Sovereign-Bank Nexus in the Eurozone during the COVID-19 Crisis: Empirical Analysis and Policy Implications

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Submitted to Central European University - Private University,
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In partial fulfilment of the requirements for the degree of Master of Arts in Economic Policy in Global Markets

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Vienna, Austria
2022

Abstract

In this thesis, I investigate the connection between bank and sovereign credit risk during the COVID-19 crisis. In the first part of the thesis, I provide an overview of the European sovereign debt crisis and the subsequent policy responses from the perspective of the sovereign-bank nexus and contrast it with the COVID-19 crisis. Then, I estimate the strength of the sovereign-bank nexus using panel regressions on bank and sovereign CDS spreads, employing a dataset of 24 banks and 11 Eurozone countries between 2018 and 2022 February. I investigate the hypotheses that there was a significant connection between bank and sovereign credit risk preceding and during the COVID-19 crisis, and that the connection between the two actors has declined over the course of the pandemic. Consistent with the hypotheses, I find that the nexus between sovereigns and banks has declined in the two-year period after February 2020, when the first cases of the COVID-19 appeared in Europe. The relationship was, however, still significant on average in the 11 Eurozone countries in the sample during the investigation period. Moreover, results arising from country subsamples suggest that the nexus was present primarily in the peripheric (rather than the core) countries of the Eurozone.

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1. Introduction

There is an inherent relationship between the risk of sovereigns and domestic banks. Whereas the prospects of sovereigns largely depend on their domestic banking system, banks are also exposed to risks related to the sovereign due to holding significant amount of sovereign debt. Furthermore, in times of crisis, domestic banks tend to exhibit a home bias towards domestic debt instruments, meaning that they are more likely to purchase domestically issued debt than their foreign counterparts (Ongena et al., 2019). After an adverse shock on economic activity, the increase in credit risk of the sovereign reduces the market value of banks' balance sheets containing sovereign debt. This can trigger perceptions of increased solvency risk of banks, by further aggravating the possibility that they will have to rely on guarantees of their domestic government and can in turn impact sovereign risk as well (Brunnermeier et al., 2016). This relationship is generally referred to as the "sovereign-bank nexus" and its existence has been confirmed in times of crises by a wide body of research. Prior contributions highlighted the importance of sovereign exposures and public debt level (Acharya et al., 2014; De Bruyckere et al., 2013), bank capitalization (Acharya-Steffen, 2013) and the effects of policy interventions (Fiorderlisi et al. 2020; Bechtel et al.,2021) on the nexus.

This topic is particularly important in the Eurozone, where the European Sovereign Debt crisis of 2010-12 provided a striking example of the mentioned vulnerabilities. During that crisis, credit risk spread from the financial sector and worsened perceptions of sovereign risk to the greatest extent in GIIPS[1] countries (Horvath et al., 2015). Since then, several actors have advocated for the reform of the Eurozone and the creation of a more resilient institutional framework that prevents the vicious circle of events that happened during that crisis. As a

[1] Referring to Greece, Ireland, Italy, Portugal and Spain.

response, two pillars of the EU's Banking Union, the Single Supervisory Mechanism (SSM)[2] and the Single Resolution Mechanism (SRM)[3] were put in place in 2014 (Carboni et al. 2017). Prudential requirements of banks have been strengthened by the creation of a Single Rulebook[4] for European Banks, aimed at ensuring the uniform application of global standards. Under the SRM, the Bank Recovery and Resolution Directive (BRRD)[5] was also implemented, shifting the burden of bailouts from taxpayers to banks. Nonetheless, the proposed banking union is still incomplete, leaving the problem of elevated sovereign debt holdings of banks unsolved.

The outbreak of the COVID-19 pandemic and the fiscal measures to support the economy that followed have prompted an increase in sovereign debt, and in the exposures between governments and their domestic banking systems. Monetary and fiscal policy measures on the other hand, proved successful in containing the crisis, and the financial system remained stable. The ECB's reaction via the Pandemic Emergency Purchase Programme (PEPP), and the suspension of the rules limiting member state budget deficits and debt in the Stability and Growth Pact (SGP) provided the necessary room for member states to counteract the economic consequences of COVID-19 (Dias-Grigaitė, 2020). Thanks to these interventions, the pandemic did not appear to spill over into corporate defaults and bank profitability, and the relationship between banks and sovereigns was described as virtuous rather than vicious (Schnabel, 2021).

On the other hand, there is a possibility that the support has masked increasingly vulnerable connections between banks and sovereigns. Countries' aggressive borrowing to finance

[2] Under the SSM, the most significant banks in Eurozone countries (representing the majority of total banking assets) are supervised directly by the ECB. National Supervisory Authorities (NSAs) maintain the direct supervision of the remaining banks (Carboni et al. 2017).
[3] The purpose of the SRM is to ensure an orderly resolution of failing banks, by providing a uniform resolution framework in member countries. (Carboni et al. 2017).
[4] The "Single Rule Book" established a set of harmonised prudential rules, binding for all banks in EU member states, with the aim of ensuring uniform application of Basel III standards. (European Union, 2021)
[5] The BRRD includes rules to set up a national resolution fund that must be established by each EU country. All financial institutions have to contribute to these funds. Contributions are calculated based on the institution's size and risk profile (European Commission, 2022).

counteracting measures to the effect of the COVID-19 pandemic led to public debt to GDP ratios in Italy, Spain and France higher than the levels prevailing during the European sovereign debt crisis (Eurostat, 2022). In parallel, euro area banks' exposures to domestic sovereign debt securities have seen their largest increase upon the outbreak of the pandemic since 2012 (Arnold, 2021). Given these developments, a withdrawal of COVID-related fiscal and monetary measures therefore can easily feed back into the financial sector through corporate defaults and an increasing rate of non-performing loans (Schnabel, 2021).

Motivation for further research on this topic is twofold. Firstly, prior research focused on the sovereign-bank nexus during and after the EU sovereign debt crisis and aimed to evaluate the effects of bailouts (e.g. Acharya et al., 2014), banking regulation (e.g. Fiordelisi et al., 2020), monetary policy (e.g. Bechtel et al., 2021) and the potential channels of the nexus (Acharya et al. 2018). As the COVID-19 crisis exhibited different features than the EU debt crisis, further research could broaden our knowledge on the effects of a real economy shock on the nexus between sovereigns and banks. Furthermore, assessing the strength of the sovereign-bank nexus during the pandemic would also test if the policy responses to the COVID-19 crisis have effectively mitigated sovereign-bank interlinkages as well.

In my thesis, I investigate the connection between bank and sovereign credit risk during COVID-19 crisis and compare strength of the nexus with the preceding two years. In the empirical analysis of this paper, panel data on 24 banks from 11 Eurozone countries will be used, with observations spanning from 2018 until 2022 February. The strength of the sovereign-bank nexus will be estimated on different time windows and geographical subsamples. The baseline model will be a panel regression of first differences. As a proxy for credit risk, daily Bank and sovereign credit default swap (CDS) spreads will be used. Furthermore, global controls (volatility and stock market indices), along with bank-specific (equity returns and balance sheet indicators) and country-specific macroeconomic controls (GDP growth, public

debt to GDP) will be included in the models. My main result is that the strength of the nexus between sovereigns and banks has declined significantly after the outbreak of the COVID-19 crisis but was present primarily in the peripheric (rather than the core) countries of the Eurozone. I conclude that the distinct characteristics of the COVID-19 crisis, and the policy responses successfully kept the sovereign-bank nexus under control, but measures to mitigate the nexus might be necessary in the future.

The remainder of the paper will be structured as follows: **In Section 2**, I explain the sovereign-bank nexus relationship, and review existing empirical evidence on its strength during normal and crisis times. **In Section 3** the European sovereign debt crisis and subsequent policy responses will be introduced in relation to the sovereign-bank nexus, including a comparison to the measures taken in the period of the COVID-19 crisis. **In Section 4**, an empirical analysis will follow, in which the correlation of sovereign risk with bank credit risk will be quantified during the COVID-19 crisis and compared with the two-year period preceding the crisis. Finally, **in Section 5**, I will briefly discuss the policy implications of my findings and **in Section 6**, I will conclude by summarizing my results, presenting the limitations of this thesis, and by providing potential proposals for future research.

2. Review of Literature

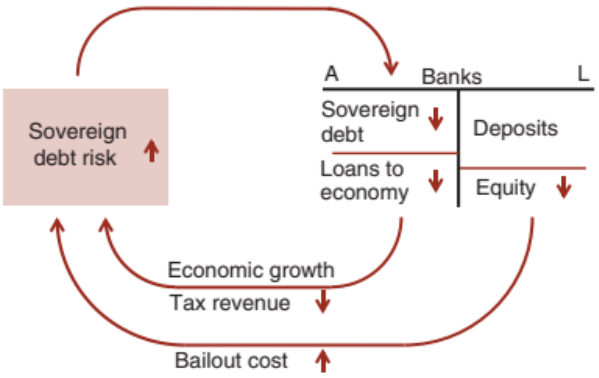
In the following section, I will provide review the main theoretical literature on the sovereign-bank nexus, and I will also introduce the existing literature that provides empirical evidence on the topic.

2.1. The Mechanism of the Sovereign-Bank Nexus

The European sovereign debt crisis provided a striking example of the vulnerabilities the doom loop can cause. As outlined in the work of Brunnermeier et al. (2016, p. 508), the sovereign-bank credit risk nexus consists of two interrelated feedback loops: a "bailout loop" and a "real economy loop." (Figure 1.)

- After an adverse direct shock on economic activity, the increased credit risk of the sovereign decreases the market value of banks' balance sheets, through their holdings of domestic sovereign debt.
- In turn, banks deteriorating balance sheets trigger perceptions of increased solvency risk, aggravating the possibility that they will have to be bailed out by their (domestic) government. The weakened banking system then reinforces credit risk of the sovereign even further.
- The effect the doom loop is transmitted to the real economy as distressed banks cut back on lending and reducing in economic activity as a result. The fiscal position of the sovereign is impacted due to the decline in tax revenues, which in turn raises concerns about the solvency of governments in the affected countries.

Figure 1.: Channels of the sovereign-bank nexus
(Brunnermeier et al., 2016 p. 508.)



The intensity of the doom loop effect is largely dependent the banks' degree of home bias – an indicator that reflects the preference of domestic banks for holding domestic sovereign debt instruments compared to other sovereign debt instruments. The degree of home bias is measured by the domestic sovereign debt holdings in percent of total assets, and in percent of total debt (Asonuma et al., 2015). The higher the home bias of financial institutions in a particular country – and therefore the size of domestic government debt on their balance sheets - the more reliant are these institution on the perceived solvency and market value of their own government's debt.

From the perspective of the sovereign, home bias can have a positive effect on fiscal space, resulting mainly from the impact of high home bias on the rollover risk of debt - which is particularly important during crisis periods. Acharya and Steffen (2013) found that home bias (i.e. the banks' holdings of domestic sovereign debt relative to their total assets) helped to lower CDS spreads in the European periphery after the systemic crisis. The overall impact of the bank-sovereign nexus is determined by several factors, such as the size of the existing interconnectedness between banks and the sovereign, and the magnitude of the crisis, and potentially, country-specific factors (Acharya and Steffen, 2013). For instance, in case of a moderate crisis when the level of dependence is relatively low before the stress event, banks

may be better positioned to act as shock absorbers. On the contrary, when a country is severely hit by a crisis, where banks' sovereign exposures are relatively high before the stress event, the bank-sovereign nexus can push the crisis to a next level (Basel Committee on Banking Supervision, 2017).

2.2. Motives for High Sovereign Debt Home Bias

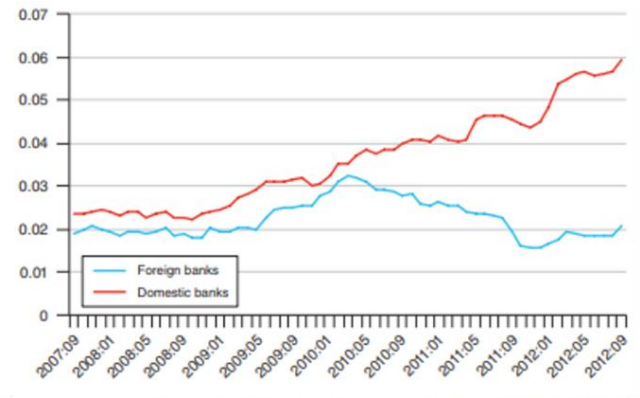
There can exist several sets of distinct motives for banks' (and sovereigns') home bias, from which the following will be outlined: Regulatory incentives concerning capital adequacy; moral suasion or financial repression used by the government; risk shifting in bank behavior, and finally country-specific advantages.

The existing regulatory framework of capital adequacy provides a more favorable capital treatment of sovereign exposures than for other exposures, giving zero risk-weight to certain sovereign debt assets (Nouy, 2012). Additionally, liquidity standards require banks to hold a buffer of liquid assets, which also include sovereign debt. In principle, Basel capital requirements contain that capital for all asset classes are needed to be held by banks, either based on a given regulatory risk weight or based on internal assessment of default probabilities (Basel Committee on Banking Supervision). However, this key idea of the Basel Accord has not been followed in the Capital Requirements Directive (CRD) of the European Union (Korte-Steffen, 2014). This may give incentives for banks to overweight sovereign debt, as banks do not need to hold capital against any of the sovereign exposures to EU member states.

Theories of financial repression suggest that the sovereign may pressure or incentivize domestic banks to absorb domestic sovereign bonds at above market prices to reduce its financing cost. This motive is said to be stronger when the sovereign is perceived to have a higher risk and yields are high (Farhi-Tirole, 2018 and Horváth et al. 2015), leading to the re-nationalization of domestic sovereign debt. Ongena et al. (2019) found that during the most severe episodes of

the sovereign debt crisis, domestic financial institutions were more likely to purchase domestically issued sovereign debt than foreign banks during months when the government had refinance large amounts of maturing sovereign debt (Figure 6.). The difference can partly be attributed to the sovereigns' ability to pressure domestic institution, while foreign banks are less easy to influence. Financial repression can affect banks' behavior, even though their purchases of government debt can generally be regarded as voluntary actions, that are aimed return maximization for shareholders, rather than motivated merely by government pressure (Ongena et al., 2019).

Figure 2.: Domestic sovereign bond holdings of banks in stressed countries during the EU sovereign debt crisis (Source: Ongena et al. 2019)



Notes: Average holdings of domestic sovereign bonds, divided by total assets, for 46 domestic banks and 14 foreign banks in five stressed euro area countries (Greece, Ireland, Italy, Portugal, and Spain) for the period September 2007–September 2012.

According to the argument of risk-shifting described in the work of Horvath et al. (2015), banks can face incentives not only to build up large exposures to their domestic sovereign, but to troubled foreign sovereigns as well. High-risk instruments such as the government bonds of troubled countries are preferred by banks with low capital ratios, as their shareholders would asymmetrically benefit from a resurrection of the country while their losses would be limited in case the sovereign defaults. (Acharya-Steffen 2013, Horvath et al. 2015). Acharya and Steffen (2013 p. 6.), found that "risk shifting" was a major factor between 2007 and 2012 in the build-up of sovereign exposures: poorly capitalized banks with short-term unsecured funding were more likely to engage in "carry trades" of riskier sovereign debt securities of stressed

countries' - to earn higher returns, while meeting regulatory capital requirements. With respect to the sovereign-debt crisis, Crosignani (2020) shows that part of ECB's Longer-term Refinancing Options (LTRO) financing was used to purchase sovereign debt instruments in carry trades, instead of increasing private sector lending.

Finally, in times of crisis, domestic banks can utilize their first-hand knowledge of the local economy. Based on the study of Saka (2019), well-informed banks can act as buyers of last resort absorbing the local assets, whereas foreign banks with potentially less information may decrease their sovereign exposures due to the panic on the markets. Therefore, the in the described cases, domestic banks' home bias induce positive externalities to offset the effects of sudden stops and to inefficient defaults of sovereigns (Saka, 2019) .

2.3. Empirical Evidence on the Sovereign-Bank Nexus

Prior studies testing the sovereign-bank nexus, have confirmed a significant connection between bank and sovereign credit risk in the Eurozone on multiple occasions. The main period of investigation in this literature is the financial crisis and the EU sovereign debt crisis, and CDS spreads are used primarily as the proxy for the credit risk of banks and sovereigns (e.g. De Bruyckere et al.,2020; Fiorderlisi et al. 2020; Acharya et. al., 2014, Bechtel et al.,2021).

De Bruyckere et al. (2013) investigates contagion between bank and sovereign default risk in Europe over during the great financial crisis using CDS spreads and they find bank credit risk to be more strongly associated with country credit risk if the bank has a relatively higher level of domestic sovereign debt on its balance sheet. Moreover, their results highlight the excess vulnerability of banks with low Tier-1 capital buffers to sovereign risk spillovers. Acharya et al. (2014) document a strong nexus during and after the bailout episodes of the great financial crisis in European countries, that was dependent on the banks' level of exposures to domestic

and foreign sovereigns as well. Evidence presented in their paper also confirms that an increase in public debt raised the sovereign-bank feedback effect (Acharya et al., 2014).

Another strand of literature studies the effect of policy interventions on the sovereign-bank interlinkages. Among more recent contributions, Fiorderlisi et al. (2020) finds evidence of positive and significant bank-sovereign risk spillovers in Europe between 2012-2018 and concludes that the strength of the nexus lowered considerably after the adoption of the new bail-in regime under the BRRD in 2014. While quantifying the effect of the ECB's stimulus program on the sovereign-bank nexus, Bechtel et al. (2021) show that quantitative easing (QE) was effective in mitigating the nexus through multiple channels. The direct channel emerges through the appreciation of sovereign debt held on banks' balance sheets, and the increase in their holdings of risk-free central bank reserves because of QE. Besides this, the indirect effect materializes through the asset purchase program's impact on general economic conditions, supporting economic activity, higher loan demand and improving banks' equity position. Finally, the results of Bechtel et al. (2021) also suggest the presence of heterogeneity in the sovereign-bank nexus between "core" and "peripheric" countries in the Eurozone: While in core countries they do not find evidence of sovereign-bank risk spillovers on their whole investigation period, they verify a strong and economically significant nexus in the Euro area periphery - that was substantially reduced after the asset purchases.

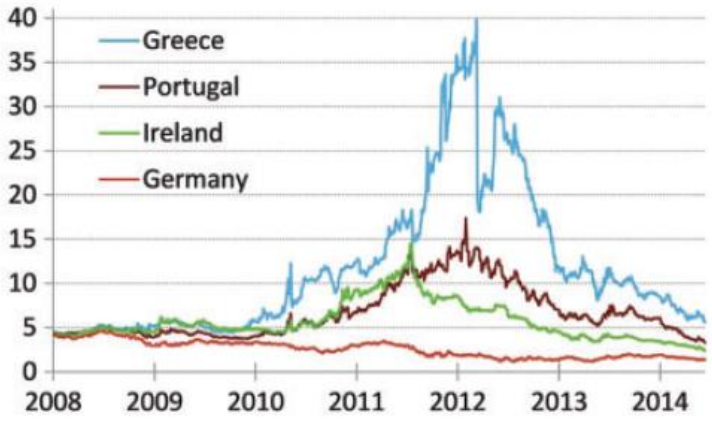
3. Overview of the Sovereign-Bank Nexus in Europe

In this chapter, the main features and policy responses of the European sovereign debt crisis and the COVID-19 crisis will be introduced. The most important developments related to sovereign and bank credit risk in both periods will be highlighted, with the aim of contrasting the two crisis episodes.

3.1. The European Sovereign Debt Crisis and the Banking Union

The European sovereign debt crisis provided a striking example of the problems the diabolic or doom loop can cause, that threatened the monetary union. For several years until 2008, economic differences between the countries in the Eurozone were not reflected accurately on credit markets (Farhi-Tirole, 2018). This was articulated in the convergence of borrowing costs for countries with widely differing background, which was then reversed from 2008, as some of the peripheral countries experienced sovereign rating downgrades and surging borrowing costs in the wake of the global financial crisis (Figure 3.).

Figure 3.: Ten-year sovereign bond yields for major European countries
(Source: Farhi-Tirole, 2018. p. 1782.)

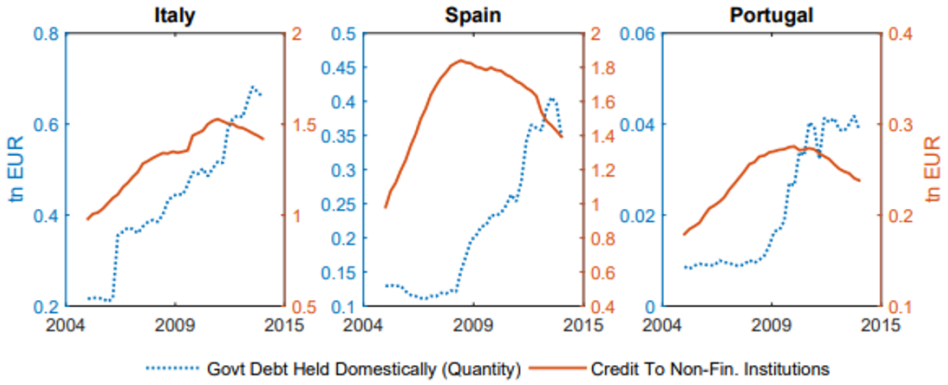


In parallel with the rise in periphery countries' bond yields, bank and sovereign CDS spreads started to comove, as banks' domestic sovereign bond holdings lost in value, while expensive bank rescues added to public debt and amplified sovereign riskiness (Mai, 2021). This raised

the question of the seriousness of the doom loop - whereby the negative perception of the sovereign can distress banks and in turn bank distress would threaten public finances and sovereign debt sustainability (Farhi-Tirole, 2018). From 2009 to 2012, the euro area shifted into a financial crisis, where risk spread from the direction of both economic actors. In Greece, Italy, Portugal, and Spain, perceptions of sovereigns' default risk surged and rising sovereign yields threatened the solvency of European banks, causing a flight-to-quality of bank sovereign debt holdings (Farhi-Tirole, 2018). On the contrary, in Ireland the sovereign spreads exploded only after investors realized that the banking system carried serious threats to the whole Irish economy (Brunnermeier et al, 2018).

The crisis also coincided with the re-nationalization of sovereign debt holdings, which was the most critical in the peripheric countries of Southern Europe but happened also in the core Eurozone countries (Farhi-Tirole, 2018). As foreign banks and investors decreased their sovereign exposures due to the panic on the markets, and cheap long-term refinancing (LTRO) became available for Eurozone banks from the ECB, many financial institutions accumulated high levels domestic sovereign debt on their balance sheets (Crosignani, 2020). While stimulus programs like the LTRO were designed to support bank lending and money market activity (European Central Bank, 2011), financial institutions used only a portion of the ECB financing to increase their lending and purchased sovereign debt instruments - as was acknowledged by President Mario Draghi (Draghi, 2019). As Crosignani (2020) shows, during the period of the sovereign debt crisis, banks increased their holdings of domestic government bonds and reduced their loans to firms and households in crisis countries. (Figure 4.) In addition, this rise during the crisis was disproportionately higher for GIIPS countries (Horváth et al., 2015).

Figure 4.: Domestic Government Bond Holdings and Credit to the Private Sector (Source: Crosignani, 2020, p.4)



In response to the sovereign-debt crisis, the formation of the banking union was announced in mid-2012 to protect the monetary union against future crises and to deepen financial integration. In their statement, the European Council's also highlighted the intention "to break the vicious circle between banks and sovereigns" (Euro Area Summit, 2012 p. 1.). The main elements of the reforms together aimed at preventing moral hazard problems that were an important factor in the build-up of vulnerabilities during the crisis (Navaretti et al, 2021). The proposal for the banking union included three pillars (Dias-Grigaitė, 2020), of which two has been implemented so far.

For the prevention of bank failures and costly public rescues, the Single Supervisory Mechanism (SSM) was established in 2014, under which the largest euro-area banks are placed under direct supervision of the ECB (Carboni et al. 2017). The common supervision of the most important banks means that in times of crisis, prudential policy measures can be taken uniformly by one supervisor, to influence all systematically important institution from SSM participant countries. Furthermore, a Single Rule Book for stringent bank supervision, including stricter capital and liquidity requirements were implemented (Dias-Grigaitė, 2020). The Single Rule Book introduced measures in line with the Basel III standards, namely the liquidity coverage ratio to measure short-term financial health of financial institution; the stable

funding ratio, accounting for medium- and long-term asset share; and finally leverage ratio, to prevent banks from financing too large a portion of their activities with debt (European Union, 2021). Besides the increase in the required levels of liquidity and capitalization of banks, these reforms also pointed towards the harmonization of rules and better coordination of prudential policies applied in Europe.

To ensure the orderly resolution of failing banks with a minimal burden on taxpayers and the economy, the Single Resolution Mechanism (SRM), along with the Bank Recovery and Resolution Directive (BRRD) was adopted. The above stated purpose is set to be achieved with the "bail-in" mechanism, that acts as a replacement for bank bailouts by domestic governments and requires financial institutions to contribute to national bail-in funds (European Commission, 2022). In principle, introducing the bail-in regime was an important step in limiting the channel of sovereign-bank interlinkages described as the "bailout loop" by Brunnermeier et al. (2016, p. 508). Fiordelisi et al. (2020) confirms that the strength of the nexus lowered considerably after the adoption of the new bail-in regime under the BRRD in 2014 but finds remaining positive connection between banks and sovereigns thereafter as well. Nevertheless, in practice many European banks do not have sufficient level of subordinated claims that would be necessary to comply with 8% bail-in-rule of the BRRD - therefore the bail-in regime of the Banking Union is not fully operational to date (Dewatripont et al., 2021).

On the contrary, the third proposed pillar of the banking union, the European deposit insurance (EDIS) has still not been put in place (Dias-Grigaitė, 2020). This practically means, that in case of a bank run, the national deposit insurance schemes would need to cover for the lost deposits, which still poses risk of increased sovereign stress. The common deposit insurance would mean a further shift the banking sector's "public safety net" from the national to the European level. Depositor confidence in a bank therefore would no longer depend on the country where it is domiciled (Véron, 2017).

3.2. The COVID-19 Crisis

As I detail below, when the unprecedented shock caused by COVID-19 hit the world economy, financial institutions could absorb the repercussions of the crisis to a greater extent than during previous ones. In contrast with the global financial crisis and the resulting European sovereign debt crisis, banks were not the source of the crisis - but acted as shock absorbers, performing the crucial role of channeling funds to firms and households. This was partly owing to the economic characteristics of the COVID-19 crisis, the swift fiscal and monetary policy responses, and targeted banking sector policies. In the following, these factors will be highlighted with a focus on Eurozone countries.

3.2.1. Main Characteristics of the COVID-19 Crisis

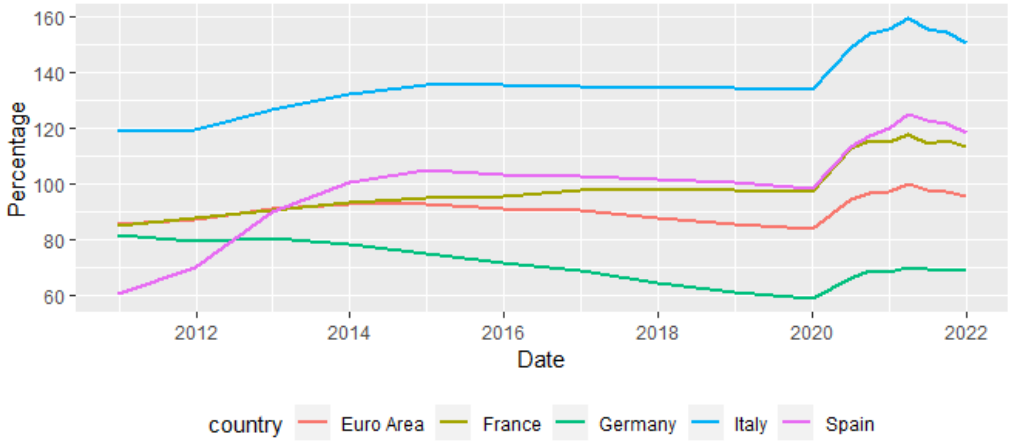
The COVID-19 crisis started out originally as a pandemic, not because of economic or financial imbalances. Its effects were the most serious on the real economy and the financial sector was affected only indirectly. In January 2020, when the World Health Organization (WHO) declared a public health emergency related to the virus, and the number of cases rapidly increased worldwide thereafter (Spiteri et al. 2020). Due to the high infectiousness and health risks associated with the virus, lockdowns and social distancing measures were put in place, causing supply and demand shocks throughout the world economy (Goldstein et al. 2021). Supply effects resulted mainly from the disruptions to production and international transportation, while demand effects were stemming from lower household income due to soaring unemployment, and lower consumption demand for services for fear of exposure to the illness (Padhan-Pranhesh, 2021). The amplitude of economic contraction resulting from these effects was heavily influenced by the severity of the pandemic itself, the strictness of lockdowns, and the structure of the economies – countries with higher reliance on tourism suffered higher declines. This was predominantly true for periphery countries of the EU, like Italy and Spain (Sapir, 2020). At EU level, the initial shock caused by the pandemic led to sharp economic

contraction, with the overall real GDP dropping by 6% in 2020, more severely than during the financial crisis year of 2009, when the decline was 4.2% (Bellia et al., 2021). On the other hand, it is yet to be seen how the longer-term effect of the pandemic will compare with the lasting recession caused by the financial crisis.

3.2.2. Fiscal and Monetary Policy Responses

To handle the adverse effects of the pandemic, government support was directed primarily towards sectors that were hit the hardest, credit-constrained but viable firms, and households, aside from healthcare expenses (European Commission, 2022). The measures included direct social transfers, tax reliefs, and liquidity support to the real economy was also given in forms of loan guarantees and moratoria, amounting to around 22-25% of GDP in 2020 of the Eurozone (EU Fiscal Board, 2021). Although at its onset, the pandemic hit countries with different strength, but in a more simultaneous manner than during the sovereign-debt crisis – resultantly, government finances experienced comparable pressures. The large-scale fiscal interventions and the economic contraction pushed the general government debt-to-GDP ratio higher EU-wide, with the Euro area debt level reaching 100% in 2020 (Figure.5.).

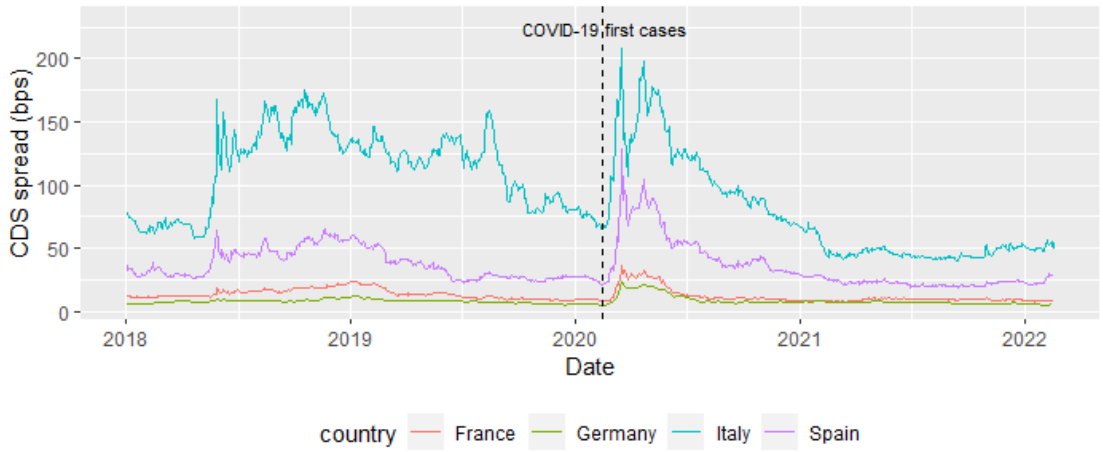
Figure 5.: General government debt to GDP in the Eurozone. Own figure (Source: Eurostat)



The elevated risks originating from sovereign debt levels were tackled by both fiscal and monetary policy actions. The suspension of the fiscal rules of the Stability and Growth Pact (SGP) in late March 2020 (European Commission, 2020), contributed to the fiscal space of member states which could run massive deficits to counteract the pandemic's economic effects. Another coordinated fiscal measure was the first EU level common debt issuance, as part of the Next Generation EU (NGEU) initiative, adopted in July 2020 (European Fiscal Board, 2021). The announcement of the instrument helped to offset growth of government debt yields and CDS spreads (Figure 7.), even though disbursements only started after 2020 (European Fiscal Board, 2021).

With respect to monetary policy, the ECB topped up its existing stimulus measures, and announced further asset purchases of public and private sector securities in March 2020, under the Pandemic Emergency Purchase Programme (PEPP) (European Parliament, 2021). The principal objectives were to provide market liquidity and curb government and corporate borrowing yields, but through these channels, the purchases had positive indirect effects on banks' balance sheet position and lending ability (De Marco-Brunella, 2021). As introduced in Chapter 2, the introduction of QE policies has also proved beneficial for the mitigation of the sovereign-bank nexus in previous years (Bechtel et al, 2021).

Figure 6.: Sovereign CDS spreads. Own figure (Source: Bloomberg)



3.2.3. Banking Sector Policies

Due to the stricter regulatory requirements under the common supervisory framework and the Single Rule Book, most European banks had high capital levels, adequate liquidity buffers and better asset quality when the pandemic hit, with their overall level of solvency improving significantly since the great financial crisis (Campa-Quagliariello, 2021). Bank profitability has not recovered fully since the great financial crisis however, due to the lower interest rate environment, which was also coupled with expanding competitive pressures coming from non-banks (Navaretti et. al., 2021).

The ECB's main policy measures aimed at banks were introduced in a similarly rapid manner as the asset purchase programs, and were related to long-term liquidity provisions, and relaxation of supervisory capital requirements. Banks were offered direct loans at negative rates under the Targeted Longer-term Refinancing Operations (TLTROs) program of the ECB, providing that they were using the funds for lending to firms and households (European Parliament, 2021). Accordingly, the restrictions on the liquidity injection ensured during the COVID-19 crisis that funds are not used for purchasing sovereign debt by banks, like over the course of the sovereign debt crisis (Crosignani, 2017). De Marco and Brunella (2021) also show that the use of TLTRO liquidity during the pandemic was more dispersed across banks and countries, as opposed to LTRO operations during the European sovereign debt crisis, when periphery countries' banks used this kind of borrowing primarily. As an important coordinated countercyclical prudential measure, banks under ECB supervision all over Europe were allowed to use their liquidity and capital liquidity buffers, to free-up resources from regulatory constraints and support lending (European Central Bank, 2020). According to Navaretti et al. (2021), the framework of single supervision under the Banking Union was a key prerequisite for the successful policy response to the COVID-19 crisis, as it enabled a faster and more effective cross-border reaction.

Finally, until the end of 2022, a temporary prudential filter was made available to be applied on their sovereign debt holdings that are measured at fair value, meaning a that their possible unrealized losses are more favorably treated (De Marco and Brunella, 2021. p. 21.). Due to the provided excess liquidity and the changes in the prudential treatment, Eurozone banks' exposures to domestic sovereign debt securities and loans have seen their largest increase since 2012 (Figure 9.). The increase in the ratio of sovereign bond holdings to total assets was more pronounced in periphery countries (Figure 8.). This growth of domestic sovereign exposures of Eurozone banks in the first year of the COVID-19 has induced concerns of several experts and market actors regarding the longer-term effects of this tendency on the sovereign-bank nexus (e.g. Arnold, 2021; Mai, 2021; S&P Global, 2021). Yet, as government debt markets regained their stability after the mentioned fiscal and monetary measures were put through (European Fiscal Board, 2021) and supervisory rules have also been relaxed, the rise in exposures posed a less serious threat than during the sovereign debt crisis.

Figure 7.: Euro area banks' exposures to domestic government debt securities and loans (Source: Arnold, 2021 based on ECB data)

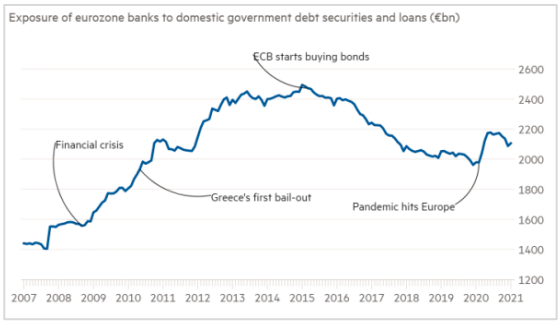
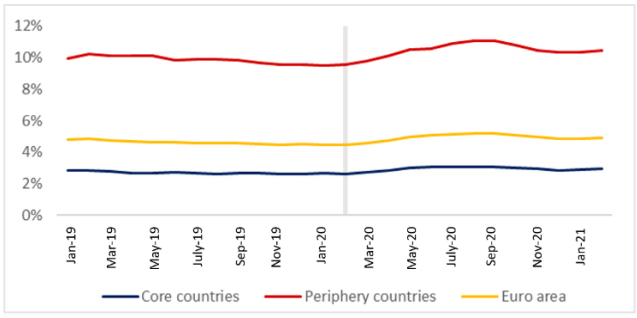


Figure 8.: Domestic sovereign bond holdings of banks to their total assets (Source: Mansilla-Fernández, 2021 based on ECB data)



Note: Periphery countries include Portugal, Ireland, Italy, Greece and Spain. Core countries include Austria, Belgium, France, Germany, the Netherlands and Finland.

Given the developments described above, banks proved to be relatively resilient to the Coronavirus crisis and actively expanded their lending activity, especially towards small and medium-sized enterprises (Campa-Quagliariello, 2021). Furthermore, thanks to the

governmental fiscal policies and the loan moratoria, non-performing loans (NPLs) to total loans ratios and volumes remained low, even though the rate of their decline continued at slower pace than pre-Covid-19 (Navaretti et. al., 2021). Overall, banks initial strong positions and the support measures both on the fiscal and prudential side were key factors in ensuring their resilience to the crisis.

4. Empirical analysis

4.1. Research Hypotheses

In the empirical analysis of this study, I aim to examine the relationship between the credit risk of sovereigns and banks in the Eurozone and assess how their interdependence changed since the outbreak of the COVID-19 crisis. As outlined in chapter 2, the existing empirical literature confirmed the presence of a positive and significant relationship between bank and sovereign credit risk during prior crises. Based on these findings, the first research hypothesis of this study is the following:

H1. There was a positive relationship between the credit risk of banks and sovereigns on the entire horizon of the analysis.

The COVID-19 crisis amplified global volatility and the pandemic measures constrained economic activity significantly. Nevertheless, support to both the real economy and the financial sector was provided in a timely and successful manner in the Eurozone, avoiding the health and economic crisis of turning into a financial crisis. Therefore, my second hypothesis is the following:

H2. After the outbreak of the COVID-19 pandemic, I expect that bank-sovereign interlinkages decreased compared with the preceding period in the Eurozone.

To test my second hypothesis, I estimate the regression models with same specifications on two subperiods, with a cutoff point corresponding to the outbreak of the COVID-19 in Europe. The estimated coefficients on the key independent variable will therefore be comparable between the two subperiods. Furthermore, I estimate my final model on country, and country-group subsamples to assess the heterogeneity of the results, and I also test the change in the sovereign bank nexus with time interaction terms.

4.2. Empirical Model

The main regression model that will be used to estimate the strength of the sovereign-bank nexus is a first difference model, where bank CDS spread is the dependent variable, whereas the key independent variable is the sovereign CDS spread. The empirical model used in the analysis builds on the works of Acharya et. al (2014), Fiordelisi et al. (2020). To isolate the direct link between sovereign and bank risk, we need to control for other factors that can impact the perceived default risk of both entities.

$$\Delta\ln(Bank\_CDS_{ijt}) = \alpha_i + \delta_i + \beta\Delta\ln(Sov\_CDS_{jt}) + \gamma Bank_{it} + \rho Country_{jt} + \sigma Market_t + \mu_{it} + \varepsilon_{ijt}$$

Where $\Delta\ln(Bank\_CDS_{ijt})$ stands for the daily change in the natural logarithm of CDS spreads of Bank *i* in country *j* at time *t* and $\Delta\ln(Sov\_CDS_{jt})$ denotes the daily change of the natural logarithm of CDS spreads of country *j* at time *t*. Three sets of control variables are included in the model: $Bank_{it}$ comprises of the bank-specific balance sheet control variables, $Country_{jt}$ includes country-specific macroeconomic controls and $Market_t$ represents the Europe-wide market control variables. Finally, α_i and δ_i are bank and time fixed effects, respectively. Bank and month fixed effects are used in the models to eliminate the bias, respectively from unobserved factors that vary over time but are constant across banks, and ones that differ across banks but are time-invariant. In the model, I use the natural logarithm for all control variables that are available at daily frequency, as the levels of the main variables are not of primary interest. I also take the first differences of variables, for which the presence of a stochastic trend is confirmed.

With this regression model, the effect of changes in the logarithm of sovereign CDS spreads on the logarithm of bank CDS spreads estimated, with the coefficients meaning the following:

- β shows the average percentage change in the logarithm of bank CDS, when the logarithm of sovereign CDS changes by one percent in the same time period.
- γ, ρ and σ represent vectors of covariates to be estimated from the model.

4.3. Description of Variables

For the estimation of the relationship between bank and sovereign credit risk, credit default swaps (CDS) of both banks and sovereigns are used in the analysis. A CDS is a derivative financial instrument, that can be bought by holders of debt (fixed income) securities. It is issued by a third party to the debt relationship between the lender and borrower and serves as a protection against the issuer's default. Holders of fixed income securities may buy a CDS contract to transfer the credit risk of the security to the CDS seller: In return for a periodic payment to the seller (called the CDS spread), the buyer of the CDS receives compensation if the debt issuer – a particular bank, company or country - defaults. According to Blanco et al. (2005), the CDS contracts are the most liquid of credit derivatives, as they pool more liquidity in a single contract than many individual bonds. Due to the resulting high trading volumes and their standardized nature, CDS spreads therefore serve as more accurate measures of real-time market perceptions of credit risk (Fiordelisi et al., 2020). Following existing empirical studies (Acharya et al., 2014; Fiordelisi et al., 2020, Bechtel et al., 2020) I use 5-year senior CDS spreads which are typically more liquid than other maturities (Black et al, 2018) and in return more suitable to capture changes in credit risk.

In addition to the main variables that capture credit risk, three sets of control variables will be used that correspond to the market, bank, and country level factors that can have an impact on the relationship between bank and sovereign credit risk.

To capture the effect of the heterogeneity in the banks' balance sheets, I include four variables from the EBA's stress test exercises (European Banking Authority, 2021). To incorporate the impact of the variation in banks' exposure to sovereign debt, I compute the ratio of banks' net

direct positions in financial assets, issued by domestic and foreign sovereigns, to total assets. I also include the Tier 1 leverage ratio, that is the ratio of banks' liquid assets to their total assets. The leverage ratio serves as an indicator of short-term financial resilience to shocks and is consequently assumed to be negatively related to bank credit risk.

As the third set of control variables, I include country-specific macroeconomic variables in the models. These are quarter-on-quarter real GDP growth and general government debt over GDP. The quarter-on-quarter real GDP growth rate captures the impact of economic changes. I therefore expect that higher GDP growth will be negatively related to bank credit risk. In contrast, the government debt-to-GDP ratio is expected to be positively correlated with bank credit risk, as a high level of indebtedness is generally leads to higher perceived default risk.

The selection of market control factors follows previous studies that quantified the sovereign-bank nexus in Europe (e.g. De Bruyckere et al. 2013; Bechtel et al. 2021; Kouffeld, 2021). Two indexes are included that can serve as proxies of overall risk in European markets, the iTraxx Europe index and the VSTOXX volatility index. The iTraxx Europe Index is composed of the most liquid European entities with investment grade credit ratings that trade in the CDS market, therefore it is aimed to proxy in the models the general level of default risk continent-wide. The VSTOXX index measures the market expectations of volatility, based on the implied variance across options of the same maturity on the largest Eurozone stocks. In case of both indexes, a positive relationship with bank CDS spreads is anticipated, as higher general default risk and market volatility can worsen the credit risk conditions of all sectors, including the banking sector. Finally, I include the STOXX 600 index, which tracks the returns of 600 publicly traded equities on 17 European stock markets. This index is used to account for overall stock market conditions in the models, and proxies the developments in the real economy, which is thought to be correlated negatively with bank credit risk.

4.4. Dataset

4.4.1. Data Collection

The final dataset contains 11 main variables (and their transformed values) and the observations are spanning from 2018 January to 2022 February. Overall, there are over 24000 rows in the final dataset and the sample contains data on 24 banks from 11 Eurozone countries.

The data on sovereign and bank CDS spreads, bank equity returns, and market control indices are collected from Bloomberg. The bank-level control variables are sourced from the EBA Stress Test and Transparency Exercise results. The series for real GDP growth rate and public debt level to GDP are obtained from Eurostat. The CDS spreads, the bank equity returns, and the market control indices are available at daily frequency, whereas the bank-level variables are on annual and country level controls are on quarterly basis. Due to the difference in the frequency of the variables, the dataset is unbalanced, but following previous studies (eg. Fiordelisi et al., 2020), I include these lower frequency data in my regression models as constants for the missing time periods.

As a first step for sample selection, I searched for all Eurozone banks that have a traded CDS and also publicly traded equity, which limited my sample to 24 banks for which both series were available without missing values. Secondly, I checked their participation in the EBA's Stress Test and Transparency Exercise, which was confirmed for all the selected banks. Finally, I added the variables for the corresponding domestic sovereigns and the market controls to the dataset. Overall, there are 1080 observations for each pair of banks and sovereigns, and for 6 countries there are more than one bank available in the dataset (Table 8. in the appendix).

4.4.2. Descriptive Statistics

On Table 1, the number of observations, the mean, and the standard deviation are presented for the variables included in the dataset. I present the summary statistics for all independent variables before their transformation.

Table 1.: Descriptive statistics of the dataset

	2018 – 2022 February			**2018-2020 January**			**2020 February – 2022 February**			**Freq.**	**Unit**	**Source/Note:**
Variables	**Obs.**	**Mean**	**SD**	**Obs.**	**Mean**	**SD**	**Obs.**	**Mean**	**SD**			
Bank CDS	24,669	127.36	193.92	12,401	136.89	215.28	12,269	105.94	155.81	Daily	Bp.	Bloomberg
Sovereign CDS	11,693	41.47	65.61	5,874	53.342	83.94	5,818	29.492	35.40	Daily	Bp.	Bloomberg
Bank equity returns	24669	0.0035	0.46	12,401	0.00	0.41	12,269	0.00	0.48	Daily	EUR	Bloomberg
Tier 1 leverage ratio	187	5.85	1.61	99	5.82	1.66	69	5.85	1.50	Annual	%	EBA/Tier 1 capital over total assets.
Domestic exposure	187	5.356	3.42	99	5.66	3.58	69	5.55	3.50	Annual	%	EBA/Domestic sovereign exposures over total assets
Foreign exposure	187	4.707	3.87	12,401	7.01	4,38	12,269	6.70	3.80	Annual	%	EBA/Foreign sovereign exposures over
VSTOXX Index	1062	20.03	8.92	533	15.43	3.55	529	24.67	10.22	Daily	Bp.	Bloomberg
ITRAXX Index	1062	58.46	13.1	533	60.41	11.46	529	56.49	14.33	Daily	Bp.	Bloomberg
STOXX 600 Index returns	1062	0.0749	4.06	533	0.0475	2.84	529	0.09	5.01	Daily	Bp.	Bloomberg
Real GDP growth	187	0.44	3.043	99	0.49	1.59	88	0.38	6.52	Quarterly	%	Eurostat/Quarter-on-quarter real GDP growth
Government debt to GDP	187	100.19	40.75	99	96.02	38.22	88	104.878	43.16	Quarterly	%	Eurostat/Quarterly general Gov. gross debt to GDP

As visible on the summary statistics, the CDS spreads for banks tended to be higher than for the sovereigns, reflecting their higher perceived default risk. In the time period between 2018-2020, the standard deviation of bank and sovereign CDS spreads were significantly more

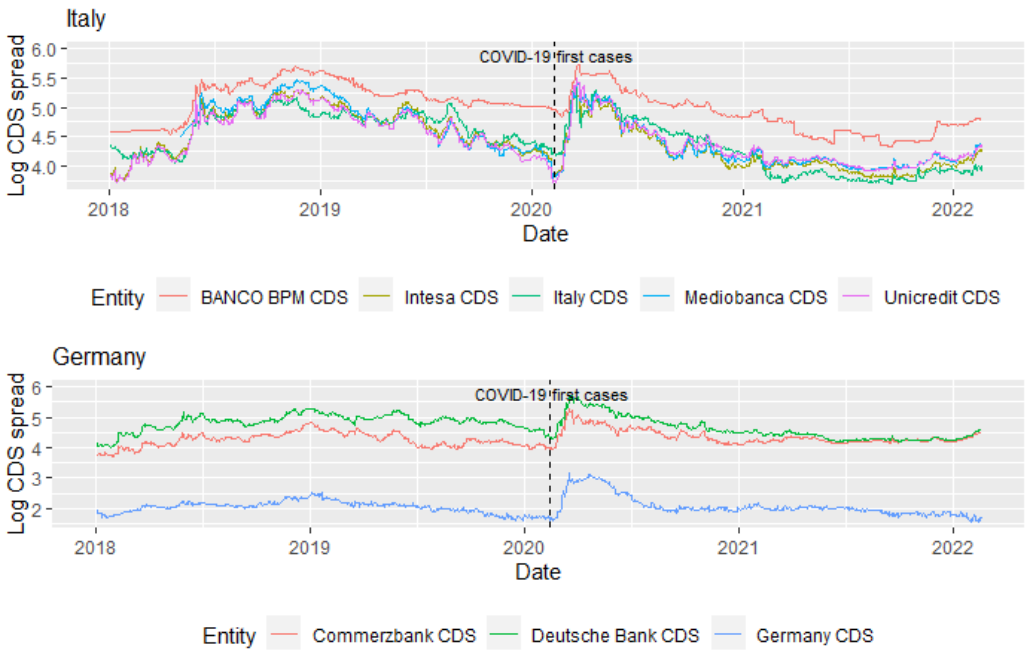
elevated than after the outbreak of the COVID-19 pandemic. Bank-specific variables remained similar during both time periods, with both the domestic and foreign exposures to total assets changing negatively on average. On the other hand, factors capturing market risk and volatility exhibited a stronger variation during the period of the COVID-19 crisis. The variation of real GDP growth and government indebtedness also increased from 2020. The average level of public debt was higher for the second period, in line with increased fiscal spending, while the real GDP growth rate was lower on average, due to disruptions to economic activity during the pandemic.

The VIF test values and the pairwise correlations of the independent variables used in the regression models are displayed in Table 6 of the Appendix. In accordance with the correlogram, there are three pairs of variables, that have a correlation above 0.4. The VIF test values are below 10 for the included variables, therefore multicollinearity is not a problem in the dataset (Wooldridge, 2018).

4.5. Results

In this section I address the issues related to model specification, and then present the estimation results of the models. I estimate the model first without control factors (Model 1), after which I include bank- and country-specific controls and bank fixed effects (Model 2), then finally with market control factors and bank and time fixed effects (Model 3). All three model specifications are estimated over the entire sample period, spanning from 2018 until February 2022, and for the subperiods 2018-2020 January and from 2020 February until 2022 February. The cutoff point is 24 January 2020, which was the date of the first reported COVID-19 case in Europe (Spiteri et al.,2020), after which sovereign and bank CDS spreads started to increase in parallel (Figure 10).

Figure 9.: Logarithm of sovereign and bank CDS spreads in Italy and Germany during the investigated period. Own figure (Source: Bloomberg)



4.5.1. Model Specification and Base Results

As introduced in the previous chapter, I conduct panel regressions analysis. To test the research hypotheses, and to specify the models that will be used, I report the results of the necessary statistical tests. I test the stationarity of all my variables that are available at the daily frequency with the Augmented Dickey-Fuller test. Based on the results, I use the first differences of the logged values of bank and sovereign CDS spreads, bank equity returns and the STOXX 600 index in the regression models. In case of the other variables the presence of unit roots can be rejected according to the ADF-test's results (Table 8. in the appendix).

I test for panel-level heteroskedasticity with the Breusch-Pagan test. For the main estimated models, the test returns a p-value of zero, confirming that heteroskedasticity is present. I also test if serial correlation needs to be corrected for in the models by using Woolridge's test for serial correlation in panel data (Wooldridge, 2002). With the respective test, I obtained a p-value of 0.54, indicating that I need to reject the null hypothesis of no serial correlation. In the models below, heteroskedasticity is corrected for by using robust standard errors clustered at bank level in (Model

1) and (Model 2), and at bank and time (month) level (Model 3). I present the main coefficient of interest for four estimated models in Table 2., where I run the models on the entire period.

Table 2.: Main regression results and model comparison

Variables	(1)	(2)	(3)
	Δln(B)	**Δln(B)**	**Δln(B)**
Δln(Sov_CDS)	0.172***	0.151**	0.102***
	(0.038)	(0.034)	(0.030)
Bank and country	No	Yes	Yes
Market controls	No	No	Yes
Bank FE	Yes	Yes	Yes
Month FE	No	Yes	Yes
Lag term of Δln(Sov_CDS)	No	No	No
Cluster SE	Bank	Bank	Bank & Time
N	24670	24670	24670
R2	0.038	0.051	0.098

*** p < 0.001; ** p < 0.01; * p < 0.05

Note: The table reports estimations obtained from linear regressions on a panel of 24 banks from 11 Eurozone countries. The sample includes 24670 daily observations on the 24 banks during the period between 2018 January and 2022 Februrary. Δln(B) is the daily change in the natural logarithm of bank CDS, while Δln(Sov) denotes the daily change in the sovereign CDS of the country in which the bank is headquartered. Bank-specific control variables include the log of daily bank equity returns, domestic and foreign exposures to total assets and the Tier-1 leverage ratio of banks. Country-specific control variables include quarterly real GDP growth and quarterly general government debt to GDP. Market controls include the logarithm of daily values of the VSTOXX and the logarithm of the iTraxx indices, and log differenced daily values of the STOXX 600 index. Models (1-2) include bank fixed effect, and Model (3) includes bank and time (month) fixed effects. In Models (1-2) standard errors are clustered at bank level, and in Model (3) at bank and time (month) level.

The β is highly significant in every model, indicating that a connection between sovereign and bank credit risk was present during the entire horizon of the analysis. In the models, I gradually add the control factors, of which the country and bank-specific variables and market controls have, that reduced the estimated coefficient. In Model (2) and (3) both bank and time fixed effects are used, to overcome the bias stemming from unobserved time and entity-variant factors. Following Fiordelisi et al. (2020), in Model (3), I cluster standard errors on two dimensions of banks and months simultaneously, to complement the relatively low size of clusters of 24 banks with the 51 months available.

The estimation results change significantly in response to including market control variables; therefore, I choose Model (3) as my main model for estimation. Based on the results of Model (3) on the entire sample from 2018 to 2022 February, a 10% increase in the logarithm of sovereign CDS spreads led to a 1.027% increase in the logarithm of the bank CDS spreads, on average. To express the changes in basis point terms, I transform the coefficients to a linear scale[6] in the following part of thesis, when I evaluate my results. Therefore, the results of Model (3) imply that a 10 basis point increase in Sovereign CDS spreads was associated with a 1.07 basis point increase in Bank CDS spreads.

4.5.2. Detailed Model results on Time Period Subsamples

The detailed model results are shown in Table 3. for the two subperiods, the time period between 2018 and 2020 January, and the period after the first reported COVID-19 case in Europe until 2022 February. According to the estimations, the connection between sovereign and bank CDS spreads was significant across model specifications both before and after the pandemic period. When controlling for all dependent variables in Model (3), in the pre-pandemic period, the coefficient suggests that a 10 basis point increase of sovereign CDS spreads translated into a 2.57 basis point increase of bank CDS spreads, on average.

Estimations obtained with Models (4-6) for the second period reveal that this relationship was less robust between specifications and smaller in size, but with the specifications of Model (6), the key coefficient kept its significance, implying a 0.32 basis point increase in bank CDS spreads in case of a 10 basis point increase in sovereign CDS spreads, on average. This confirms my first hypothesis (H1), that there was a significant and positive connection between bank and sovereign credit risk.

[6] If we exponentiate the regression coefficient obtained by the model estimations and subtract one from it ($\exp(\beta)$-1 = β_{linear}), we get the back the change in the original unit of the variables.

Table 3.: Detailed regression results for the two analyzed subperiods

	2018-2020 Jan			2020 Feb – 2022 Feb		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Δln(B)	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**
Δln(Sov)	0.2893***	0.2771***	0.2288***	0.1211***	0.0830**	0.0317*
	(0.0574)	(0.0557)	(0.022)	(0.0277)	(0.0230)	(0.0143)
Δln(Bank_Equity)		-0.0999	-0.0375		- 0.1943**	-0.0347*
		(0.0759)	(0.0279)		(0.0503)	(0.018)
Sov_Exp_Dom		0.0017	0.0018**		0.000	0.0001
		(0.0012)	(0.0006)		(0.000)	(0.0001)
Sov_Exp_F		-0.0006	0.0005		0.000	-0.0001
		(0.0013)	(0.0008)		(0.000)	(0.000)
Leverage_ratio		-0.0028*	-0.0037*		-0.000	-0.0000
		(0.001)	(0.0017)		(0.000)	(0.000)
GDP Growth		0.0007**	-0.0007		-0.0001**	-0.0002**
		(0.000)	(0.000)		(0.0000)	(0.0001)
Gov debt to GDP		0.0001	-0.0008***		0.000	0.000
		(0.000)	(0.000)		(0.000)	(0.000)
ln(VSTOXX)			-0.0031			0.0117**
			(0.0049)			(0.0041)
ln(iTraxx)			0.0593***			0.0373***
			(0.0074)			(0.0085)
Δln(STOXX 600)			-0.7965***			-0.5176***
			(0.0706)			(0.0821)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	Yes	Yes	No	Yes	Yes
N	12401	12401	12401	12269	12269	12269
R2	0.060	0.081	0.103	0.022	0.069	0.105
Cluster SE	Bank	Bank	Bank & Time	Bank	Bank	Bank & Time

*** p < 0.001; ** p < 0.01; * p < 0.05.

Note: The table reports estimations obtained from linear regressions on a panel of 24 banks from 11 Eurozone countries. The sample includes 12401 daily observations on the 24 banks during the period 2018-2020 January, and 12269 daily observation for the period between 2020 February and 2022 Februrary. Δln(B) is the daily change in the natural logarithm of bank CDS, while Δln(Sov) denotes the daily change in the sovereign CDS of the country in which the bank is headquartered. Bank-specific control variables include the log of daily bank equity returns (Δln(Bank_Equity), domestic and foreign exposures to total assets (Sov_Exp_Dom, Sov_Exp_For, respectively) and the Tier-1 leverage ratio of banks (Leverage_ratio). Country-specific control variables include quarterly real GDP growth and quarterly general government debt to GDP. Market controls include the logarithm of daily values of the VSTOXX and the logarithm of the iTraxx indices, and log differenced daily values of the STOXX 600 index. Models (1 and 3) include bank fixed effect, and Models (2, 3, 5 and 6) include bank and time (month) fixed effects. In Models (1, 2, 4 and 5), standard errors are clustered at bank level, and in Models (3 and 6) at bank and time (month) level.

Apart from the overall strength of the sovereign-bank nexus, the importance of further independent variables has also changed between the two periods. Regarding the bank-specific balance sheet control variables, mainly the direction of their association with bank credit risk can be determined, as most of them were not significant in the estimated models. In the first period, the level of domestic sovereign exposures displayed a positive connection with bank CDS spreads, suggesting that tighter connection with the domestic sovereigns impacted the bank risk perception negatively. This was not the case in the second period, where none of the balance sheet variables were significant. With respect to the short-term resilience of banks against shocks, the model results imply that the Tier-1 leverage ratio of banks had a significant connection with bank CDS movement only in the first period. In the period of the COVID-19 crisis, the relative size of the bank's capital buffer has not had a significant association. Based on the balance sheet variables included in the model, it can be concluded that the banks' individual characteristics - such as their level of capitalization and their sovereign exposure level - mattered less for their CDS spread movements during the COVID-19 crisis. This can be a result of relatively lower variability in bank credit risk that was ensured by the rapid and successful policy responses to preserve financial stability after the outbreak of the COVID-19 crisis.

With reference to the effects of the macroeconomic control variables in the dataset, it can be stated that the level of government debt was negatively correlated with bank credit risk before the pandemic, nevertheless this indicator was not significant in Models (2)-(3) during the COVID-19 crisis. The government debt-to-GDP levels of all countries in the dataset increased due to increased fiscal spending and lower economic activity, as the crisis affected all countries. Moreover, as discussed previously, EU fiscal rules have been suspended to allow governments effectively tackle the crisis even with deficit spending and eventually increasing public debt. It is therefore intuitive that risk perception of banks was not intertwined with their domestic sovereign's debt levels. Conversely, the rate of GDP growth in the home countries of banks had a small, but significant

effect on their CDS spreads only during the pandemic period, implying that the dynamics of real economic conditions were a determinant of bank credit risk.

Finally, the correlation of market factors with bank credit risk remained strong and significant across the two samples. During the pandemic period, the relationship between sovereign and bank credit turns non-significant after the inclusion of market factors in Model (3), signaling their importance. As expected, Europe-wide corporate market risk perceptions - captured by the iTraxx index - are positively correlated with individual bank credit risk in both periods. The high significance of the STOXX 600 stock market index in Model (3) confirms that real economic performance of European companies was strongly negatively linked with bank credit risk. Finally, the changes in market volatility expectations - as measures by the VSTOXX index – became significantly coupled with bank credit risk perceptions, the former affecting the latter positively: As volatility expectations of market participants are generally driven by uncertainty of the actual economic conditions, the unfolding waves of the COVID-19 pandemic boosted market volatility.

4.5.3. Model Results on Country Subsamples

To statistically test the difference in sovereign-bank interlinkages between the two subperiods, I run the previously estimated Model (3) with an interaction term of a dummy variable that takes the value of 1 for dates after the outbreak of the COVID-19 crisis in Europe and zero before. I run this model on all country subsamples, in which there are more than 1 banks are available. Furthermore, I estimate the model on two subsamples containing either "Periphery" and "Core" Eurozone countries[7], and lastly on the whole sample. I present the results on Table 4.

[7] Portugal, Ireland, Italy, Greece, and Spain are classified as „Periphery" countries, while Austria, Belgium, France, Germany and the Netherlands are grouped as „Core" countries of the Eurozone.

Table 4.: Subsample comparison of model 3 with covid interaction term (2018 – 2022 February)

	Total sample	**Periphery***	**Core****	**AUT**	**GER**	**FRA**	**IRL**	**ITA**	**ESP**
	Δln(B)	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**	**Δln(B)**
Δln(Sov)	0.223**	0.362*	0.084***	-0.008	0.119***	0.233***	0.134**	0.543***	0.309*
	(0.022)	(0.093)	(0.019)	(0.043)	(0.031)	(0.042)	(0.003)	(0.042)	(0.093)
Δln(Sov) *Covid	-0.192**	-0.299***	-0.084***	0.018	-0.145**	-0.154**	-0.197**	-0.415***	-0.318*
	(0.026)	(0.041)	(0.026)	(0.047)	(0.046)	(0.049)	(0.001)	(0.096)	(0.089)
N	24670	14271	10399	2080	2080	3119	2076	4057	5400
R2	0.102	0.116	0.113	0.043	0.195	0.239	0.028	0.197	0.084

*** p < 0.001; ** p < 0.01; * p < 0.05

Note: The table reports estimations obtained from linear regressions on a panel of 24 banks from 11 Eurozone countries. The sample includes 24670 daily observations on the 24 Eurozone banks during the period between 2018 January and 2022 Februrary. Δln(B) is the daily change in the natural logarithm of bank CDS, while Δln(Sov) denotes the daily change in the sovereign CDS of the country in which the bank is headquartered. In all models ran on the country subsamples, the following covariates are included: Bank-specific control variables include the log of daily bank equity returns, domestic and foreign exposures to total assets and the Tier-1 leverage ratio of banks. Country-specific control variables include quarterly real GDP growth and quarterly general government debt to GDP. Market controls include the logarithm of daily values of the VSTOXX and the logarithm of the iTraxx indices, and log differenced daily values of the STOXX 600 index. Models include bank and time (month) fixed effects ans standard errors are clustered at bank and time (month) level. The Covid variable is dummy that takes the value of one after 2020 January 24 and zero before.

*Periphery countries include Portugal, Ireland, Italy, Greece and Spain.

**Core countries include Austria, Belgium, France, Germany and the Netherlands.

Comparing the changes in the strength of the sovereign-bank nexus, it is visible from Table 4, that in peripheric Eurozone countries, bank credit risk exhibited a significantly higher correlation with sovereign credit risk during the entire time horizon of the analysis, than in core countries. The heterogeneity of the connectedness between countries also appeared to be very strong, indicating that the same magnitude of change in sovereign risk perception led to a change more than five times higher in Italy, than in Germany, on average. However, the reduction in the closeness of this nexus was sizeable in the pandemic period for all subsamples where the coefficient of Sovereign CDS spreads was significant. In conclusion, the results in Table 4 support my second hypothesis (H2) that the strength of the sovereign-bank nexus decreased after the outbreak of the pandemic, confirmed by the significant negative interaction term obtained in regressions run on the whole sample. According to the results, a 10 basis point

increase in sovereign CDS resulted in a 1.7 basis point lower increase on average in bank CDS spreads, than before the crisis.

Finally, I present the results of a model, with the modification, that I include a dummy variable that captures the dates before the COVID-19 pandemic outbreak, to assess if the connection between banks and sovereigns was heterogeneous across peripheric and core countries. Table 5 therefore shows similar model results as Table 4, but here the coefficient of the sovereign CDS captures the intensity of the sovereign-bank interlinkages in the COVID-19 crisis. Based on the results of the second interaction model, it can be stated that although the connection between sovereign and bank credit risk decreased during the pandemic, there was a positive relationship between the main variables in peripheric countries of the Eurozone. In core countries, however, this relationship was not significant. In the peripheric countries, a 10 basis point increase in sovereign CDS was associated with a 0.69 basis point increase in bank CDS spreads, on average.

Table 5.: Subsample comparison of model 3 with Pre-Covid interaction term (2018 – 2022 February)

	Total sample	**Periphery***	**Core****
	Δln(B)	**Δln(B)**	**Δln(B)**
Δln(Sov)	0.031*	0.067**	0.018
	(0.014)	(0.025)	(0.016)
Δln(Sov) *pre_Covid	0.205**	0.309***	0.090***
	(0.027)	(0.041)	(0.026)
N	24670	14271	10379
R2	0.104	0.119	0.112

*** p < 0.001; ** p < 0.01; * p < 0.05

Note: The table reports estimations obtained from linear regressions on a panel of 24 banks from 11 Eurozone countries. The sample includes 24670 daily observations on the 24 Eurozone banks during the period between 2018 January and 2022 Februrary. Δln(B) is the daily change in the natural logarithm of bank CDS, while Δln(Sov) denotes the daily change in the sovereign CDS of the country in which the bank is headquartered. In all models ran on the country subsamples, the following covariates are included: Bank-specific control variables include the log of daily bank equity returns, domestic and foreign exposures to total assets and the Tier-1 leverage ratio of banks. Country-specific control variables include quarterly real GDP growth and quarterly general government debt to GDP. Market controls include the logarithm of daily values of the VSTOXX and the logartihm of the iTraxx indices, and log differenced daily values of the STOXX 600 index. Models include bank and time (month) fixed effects ans standard errors are clustered at bank and time (month) level. The Covid

*Periphery countries include Portugal, Ireland, Italy, Greece and Spain.

**Core countries include Austria, Belgium, France, Germany and the Netherlands.

5. Policy Implications

The main empirical finding of the thesis is that the strength of the sovereign-bank nexus declined during the COVID-19 crisis in the Eurozone, despite a major shock on the economy that could have easily induced another financial crisis. The dynamics of sovereign-bank interlinkages witnessed during the pandemic can be attributed to several factors highlighted in the first part of thesis.

Firstly, COVID-19 crisis originated as an exogenous health crisis without underlying economic or financial imbalances, while its effects were the most pronounced on the real economy and the financial sector was only affected indirectly. Secondly, thanks to Eurozone-level monetary and fiscal policy actions, national governments had the necessary fiscal space to tackle adverse effects on corporations and households, while banks had the necessary liquidity to provide lending to them. Thirdly, the framework of the Banking Union ensured that most European banks were well positioned to absorb the shock of the pandemic and enabled coordinated supervisory policies action that would not have been possible during the sovereign-debt crisis.

It is worth highlighting that the Banking Union and most importantly its pillar of Single Supervision, and stricter prudential requirements under the Single Rulebook were key improvements in the regulatory framework relative to the previous crisis, which helped to prevent the build-up of vulnerabilities in the bank and the crisis response. Nonetheless, the absence of a fully operational bail-in regime of the Single Resolution framework and the Common Deposit insurance still constitute missing links of the Banking Union.

Given the broad range of policies enacted during the COVID-19 crisis, the effects of phasing out support is of utmost importance, also in the light of current economic developments related to the conflict between Russia and Ukraine. While the ECB is already in the process of unwinding its asset purchases (ECB, 2022), the Stability and Growth pact has been suspended

until 2023 (Valero, 2022). The elevated levels sovereign debt levels on the other hand will need to be addressed on the, alongside with question of corporate indebtedness, in order prevent the vicious cycle between banks and sovereigns from materializing again.

Last but not least, the heterogeneity in the strength of the sovereign-bank nexus between the core and periphery of the Eurozone, that is confirmed by the empirical results of this study, can mean an obstacle for deeper financial integration. If member states' experience diverging dynamics in their fragility towards risks, financially more stable countries might be opposed to further exposure to the risks of other countries' banks, national deposit insurance systems and public finances that are more vulnerable than their own (Mai, 2021). Therefore, in the post-crisis era, the possibility to reach an EU-wide consensus to complete the Banking Union will be dependent on further risk reduction, by which the dangerous incentives of sovereigns and banks can be eliminated.

6. Conclusion

In this thesis, I investigated the connection between bank and sovereign credit risk during COVID-19 crisis. In the first part of the thesis, I provided an overview of the European sovereign debt crisis and the subsequent policy responses from the perspective of the sovereign-bank nexus, which I contrasted with the COVID-19 crisis. In the empirical analysis, the strength of the sovereign-bank nexus was estimated with panel regression models, using bank and sovereign CDS spreads on a sample of 24 banks in 11 Eurozone countries. I controlled in the models for market-related, bank and country-specific variables. I found that nexus between sovereigns and banks has declined after the outbreak of the COVID-19 crisis but was still significant on average in the Eurozone. My estimations revealed that a 10 basis point increase in sovereign CDS spreads resulted in a 1.7 basis point lower increase of bank CDS spreads on average, than before the crisis in case of Eurozone banks. Furthermore, the model results on country subsamples suggested that the nexus was not significant in core Eurozone countries during the COVID-19 crisis, but remained present in the peripheric countries, where a 10 basis point increase in sovereign CDS spreads was associated with a 0.69 basis point increase of bank CDS spreads, on average.

Although based on the results of the empirical models, I can accept my two hypotheses related to the existence of the sovereign-bank nexus and its decline during the COVID-19 crisis, but the analysis certainly has limitations. First, the sample selection of banks was limited by the availability of CDS contracts and publicly traded equity, due to which a relatively low number of banks were included in the final dataset, representing the largest banking groups in the Eurozone. Another related issue was the availability of bank-level balance sheet data, which was only available on an annual basis from of the EBA's Annual Transparency Exercise and Stress Test results. Resultantly, the power of my models was limited to draw conclusions from the individual balance sheet indicators of the banks. Both mentioned limitations are present in

most studies of the existing empirical literature on the sovereign-bank nexus (e.g. Fiordelisi et al., 2020; Acharya et al. 2014), that use publicly available data for their analysis.

In my opinion, potential directions of future research can arise from this study. As the relationship between sovereigns and banks can change dynamically, the short-term effects of the COVID-19 crisis, and its response measures on sovereign-bank interlinkages would be worth investigating. Moreover, as mentioned in the previous section, the unwinding of COVID-19 related policies will also have important implications for the sovereign-bank nexus.

To conclude, this thesis provided an overview on the connection between sovereign and bank credit risk and estimated how its' strength changed after the outbreak of the COVID-19 crisis. The thesis assessed the complex financial architecture of the Eurozone that was built up in response to the prior financial crisis, and the pandemic-related policies, which altogether prevented the relationship between sovereigns and banks from becoming vicious. On the contrary, the interrelatedness of the two economic actors is still present and can be amplified again during future shocks.

Appendix

Table 6.: Banks included in the dataset

Country	Bank
Austria	Raiffeisen, Erste Bank
France	BNP Paribas, Credit Agricole, Société Générale
Germany	Deutsche Bank, Commerzbank
Greece	Alpha Bank, Piraeus Bank
Italy	Unicredit, Intesa Sanpaolo, Mediobanca, Banco BPM
Ireland	AIB Group, Bank of Ireland
Netherlands	ING Group
Portugal	Banco Commercial
Spain	Banco Santander, Banco Bilbao, Caixa Bank, Banco de Sabadell, Bankinter SA
Belgium	KBC Group
Finland	Nordea Bank

Table 7.: VIF values and pairwise correlations of independent variables

Variables	VIF		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δln(Sov CDS)	1.08	(1)	1.000									
Δln(Bank_Equity)	1.32	(2)	-0.209	1.000								
Leverage ratio	1.10	(3)	-0.001	-0.009	1.000							
Sov_Exp_Dom	1.11	(4)	0.008	0.000	-0.352	1.000						
Sov_Exp_For	1.03	(5)	-0.010	0.005	0.131	-0.216	1.000					
ln(VSTOXX)	1.00	(6)	-0.010	-0.010	-0.014	-0.026	0.027	1.000				
ln(iTraxx)	1.00	(7)	-0.010	0.002	0.456	-0.172	0.284	0.003	1.000			
Δln(STOXX 600)	1.79	(8)	0.104	-0.102	0.001	-0.018	0.015	-0.225	0.054	1.000		
GDP growth	1.00	(9)	0.069	-0.072	0.016	0.013	0.006	-0.270	-0.039	0.501	1.000	
Government debt to GDP	1.00	(10)	-0.321	0.472	0.000	-0.003	0.001	-0.016	0.009	-0.169	-0.076	1.000

Table 8.: ADF-test results for daily frequency variables in the dataset

Variables	Dickey-Fuller	Lag order	P-value
Bank CDS	-2.6612	2	0.2984
Sovereign CDS	-2.9886	2	0.1598
Bank equity	-3.232	2	0.08241
VSTOXX Index	-4.1328	2	0.01
iTraxx Index	-3.4751	2	0.0447
STOXX 600 Index	-2.386	2	0.4149

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