the Euro Area in 2007-2019. Discussion Paper, European Commission.

Gómez-Puig, Marta, Manish K. Singh, and Simón Sosvilla-Rivero. 2018. The robustness of the sovereign-bank interconnection: Evidence from contingent claims analysis. Working Paper, Research Institute of Applied Economics.

Gray, Dale, Marco Gross, Joan Paredes, and Matthias Sydow. 2013. Modeling Banking, Sovereign, and Macro Risk in a CCA Global VAR. Working Paper, International Monetary Fund.

Honohan, Patrick. 2010. “Two-way interdependence between the banking system and the State.” Bank for International Settlements. https://www.bis.org/review/r100517a.pdf.

Horváth, Bálint, Harry Huizinga, and Vasso Ioannidou. 2015. European Banks’ Sovereign Debt Home Bias: Voluntary or Involuntary? July. Accessed January 2021. https://voxeu.org/article/determinants-bank-s-sovereign-debt-home-bias.

IMF. 2016. Analyzing and Managing Fiscal Risks - Best Practices. Washington DC: International Monetary Fund.

—. 2009. Global Financial Stability Report: Responding to the Financial Crisis and Measuring Systemic Risks. Accessed 2017. http://www.imf.org/external/pubs/ft/gfsr/2009/01/.

IMF. 2020. Italy: Financial Sector Assessment Program - Systemic Risk Analysis and Stress Testing of the Banking and Corporate Sectors. Technical Note, International Monetary Fund.

—. 2014. “Monetary and Financial Statistics Manual & Compilation Guide -- Classification of Financial Assets and Liabilities.” International Monetary Fund. https://www.imf.org/external/pubs/ft/mfsmcg/c4.pdf.

IMF. 2019. Republic of Poland: Financial Sector Assessment Program - Stress Testing and Systemic Risk Analysis. Technical Note, International Monetary Fund.

IMF. 2018. Romania: Financial Sector Assessment Program. Country Report, International Monetary Fund.

IMF. 2017. Spain: Financial Sector Assessment Program - Interconnectedness and Spillover Analysis in Spain’s Financial System. Technical Note, International Monetary Fund.

IMF. 2010. United States: Publication of Financial Sector Assessment Program Documentation - Technical Note on Stress Testing. IMF Country Report, International Monetary Fund.

Jobst, Andreas A., and Dale F. Gray. 2013. Systemic Contingent Claims Analysis – Estimating Market-Implied Systemic Risk. Working Paper, International Monetary Fund.

Kaminsky, Graciela L., and Carmen Reinhart. 1999. “The Twin Crises: The Causes of Banking and Balance-of-Payments Problems.” American Economic Review 89(3): 473-500.

Korte, Josef, and Steffen Sascha. 2013. “Zero Risk Contagion: Banks' Sovereign Exposure and Sovereign Risk Spillovers.” 22nd International Conference on Money, Banking and Finance. pp. 12-13.

Laeven, Luc, and Fabián Valencia. 2012. Systemic Banking Crises Database: An Update. Working Paper, International Monetary Fund.

Laeven, Luc, and Fabian Valencia. 2018. Systemic Banking Crises Revisited. Working Paper, International Monetary Fund.

Laeven, Luc, and Fabian Valencia. 2008. Systemic Banking Crises: A New Database. Working Paper, International Monetary Fund.

León, Carlos. 2015. "Financial Stability from a Network Perspective." Discussion Series. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2574686.

León, Carlos, Clara Machado, and Andrés Murcia. 2015. Assessing Systemic Importance With a Fuzzy Logic Inference System. Research Article, John Wiley & Sons, Ltd.

Leonello, Agnese. 2017. Government guarantees and the two-way feedback between banking and sovereign debt crises. Working Paper, European Central Bank.

Lovreta, Lidija, and Joaquín López Pascual. 2020. "Structural breaks in the interaction between bank and sovereign default risk." SERIEs - Journal of the Spanish Economic Association 11: 531-559.

Merton, Robert C. 1973. "Theory of Rational Option Pricing." The Bell Journal of Economics and Management Science 4(1): 141-183.

Ogawa, Sumiko, Joonkyu Park, Diva Singh, and Nita Thacker. 2013. Financial Interconnectedness and Financial Sector Reforms in the Caribbean. Working Paper, International Monetary Fund.

Polackova, Hana. 1999. "Contingent Government Liabilities." World Bank. March. Accessed August 25, 2021. https://www.imf.org/external/pubs/ft/fandd/1999/03/polackov.htm.

Reinhart, Carmen M., and Kenneth S. Rogoff. 2011. A Decade of Debt. Working Paper, National Bureau of Economic Research.

Reinhart, Carmen M., and Kenneth S. Rogoff. 2013. Financial and Sovereign Debt Crises: Some Lessons Learned and Those Forgotten. Working Paper, International Monetary Fund.

Reinhart, Carmen M., and Kenneth S. Rogoff. 2010. From Financial Crash to Debt Crisis. Working Paper, National Bureau of Economic Research.

Roukny, Tarik, Co-Pierre Georg, and Stefano Battiston. 2014. A network analysis of the evolution of the German interbank market. Discussion Paper, Deutsche Bundesbank. https://pdfs.semanticscholar.org/9ab7/8887967a85c98ca2c4b3368bd8be572de8c2.pdf.

S&P Global Ratings. 2020. How We Rate Banks. Standard & Poor's. https://www.spglobal.com/ratings/_division-assets/pdfs/070813_howweratebanks.pdf.

Schich, Sebastian, and Sofia Lindh. 2012. "Implicit Guarantees for Bank Debt: Where Do We Stand?" OECD Journal: Financial Market Trends 1: 1-22.

Signori, Daniele, and Ramazan Gençay. 2007. Economic Links and Credit Spreads. SSRN Working Paper, Social Science Reserach Network.

The World Bank. 2021. Debt & Fiscal Risks Toolkit. Accessed August 2021. https://www.worldbank.org/en/programs/debt-toolkit/fiscal-risk.

Thomas, Natalie, and Chantal Garcia-Singh. 2019. "Sovereign-bank Interlinkages: Can Risk Ratings and Exposure Limits Reduce Systemic Risk from Sovereign Exposures?" Unpublished Manuscript, Port of Spain.

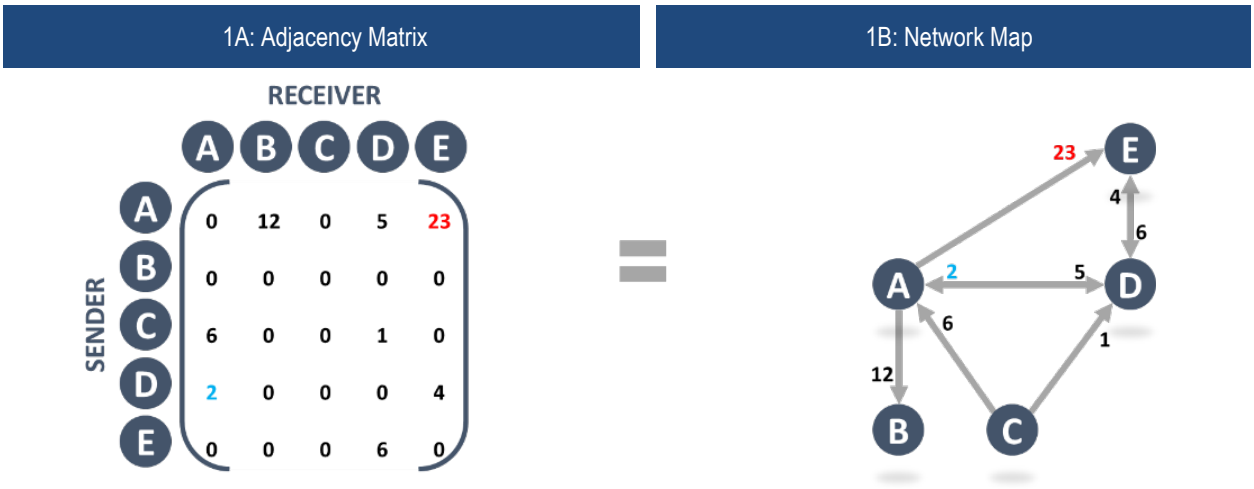
Westphal, Annika. 2015. "Systemic Risk in the European Union: A Network Approach to Banks' Sovereign Debt Exposures." International Journal of Financial Studies 3: 244-279.

10.0 Annex

Static Network Analysis Methodology

Figure A1 illustrates a hypothetical financial network of entities where the links between the nodes (●) are directed and weighted. The direction of links (➡) gives meaning to the relationship between nodes, while the weight signifies the importance of the relationship. For example, if there is a directional link from A to E with an exposure of 23, this implies that the relative value of the claim A has on E is 23; A is therefore a lender (or sender of payment) and E, a borrower (or receiver of payment).

Figure A1
Hypothetical Financial Network



Source: Central Bank of Trinidad and Tobago.

Statistical properties of the network complement the network map and allow for the quantification of systemic risks. The assessment may be conducted on two levels. The network-level analysis, which focuses on topological properties of the entire network, describes the level of connectivity within the network. The node-level analysis identifies core players in the network. Table A1 presents the metrics used for both network-level and node-level analyses, though interpretation and computation refer to the overall network.[28]

[28] In most instances, the sum, average or standard deviation of individual node scores is used to compute the network score.

Table A1
Major Statistical Network Measures

Measure	Description	Interpretation	Computation
Density	The overall level of connectivity in the network	Higher values indicate higher network connectivity	Ratio of the number of realised links (contagion paths) to the number of all possible links in the network
Diameter	The longest path that it will take for contagion to pass through the network	Lower values indicate higher network connectivity	The maximum value of the minimum connections (contagion paths) between each pair of nodes
Distance	The speed of transmission or flow of contagion throughout the network	Lower values indicate higher network connectivity	The average of the minimal amount of intermediary connections between each pair of nodes
Degree	The connectivity of nodes in the network	Higher values indicate higher network connectivity	The average (standard deviation) number of connections that nodes have in the network irrespective of the direction
Strength	The intensity of connections in the network	Higher values indicate higher network connectivity	The average (standard deviation) of link weights of nodes in the network
Reciprocity	The likelihood of 'bi-directional' relations between nodes in the network	Higher values indicate higher network connectivity	The ratio of reciprocated (bilateral) links in the network
Clustering Co-efficient	The size of counterparty risk of a node	Higher values indicate higher network connectivity	The relative frequency of triangles (clusters) in the network

Source: Roukny, Georg and Battiston (2014), León (2015).
Note: For financial network analysis, the links or connections are synonymous to the bilateral exposures and thus are assumed to map the flow of contagion throughout the network. Scores for a given network indicate the complexity of the network at a given point in time. Most studies compare past network scores or cross-country/system scores to assess the relative depth of their network's complexity.