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Examining Banking Doom-Loop Dynamics Within the European Union: Evidence from 2015-2025 and a Comparison between Core and Peripheral Countries

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Abstract

This study examines whether a sovereign-bank doom-loop existed in core and peripheral European countries between 2015-2025. Through the use of an entity fixed effects PVAR framework, the bidirectional risk transmission between the two entities is analysed. The sample is split into four core countries (Belgium, France, Germany, and the Netherlands) and four peripheral countries (Greece, Italy, Portugal, and Spain) for a comparison.

The econometric results do not provide concrete evidence of a bidirectional doom-loop in each of the groups. The transmission of risk is absent in both directions in core countries, consistent with having stronger capital reserves. In the peripheral group, there is an asymmetric transmission of risk, suggesting that there exists a short-lived transmission from the banking system to the sovereign. These results suggest that supervisory measures put in place have mitigated the doom-loop to an extent, but not completely eliminated it in the periphery. This study makes a contribution to pre-existing literature by giving a comparative assessment of the sovereign-bank nexus between 2015-2025 across Euro Area economies that differ structurally.

Abstract (in German)

Diese Studie untersucht, ob zwischen 2015 und 2025 in den Kern- und Peripherieländern Europas ein Teufelskreis zwischen Staat und Banken bestand. Mithilfe eines PVAR-Modells mit festen Effekten für die einzelnen Länder wird die bidirektionale Risikoübertragung zwischen diesen beiden Akteuren analysiert. Die Stichprobe wird zum Vergleich in vier Kernländer (Belgien, Frankreich, Deutschland und die Niederlande) und vier Peripherieländer (Griechenland, Italien, Portugal und Spanien) unterteilt.

Die ökonometrischen Ergebnisse liefern keine konkreten Belege für einen bidirektionalen Teufelskreis in den einzelnen Gruppen. In den Kernländern findet keine Risikotransmission in beide Richtungen statt, was mit den stärkeren Kapitalreserven im Einklang steht. In der Peripheriegruppe besteht eine asymmetrische Risikotransmission: Dies deutet darauf hin, dass eine kurzlebige Übertragung vom Bankensystem auf den Staat vorliegt. Diese Ergebnisse deuten darauf hin, dass die ergriffenen Aufsichtsmaßnahmen den Teufelskreis in den Peripherieländern zwar bis zu einem gewissen Grad abgeschwächt, aber nicht vollständig beseitigt haben. Diese Studie leistet einen Beitrag zur bestehenden Literatur, indem sie eine vergleichende Bewertung der Verflechtung zwischen Staat und Banken im Zeitraum 2015–2025 in den strukturell unterschiedlichen Volkswirtschaften des Euroraums vornimmt.

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Lastly, I owe a great deal to my loved ones, both family and friends. None of this would ever be possible without their unwavering support in my life. They always firmly stood behind me and cheered me on. Who I am today is the sum product of everybody who has ever touched my life, and for that, I thank them all.

Use of external tools

I acknowledge the use of Claude AI (https://claude.ai/new) to generate the sections 'List of tables', and 'List of Abbreviations'. The LLM model gathered all the headings, subheadings, and abbreviations into sections. The following prompts were used to achieve the same: "I need to make a list of tables, create a bulleted list for me", "find and create an ordered list of all the abbreviations used here". I also made use of DeepL (https://www.deepl.com/) to generate the German version of my abstract as I am not a native speaker of the language. The output was reviewed and then inserted into this document. I take full responsibility for the contents of this thesis.

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List of abbreviations

1. **ADF** – Augmented Dickey-Fuller
2. **AIC** – Akaike Information Criterion
3. **BRRD** – Bank Recovery and Resolution Directive
4. **CBD-2** – Consolidated Banking Data (dataset version 2)
5. **CD** – Cross-sectional Dependence
6. **CDS** – Credit Default Swap
7. **CET-1** – Common Equity Tier 1
8. **CIPS** – Cross-sectionally Augmented Im, Pesaran and Shin
9. **COVID-19** – Coronavirus Disease 2019
10. **DCC-MIDAS** – Dynamic Conditional Correlation-Mixed Data Sampling
11. **EA** – Euro Area
12. **ECB** – European Central Bank
13. **ESB / ESBies** – European Safe Bonds
14. **ESM** – European Stability Mechanism
15. **EU** – European Union
16. **EV** – Eigenvalue
17. **FPE** – Final Prediction Error
18. **FRED** – Federal Reserve Economic Data
19. **GDP** – Gross Domestic Product
20. **HQ** – Hannan-Quinn Information Criterion
21. **LM** – Lagrange Multiplier
22. **LR** – Likelihood Ratio
23. **NBFI** – Non-Bank Financial Intermediaries
24. **NPL** – Non-Performing Loan
25. **OECD** – Organisation for Economic Co-operation and Development
26. **PCA** – Principal Component Analysis
27. **PSPP** – Public Sector Purchase Programme
28. **PVAR** – Panel Vector Autoregression
29. **PVECM** – Panel Vector Error Correction Model
30. **SC** – Schwartz Information Criterion
31. **SRM** – Single Resolution Mechanism
32. **SREP** – Supervisory Review and Evaluation Process
33. **SSM** – Single Supervisory Mechanism
34. **TPI** – Transmission Protection Instrument
35. **VAR** – Vector Autoregression
36. **VEC** – Vector Error Correction
37. **VECM** – Vector Error Correction Model

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Chapter 1: Introduction

Over the last decade, domestic banks in developing economies have rapidly increased their exposure to local sovereign debts (The Rise of Sovereign–Bank Nexus Risks in Developing Economies, 2024). This phenomenon is now sparking concern amongst several financial regulatory bodies, with the fear that a repeat of the 2012 Eurozone crisis might be possible. One of the main indicators of such crises: a rise in sovereign debts (Mody et al., 2012), is being observed widely in member European Union countries (Armendariz et al., 2024). These governments then end up watching their own borrowing costs start to spiral afterwards.

This represents the fundamental downside of integrating financial systems into the government. A failure on either side can easily lead to a contagion: widespread failure across the banking sectors and in the case of the European Union, widespread failure across countries as well (Ahmad et al., 2014). A weakened sovereign credit leads to the banking system getting distressed, which further leads to the sovereign being undermined. Even with the European Central Bank (ECB) introducing several measures such as Transmission Protection Instrument (TPIs) and European Safe Bonds (ESBs), recent financial crises like the Silicon Valley collapse show that the threat of a doom-loop still persists. The banking doom-loop (also known as a 'diabolic' loop in some literature) refers to the feedback mechanism that can exist between a country's sovereign debt distress and its domestic banking distress (Brunnermeier et al., n.d.).

Government-sponsored recapitalisations, the provision of guarantees, or other increases in the contingent liabilities of the government can lead to an increase in actual or expected government debt levels, thereby putting downward pressure on sovereign bond prices. Given banks' holdings of domestic sovereign debt, this contributes to further weaken their balance sheets (when measured in market value terms), which further iterates the loop (European Commission. Directorate General for Economic and Financial Affairs., 2019). There also exist other channels for the propagation of these risks, which will be discussed at another point in the paper.

There already exists extensive literature documenting the history of banking doom-loops in Europe, linking it to financial crises like the sovereign debt crisis of 2012 (Gómez-Puig & Sosvilla-Rivero, 2024). Further research has even been done on the effectiveness of the measures put in place by the ECB. But there still remain dimensions that are relatively unexplored. Geographical focus in this field has been primarily placed on European peripheral countries that are more likely to experience doom-loops. The few publications that do focus on the core countries are unlikely to have a comparison with their peripheral counterparts. There is also a chronological aspect where most of these studies focused on time periods before 2020.

This thesis aims to address these gaps via the following central question: Did a bank-sovereign doom-loop exist in the European region during 2015-2025? The primary question can be decomposed into the following two questions:

- Can banking sector stability be predicted by sovereign risk indicators in these countries in this time period?
- Conversely, can sovereign credit risk be predicted by bank fragility indicators in these countries in this time period?

This thesis argues that there still remain countries within the Eurozone (the peripheral countries in particular) where risks from the banking sector can predict the risks in the sovereign sector and vice versa. Even if there doesn't exist bidirectional Granger causality between the risks (signifying a banking doom-loop), there can still exist a unidirectional Granger causality showing that there is a possibility of one risk possibly amplifying another. This work contributes twofold to the existing literature: (1) Providing a longitudinal econometric assessment of the possible doom-loop within the listed geography; (2) Delivering a comparative analysis between the core and peripheral members.

Entity fixed effects panel vector autoregression is employed to make use of cross-sectional and temporal variation. This is done across 8 EU countries between 2015 and 2025. Key variables being used include sovereign bond yields, main refinancing rate, and banking indicators (Common equity tier-1 ratio, NPL ratio, Liquid assets %), and the data is sourced from the ECB, and FRED (Federal Reserve of Economic Data).

Chapter 2 of the thesis reviews available literature regarding the sovereign-bank nexus and how the ECB's policies have evolved in response to the ever-changing financial environment. Chapter 3 encapsulates the dataset, providing justification to the chosen variables. Chapter 4 builds upon the econometric methodology being used in the study. Chapter 5 tabulates the empirical results, which include the Granger causality tests and regression estimates. Chapter 6 discusses the econometric findings, what they mean, and provides policy implications. Chapter 7 concludes the paper by summarizing all the evidence on core-periphery divergence, acknowledging limitations, and proposing avenues for future research.

Chapter 2: Literature Review

2.1 Introduction

The banking doom loop is one of the most complex phenomena that can be observed within modern financial economics. It can transform banking distress that is localised into sovereign crises, and vice versa as well. This process has occupied the brains of both academics and policymakers alike ever since the Eurozone debt crisis exposed how devastating this interdependence can be. Understanding whether the measures put in place by the ECB have succeeded in dismantling this nexus needs prior understanding of the intellectual foundations upon which this problem rests.

This chapter will review available literature on the sovereign-bank nexus with 3 objectives that are interrelated. The first is to trace the origins of the concept of a doom loop in finance, distinguishing the different channels through which sovereign and bank risks can transmit and reinforce one another. This will help us understand the analytical vocabulary through which this thesis will operationalise its empiricism. This elaboration upon the origins and channels of the doom-loop will be discussed in Section 2.2.

Second, Section 2.3 will critically evaluate the empirical evidence on doom loops. Section 2.3.1 examines the studies based on the Eurozone crisis era (between 2009-2014), which proved the existence and significance of the sovereign-bank contagion. Different econometric methods like VAR, VECM, and time study models are explored here. Section 2.3.2 then examines the emerging body of research in the post-2015 regulatory landscape. It assesses whether early evidence suggests if associated reforms have mitigated or merely transformed these problems.

Third, Section 2.3.2 also shows the comparative dimension between the core and periphery of the geographical region. This portion then demonstrates that while existing models predict that doom loop intensity varies across countries with differing fiscal capacity and institutional quality, there haven't been dedicated comparisons between core and peripheral members of the European Banking Union's first full operational decade (2015-2025). There is also the question of whether a common supervisory and resolution framework would prove convergent stability outcomes across structurally divergent economies.

Section 2.4 will expand on these points, articulating the research gap that exists within this domain, and positioning this thesis's contribution within the broader academic conversation. The chapter concludes by illustrating that this study is a logical and required extension of a debate that remains largely unsolved within the world of financial and economic scholars. By the end of this chapter, the reader will have the necessary knowledge to understand banking doom loops and also be able to question why answering this problem is crucial for academic understanding and policy design in Europe.

2.2 Theoretical Foundations of the Sovereign-Bank Nexus

The proposal that sovereign credit risk and banking sector fragility are connected is not new, nor is it controversial. What differentiates present-day literature from older observations of financial contagion is the attention to the specific mechanisms through which this interdependence occurs, and recognising that they become self-reinforcing to the point of

creating a crisis. This section traces the history of the nexus, from its origin in the literature related to the 'twin-crises' to the formalisation of the doom loop concept. We finally conclude the section by disaggregating the transmission channels constituting the doom loop's modern understanding.

2.2.1 The Origin of an Idea: From Twin Crises to Sovereign-Bank Interdependence

The foundations of the doom loop theory can be traced to the literature on twin banking and currency crises. Kaminsky and Reinhart (1999) studied 20 emerging and industrial economies and would establish that currency crises are often preceded by banking crises. It also stated that the financial systems being liberalised without adequate prudential supervision could create a scenario for this sequential contagion. Even though their primary focus was on the balance-of-payments consequences of banking distress, they raised an eventually important question: what would happen when the sovereign itself is also the guarantor of last resort to a banking system? The concern here was that the banking system's failure could threaten the state's creditworthiness.

The apparatus to address this question came from two distinct but complementary places. The first was rooted in corporate finance and banking theory, and would ask why banks are holding domestic sovereign bonds at all? Diamond and Dybvig's (1983) paper about liquidity provision would give a direct answer: banks transform illiquid assets into demandable deposits, and safe, liquid assets (including sovereign bonds) serve as a buffer i.e. a safety precaution against liquidity shocks. Holmström and Tirole (1998) would then formalise this, showing that public sector liquidity provision through the issuance of sovereign debt enables private sector investment. But neither model could anticipate that this practice could become the primary transmission mechanism for systemic contagion under sovereign stress.

The second came from public finance literature covering implicit guarantees and moral hazard. Acharya and Yorulmazer (2007) described the "too-many-to-fail" problem. This problem demonstrated that whenever multiple banks simultaneously fail, the sovereign's optimal ex-post policy is to hand out broad-based bailouts, creating ex-ante incentives for banks to have their risks correlated. This idea anticipates the doom loop: whenever banks anticipate support from sovereigns during systemic crises, they have less incentive to diversify away from domestic sovereign exposure. This increases their vulnerability to sovereign distress and thus makes sovereign support likelier and costlier.

2.2.2 Formalizing the Doom Loop

The Eurozone crisis gave rise to a significant advancement in theory: the explicit formalisation of the two-way feedback mechanism between banking and sovereign risk. Brunnermeier (2016) gave it the most influential articulation, creating the term "diabolic loop" to describe a self-reinforcing cycle in which sovereign debt being issued to finance bank bailouts will decay the sovereign's creditworthiness, which would then decrease the value of the sovereign bonds being held by the domestic banks, creating demand for more bailouts. They analytically demonstrated how the loop is intensified through a "sovereign-bank-nexus" that is inherent within monetary unions.

Farhi and Tirole (2018) expanded upon this by looking at the problem through the lens of moral hazard. In their interpretation of the framework, the interdependence isn't just a mechanical consequence of balance-sheet linkages but a strategic equilibrium. Both actors underinvest in

precaution after anticipating that distressed banks will eventually be bailed out by financially constrained sovereigns, and that distressed sovereigns will be supported by the financially exposed domestic banks.

2.2.3 Demystifying the Transmission Channels

Coherent theoretical literature has already been established stating that banking risk and sovereign risk are interdependent and how they can become self-reinforcing. It is also important to understand how these risks are propagated from one side to the other. There are three main transmission channels discussed here.

Balance-Sheet Channel: This is the mechanism that is the most direct, and it operates through banks' holdings of domestic sovereign bonds. In the scenario that a sovereign's creditworthiness drops, these bonds' market value also falls, which deteriorates bank capital and is enough to trigger possible bank runs (Gennaioli et al., 2013).

Collateral Channel: While sovereign bonds can serve as investments, they also act as collateral in case banks decide to borrow. An incoming shock to the sovereign can diminish the value of this collateral, reducing the banks' liquidity and forcing them to hold fire sales for these assets (Bocola, 2016).

Perception/Confidence Channel: It can be easily argued that this may be the most potent transmission mechanism since it works through market expectations. Even in the absence of direct channels like the 'Balance-Sheet Channel', the mere perception that sovereign risk and banking risk are interdependent can lead to correlated pricing (Grauwe & Ji, 2012). This channel is self-fulfilling in nature, as in, if the people believe that neither bank nor sovereign will let the other fail, then they will price the joint default risk regardless of what the actual risk exposure is.

2.2.4 Section Summary and Implications

The collective literature agrees on a few points. First, the nexus is not a phenomenon that is unitary in nature, but instead is a collection of distinct transmission channels, each with its own set of properties. Second, these channels are not exclusive, but rather interact and possibly amplify each other. Finally, the degree to which each channel can wreak havoc is dependent on the institutional policies.

In order to capture the dynamic feedback between the two risks in a possible feedback loop, a PVAR framework would be the most appropriate econometric model. Then there is also the idea of conditional heterogeneity, that these channels might interact differently across different institutional frameworks. This justifies the core-periphery comparative design choice in this thesis. After reviewing the theoretical strides made in the topic of the sovereign-bank nexus, we now move on to discuss the empirical literature and see how these theories have been tested across the years.

2.3 Empirical Evidence of Banking Doom Loops

The mechanisms described in Section 2.2 showed why banking and sovereign risk should be interdependent. This section now describes the empirical literature and examines whether, and to what extent, this interdependence exists in real-life financial data.

2.3.1 The Eurozone Crisis Era (2009–2014)

V. Acharya (2014) created one of the premier contributions in the area, where it was examined what effect bank bailouts have on sovereign credit risk. An event-study method was used while focusing on the time period between 2007-2011, and all the banks inside countries in the Eurozone (and a few others) having more than $10 billion in assets. It was demonstrated that the announcement of a bailout would significantly increase sovereign CDS spreads. This pointed towards the evidence of the bank-to-sovereign transmission channel: how rescuing banks would increase sovereign risk.

De Bruyckere et al. (2013) extended upon this work through the use of a panel dataset of sovereign and bank CDS spreads across eleven Eurozone countries from 2006 to 2011. Through the use of linear regression, there was a statistically significant contagion to be found between sovereign and bank credit risk. This effect was even stronger during times of crisis. The paper also confirms that a higher amount of sovereign debt is associated with a stronger bank-sovereign contagion.

VAR-based Analysis

Alter and Schüler (2012) used both a vector autoregression (VAR) and a vector error correction (VEC) framework in their work. In addition to both of these techniques, tests were conducted on Granger-causality and impulse response functions to study the dynamics between the CDS spreads. The dataset consisted of two banks each from each of the seven countries (all Eurozone countries) for a total of 14 institutions. They conclude the following: before the government decides to intervene, sovereign credit risk is greatly affected by a movement in bank CDS spreads, but changes in sovereign CDS spreads have a smaller impact on both the bank and sovereign CDS markets. This was confirmed to happen for most of the sample countries except for Italy and Portugal. It was also concluded that during and after the interventions, changes in sovereign CDS spreads permanently affect the financial sector CDS spreads. But the banks' default risk only affects the sovereign CDS spreads momentarily.

Evidence of Balance-Sheet channel

Battistini (2014) tackled the investigation of the balance-sheet channel using a vector error-correction model (VECM) on monthly data between 2007-2013 for 10 Eurozone countries. The primary data inputs were sovereign yield differentials and CDS premia. Their primary finding was that Eurozone periphery banks would respond to an increase in their own sovereign's risk by increasing their own exposure to such risk. Their explanation could be best explained by the 'moral suasion' and the 'carry trade' hypothesis.

'Moral suasion' referred to the phenomenon where high-risk sovereign issuers would exert pressure on banks inside their own jurisdiction to inflate their domestic sovereign holdings. This would help the demand for sovereign debt when its demand is slow, and yields would be relatively high. Banks that are undercapitalized have hopes of being revived by participating in 'carry trades' where they go long on high-risk, high-yield sovereign debt. This is funded by

either borrowing from the ECB or going short on low-yield debt. This can result in a home bias that exists in the sovereign portfolios of peripheral-country banks.

2.3.2 Existing Evidence on Core-Periphery Heterogeneity

Crisis-Era Trends

As discussed earlier (Battistini et al., 2014), peripheral banks would increase their sovereign exposure whenever country-specific risk increases. But the same behaviour would not be exhibited by core countries. In the authors' data, peripheral banks would behave much less risk-averse than other investors. The increase in the home bias of these portfolios could be attributed to distorted incentives (carry trade hypothesis). The evidence was only substantial for the periphery-country banks, but the same cannot be said about the core-country banks. The available data did not allow the authors to perform the same tests for core countries.

Banking Union Era

Lamers et al., (2021) used a DCC-MIDAS model to analyse the dynamic correlation that existed between bank and sovereign risk in the Euro Area. They found out that this correlation decreased significantly once the Bank Recovery and Resolution Directive (BRRD) was put into place by the European Union. In Germany and France, the decline started before the introduction of the BRRD and continued falling afterwards. In Italy and Spain, the interconnectedness started to fade after the BRRD was introduced. In these 'peripheral' countries, the BRRD achieved its goal of mitigating the bank-sovereign doom loop. It is a necessary commitment by the state to keep applying the BRRD bail-in rules to keep its credibility in the system.

The Macroprudential Channel: Another Possibility?

Hristov, Hülsewig, and Kolb (2021) made use of Panel Vector Autoregressive models for both Euro Area core and peripheral country groups, and found that an unsystematic capital-based macroprudential policy tightening would only further the banks' exposure to domestic sovereign bonds inside the peripheral countries. Doing so only deepens the sovereign-bank nexus. On the other hand, banks inside the core countries would expand their loan portfolios. Applying regulations uniformly across the entire Euro Area may lead to unexpected results and amplify pre-existing structural problems in peripheral countries rather than ending them.

2.4 What remains to be studied?

There has been plenty of empirical evidence that points towards core-periphery heterogeneity being real when it comes to doom-loop dynamics. However, there have not been studies that do longitudinal comparisons over the Banking Union's first complete decade in effect. Whether the doom-loop's intensity has lessened, intensified, or remained as is needs to be studied.

There exists another under-researched dimension to this whole field of study. It is the possibly growing role of non-bank financial intermediaries within the sovereign-bank nexus. In recent years (notably after the global financial crisis), there has been noticeable growth within shadow banking, investment funds, and other intermediaries. These entities often hold extremely significant amounts of sovereign debt or are often providing wholesale funding to banks. There is a possibility that there are certain portions of the traditional doom-loop that are being

influenced by entities that lie outside the Banking Union's safety precautions, and also outside the scope of bank-centric supervision. Through a rise in sovereign stress, it is entirely possible that asset prices decline or funding withdrawals occur in these sectors. Banks may be at the mercy of NBFIs indirectly, even if they manage to mitigate their balance-sheet exposure to domestic sovereign bonds.

Literature Review Summary Table

Author / Year	Title	Context	Findings
Kaminsky, G. L., & Reinhart, C. M. / 1999	The Twin Crises: The Causes of Banking and Balance-of-Payments Problems	Foundational work in the origins of the doom-loop. Studied industrial and emerging economies to see how financial contagion can spread through the banking and currency sectors.	Banking sector crisis precedes currency crisis, and eventually deepen each other to create a cycle. Financial liberalization precedes banking crisis.
Diamond, D. W., & Dybvig, P. H. / 1983	Bank Runs, Deposit Insurance, and Liquidity	Foundational theory in banking that explains the existence of government intervention into the banking system. This intervention can eventually lead to doom-looping.	There is potential benefit from government intervention into banking markets. Bank-issued demand deposits improve the market, but can also cause a bank run.
Holmström, B., & Tirole, J. /1998	Private and Public Supply of Liquidity	Paper in corporate theory that looked into the link between sovereign debt and private investment, eventually leading to the doom-loop.	The government issuing bonds can help in intermediation to coordinate scarce liquidity. It justifies the government's management in the banking system.
Acharya, V. V., & Yorulmazer, T. / 2007	Too many to fail—An analysis of time-inconsistency in bank closure policies	Theoretical work that explores moral hazards in banking systems.	Explained the 'too-many-to-fail' problem. With too many banks failing at the same time, the regulator finds it best to bail out multiple or all of them. If the number is small, those banks can be acquired and herded together.

Author / Year	Title	Context	Findings
Brunnermeier, M. K., Garicano, L., Lane, P. R., Pagano, M., Reis, R., Santos, T., Thesmar, D., Van Nieuwerburgh, S., & Vayanos, D. / 2016	The Sovereign-Bank Diabolic Loop and ESBies	Landmark paper written in the aftermath of the Eurozone crisis, it named and formalized the mechanism of the doom-loop mechanism.	Coined the term 'diabolic loop', it described the looping cycle in which deterioration of sovereign trust decays the value of sovereign holdings with banks. This creates extra demand for bailouts and consequently, a sovereign-banking nexus.
Farhi, E., & Tirole, J. / 2018	Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops	Rationalizes externalised banking supervision, and to detail the doom-loop and re-nationalization mechanisms.	After an outbreak of bad news about the banks' balance sheet or the sovereign's credit-worthiness, a re-nationalization of financial markets occurs.
Gennaioli, N., Martin, A., & Rossi, S. / 2014	Sovereign Default, Domestic Banks, and Financial Institutions	Studies the link between government default and financial fragility within a model where government default is non-discriminatory.	Government defaults destroy balance sheets of domestic banks. Government defaults lead to declines in private credit, and it is worse in countries with better financial institutions, and banks holding more sovereign bonds. But in these countries, the chances of a default are lower.
Bocola, L. / 2016	The Pass-Through of Sovereign Risk	Empirical study examining the macroeconomic implications of sovereign risk in a model where banks hold domestic sovereign debt.	News of a future sovereign default tightens the liquidity channel. Afterwards, there is a precautionary motive to deleverage the debt.
De Grauwe, P., & Ji, Y. / 2012	Self-Fulfilling Crises in the Eurozone: An Empirical Test	Empirical study testing whether government bond markets in the Eurozone are more susceptible to self-	A significant part of the rise in the spreads of peripheral Eurozone countries was associated with negative self-fulfilling market sentiments. These sentiments became

Author / Year	Title	Context	Findings
		fulfilling liquidity crises when compared to standalone countries.	particularly strong since the end of 2010.
Acharya, V., Drechsler, I., & Schnabl, P. /2014	A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk	Determines if financial sector bailouts were crucial in increasing the sovereign credit risk within developed economies. Does so by allowing the government to finance bailouts by increased taxes and diluting government debtholders in the model.	Distress in the financial sector will induce government bailouts, increasing the sovereign credit risk. This increased risk weakens the financial sector by eroding the value of government guarantees and bond holdings.
De Bruyckere, V., Gerhardt, M., Schepens, G., & Vander Vennet, R. / 2013	Bank/sovereign risk spillovers in the European debt crisis	Study analyses the risk spillovers that existed between banks and countries within Europe between 2006-2011. It also seeks to explain the contagion effect.	There is significant empirical evidence of contagion between the banking and sovereign credit risk during the time period. The home-bias effect leads to stronger contagion between a bank and its home country.
Alter, A., & Schüler, Y. S. / 2012	Credit spread interdependencies of European states and banks during the financial crisis	VAR and VECM study examining whether increases in default risks originated from the financial sector. Also looks into whether the banking sector default risk is affected by the sovereign sector default risk/	Before the government intervening, contagion from the bank credit spreads would go into the sovereign CDS market. A financial sector shock affects the sovereign CDS spreads more strongly in the short run, but becomes insignificant in the long run.
Battistini, N., Pagano, M., & Simonelli, S. / 2014	Systemic risk, sovereign yields and bank exposures in the euro crisis	Exploring the dynamics between sovereign yields and the changes in banks' sovereign	In most Eurozone countries, especially the periphery, banks' sovereign exposure goes up with yield increases. In periphery, banks increase

Author / Year	Title	Context	Findings
		portfolios, and how they are related.	domestic exposure when country risk goes up, while it does not happen in core countries.
Lamers, M., Present, T., Soenen, N., & Vander Vennet, R. / 2021	BRRD Credibility and the Bank-Sovereign Nexus	The contribution of the BRRD to diminishing the interconnectedness of banks and their sovereigns is judged. It is done so by using a DCC-MIDAS methodology.	The structural dynamic correlation between the risks in the Euro Area decreased since the introduction of BRRD. In Germany and France, the decline started before the BRRD and kept declining. In Spain and Italy, the decline started post-introduction. It is an effective measure to mitigate the loop.
Hristov, N., Hülsewig, O., & Kolb, B. / 2021	Macroprudential policy and the sovereign-bank nexus in the euro area	Panel VAR study to see how macroprudential policies affect the sovereign-bank nexus from an macroeconomic perspective.	A tightening in capital-based macroprudential policy will increase the banks' holdings of domestic government debt' in the EA-periphery. But, the nexus weakens in the EA core countries. This is due to the differences in resilience and capitalization of banks in the core and periphery.

Table 1: Literature review summary

Chapter 3: Data

3.1 Sample and scope of the study

This study examines whether sovereign-bank doom loops were present in Europe over a time period starting from the second quarter of 2015 till the third quarter of 2025, resulting in 42 quarterly observations per country. This particular time frame is chosen deliberately and backed by theory. The start of 2015 coincides with the Single Supervisory Mechanism (centred on the European Central Bank) being fully operationalised in November 2014. The SSM was a huge overhaul that would go on to mark a structural reform in European banking supervision. Significant credit institutions would proceed to be overseen by the European Central Bank, and uniform reporting standards were implemented across all participating member states. Choosing this particular time period will make sure that the chosen data will portray a consistent supervisory framework and definitions. Doing so makes sure that variation introduced by definitional changes is kept to a minimum.

The dataset covers eight European Union countries whose quarterly data across all banking risk and sovereign risk indicators are available over the sample period. The countries include Belgium, France, Germany, Greece, Italy, the Netherlands, Portugal, and Spain. The selected nations consist of both core and peripheral Euro Area economies. As to how these countries were grouped into being either core or peripheral in nature, prior academic work has been done. They are classified into either category on the basis of economic indicators. Core countries are characterised by export-driven growth, high levels of GDP per capita, low levels of unemployment, and greater technological progress. On the other hand, peripheral countries can be identified by debt-driven growth, low levels of GDP per capita, high levels of unemployment, and poorer technological progress (Gräbner et al., 2020). This gives us a consequential variation when it comes to sovereign and banking risk profiles.

Country-quarter is the specified unit of observation. The panel is balanced in nature. Sovereign yield data is expressed as the average of daily rates, measured as a percentage. The main refinancing rate is also expressed as an average of daily rates, measured as a percentage. The banking variables have also been measured in terms of a percentage. The choice of quarterly frequency was made contingent on whether data would be available for the selected variables. While it is possible to find and collect government bond yield data on a daily basis, daily reporting and compilation of banking data on such a scale remains to be an inefficient endeavor.

3.2 Sovereign Risk: Difference between 10-Year Government Bond Yield and Main Refinancing Rate

3.2.1 Definition and Source

In the sample, the sovereign risk for each country is being proxied by its respective ten-year government bond yield after subtracting the main refinancing rate. The bond yield rates are finalised through the price that the lender charges, the risk that the borrower undertakes, and the amount of fall in capital value. These interest rates are then further implied by the price that government bonds trade at in financial markets, but not the rates at which the loans were issued. The data source for the bond yields is the Federal Reserve Economic Data (FRED) database,

which in turn compiles data from Organization for Economic Co-operation and Development (OECD).

The main refinancing rate is defined as the interest rate that banks pay whenever they decide to borrow money from the ECB for a week. In return for the loan, they are to provide collateral in the scenario that the bank does not repay the borrowed amount. The rate is updated once every six weeks, so the observations have been averaged and converted into quarterly observations. The data for the main refinancing rate is sourced from the Consolidated Banking Data – CBD2 from the ECB.

3.2.2 Justification for choosing the proxy

The ten-year government bond segment is quite central to the nexus within Europe. Banks often hold massive portfolios of domestic sovereign debt, of which those with ten-year maturity hold the lion's share. For example, 34% of the German Federal government's debt portfolio is accounted for by government bonds with 10-year maturities. In Mody and Sandri's 2012 paper, they used sovereign spread (measured as the difference between the secondary-market yield on 10-year bonds, and the German Bund), but the same approach is not chosen for this work primarily due to restrictions in data availability. Another concern is that Germany, Italy, and France hold almost three-fifths of all government debt within Europe. Choosing the German Bund as a benchmark would create complications in interpreting the results for Germany as a country cannot be its own benchmark, and the country is too significant to exclude from our sample.

Furthermore, the inclusion of the ten-year government bond yield makes sense from a perspective of maintaining data quality. They remain free from changes in definition that can affect sovereign risk proxies and measurement problems. Furthermore, government bond yield data is available for all countries on a daily basis and can be easily averaged for every quarter without losing information. Thus, they remain to be a consistent measure of sovereign risk across this panel. The raw bond yield by itself contains both components – the ECB's monetary policy stance and the fiscal creditworthiness of the sovereign. By removing the main refinancing rate, the risk spread component is being isolated and gauges what the market perceives the sovereign's default risk to be.

3.3 Banking Risk: Risk index from Principal Component Analysis (PCA)

Capturing the model's banking risk is done through the use of a composite index constructed by the application of Principal Component Analysis (PCA). The technique is used on three indicators of banking health: the Common Equity Tier 1 (CET-1) ratio, the Liquidity Ratio, and the Non-Performing Loan (NPL) ratio. The process of creating the index using PCA will be discussed within Chapter 4. The justification to choose each of these components will be discussed in this section. All data series have been sourced from the Consolidated Banking data – CBD2 dataset from the ECB data portal.

3.3.1 Common Equity Tier 1 Ratio

It is one of the measures to gauge a bank's financial standing. It is the highest quality of capital that is possible for a bank to hold in the Basel III framework, as it is money that can be used for a bank to absorb losses and stay stable during turbulent times. It normally includes common

equity shares and retained earnings. Currently, Basel III requires all banks under its supervision to have a minimum CET-1 ratio of 4.5% at all times. The formula for the CET-1 Ratio is:

CET-1 ratio = Common equity tier 1 capital / Total risk exposure amount

This ratio is often considered to be a crucial gauge for capital adequacy and bank solvency for two primary reasons. First off, the ECB's Supervisory Review and Evaluation Process (SREP) assign it to be the binding regulatory capital constraint. In case a bank fails to keep up with these requirements, the ECB can take corrective steps to make sure that any problems can be fixed at an early stage. These steps are meant to be preventive as well, not just a knee-jerk reaction when it is too late. Secondly, CET-1 can be affected severely whenever there is a change in sovereign stress. Increasing bond yields can lead to the value of portfolios to fall; such an event can lead to banks' CET-1 capital buffers reducing and coming close to the buffers. Thirdly, data for the CET-1 ratio is reported on a regular basis and is easily comparable. This helps enable aggregation across the panel without any changes in definition.

3.3.2 Non-Performing Loan Ratio

It is defined as the ratio between the volume of non-performing loans and advances and the total gross loans and advances. Also known as "bad debt", a loan can be considered to be non-performing if more than 90 days have passed and the borrower has not paid any instalments or interest. The bank assumes that such loans will not be paid back, and reduces their own capacity to issue new loans. The formula for the non-performing loan ratio is:

NPL ratio = Sum of non-performing loans and advances / Total gross loans and advances

It is also an important indicator of banking risk for several reasons. First, it is the most visible metric of credit eroding on bank balance sheets, which accumulates unprofitable assets which reduce profitability and diminish capital over time. Secondly, it is possible that it affects banking risk through a macroeconomic perspective. Increasing sovereign distress often weakens tax revenues and economic activity, causing corporate and household default rates to increase. This may lead to more loans going "bad" and suppress bank capital. Thirdly, this ratio is made to be directionally consistent with the interpretation of banking risk, a higher ratio would indicate greater stress upon the banking system. The NPL ratio data series used in this study includes cash advances and only accounts for significant institutions.

3.3.3 Liquid Assets %

This liquidity indicator is included in the composite index to account for short-term funding capacity and liquidity risk. While it may seem similar to the CET-1 ratio, asset quality is still quite different from liquidity. Bank solvency and asset quality are variables that change slowly over time, while liquidity is something that can materialise overnight as well, as demonstrated by bank runs throughout history. A notable example would be during the 2008 crisis, where the banks would face acute funding shortfalls. Higher liquidity indicates greater resilience to short-term risk. The formula for the Liquid assets % is:

Liquid assets % = Total unadjusted liquid assets / Total assets

Here, the "Total unadjusted liquid assets" consists of too many components to list and lies beyond the scope of this study. The Liquid Assets % data series used in this study only takes into account domestic institutions as the data is not available for significant institutions.

Banking/Sovereign Risk	Variable Name	Definition	Source
Sovereign Risk	10-Year Govt Bond Yield	Annual interest payment / Market price of bond	FRED
Sovereign Risk	Main Refinancing Rate	Rate at which ECB lends money to banks	ECB
Sovereign Risk	Sovereign_Risk	Govt Bond Yield – Main Refinancing Rate	N.A.
Banking Risk	Non-performing Loans Ratio	Sum of non-performing loans and advances / Total gross loans and advances	CBD-2, ECB
Banking Risk	Common Equity Tier-1 Ratio	Common equity tier 1 capital / Total risk exposure amount	CBD-2, ECB
Banking Risk	Liquid Assets %	Total unadjusted liquid assets / Total assets	CBD-2, ECB
Banking Risk	Banking Risk Index	PCA index made from banking risk indicators	N.A.

Table 2: Variable dataset

Statistic	Govt Bond Yield	Main Ref. Rate	Liquid Assets	CET-1	NPL Ratio	Sovereign Risk	Banking Risk Index
Mean	2.5846	1.0435	17.4699	13.9084	11.4583	1.5411	1.11E-16
Median	2.5027	0	18.1421	13.33	4.93	1.2613	-0.1335
Maximum	9.5367	4.5	32.8878	18.07	47.05	9.4955	2.8490
Minimum	0.0933	0	1.5575	10.19	2.11	-1.4833	-2.4455
Std. Dev.	1.7620	1.6226	6.9373	1.9101	13.1698	1.9628	1.5261

Statistic	Govt Bond Yield	Main Ref. Rate	Liquid Assets	CET-1	NPL Ratio	Sovereign Risk	Banking Risk Index
Skewness	1.3075	1.1364	-0.2035	0.4105	1.6801	1.7374	0.2871
Kurtosis	5.8669	2.6267	3.0784	2.2139	4.5708	7.1278	1.7915
Sum	434.209	175.308	2934.939	2336.61	1925	258.901	3.97E-14
Sum Sq. Dev.	518.475	439.698	8037.118	609.324	28964.91	643.395	388.925
Observations	168	168	168	168	168	168	168

Table 3: Summary statistics – Peripheral countries

Statistic	Govt Bond Yield	Main Ref. Rate	Liquid Assets	CET-1	NPL Ratio	Sovereign Risk	Banking Risk Index
Mean	1.097563	1.043501	16.52129	16.01018	2.024107	0.054062	5.79E-16
Median	0.660277	0	15.7574	15.925	1.87	0.163667	-0.36468
Maximum	3.48	4.5	26.2185	19.51	4.32	1.67	3.813138
Minimum	-0.61351	0	11.5827	12.58	0.92	-2.21468	-2.74061
Std. Dev.	1.254155	1.622628	3.066524	1.470654	0.841174	0.805932	1.497992
Skewness	0.510337	1.136407	0.81282	0.106804	1.022729	-0.72561	0.693733
Kurtosis	1.738082	2.626705	3.190464	2.762352	3.38121	3.156411	2.481455
Sum	184.3906	175.3081	2775.576	2689.71	340.05	9.082429	8.06E-14
Sum Sq. Dev.	262.6753	439.698	1570.396	361.1915	118.1649	108.4708	374.7444
Observations	262.6753	439.698	1570.396	361.1915	118.1649	108.4708	374.7444

Table 4: Summary statistics – Core countries

Chapter 4: Methodology

This chapter's aim is to establish the entire econometric methodology being employed in order to determine the presence and directionality of sovereign-bank doom-loops across the listed European countries during the period of 2015Q2 till 2025Q3. Several stages are dependent on the outcomes of the previous stages. The chapter starts by explaining how the banking risk is represented by a composite index created through Principal Component Analysis (Section 4.1). Following this is a test for cross-sectional dependence (Section 4.2), panel stationarity testing (Section 4.3), cointegration testing (Section 4.4), determining the optimal number of lags (Section 4.5, running a panel regression (Section 4.6), panel Granger causality (Section 4.7), and the expected hypotheses (Section 4.8). The chapter will close with a table summary of the entire methodology sequence.

4.1 Creating the Banking Risk Index via Principal Component Analysis

Capturing how fragile the banking sector can be is something that cannot be encapsulated by a single factor. A bank might be undercapitalised when compared to its risk-weighted assets and also passing its liquidity requirements, and the converse can be true as well. Keeping this in mind, three indicators were chosen for the study – the Common Equity Tier 1 (CET-1) ratio, the Non-Performing Loan (NPL) ratio, and the Liquid Assets %. Every single one of these captures a different dimension of the risk that exists in the bank sector: bank solvency, asset quality, and the capability of a bank to fund itself in the short term. If all of these factors were to be used separately in a regression, the problem of multicollinearity would arise since all of these are correlated.

Principal Component Analysis (PCA) solves this problem. By extracting the maximum joint variance across the three components, it is possible to create a single index that is a linear combination of all three. The weights are decided by the covariance matrix for the factors.

Prior to creating the index, observations are normalised into z-scores within each country. It is essential as the indicators work on different scales, and PCA is sensitive to scale. If it were not converted into z-scores, the component with the highest variance would dominate the first principal component, even if it is not economically relevant. Normalising makes sure that each weight enters with equal weights, and the resulting principal components reflect co-movement in risk. Here are the directional movements of the components according to banking theory: increasing CET-1 decreases risk, increasing liquid assets % also decreases risk, and increasing NPL ratio increases risk.

The result is the first principal component score, denoted by 'Banking_Safety_Index' for a specific country at time period t, is the safety index. As will be found later, CET-1, and liquid assets load positively, while the NPL ratio loads negatively. Theory implies that this would be a safety index since higher values of CET-1 and liquid assets contribute to a stronger bank, and higher values of NPL deteriorate banking health. This variable is multiplied by -1 to create a 'Banking_Risk_Index' variable. Higher values of this index point towards a riskier banking sector, and lower values tell us that the banking sector is relatively safe.

4.2 Cross-Sectional Dependence Testing

Why test Cross-Sectional Dependence?

Amongst economically and institutionally integrated entities such as the European Union, it is expected to find signs of cross-sectional dependence. It is normal for unobserved shocks to resonate from one country to the others as they share institutional frameworks, common policies and financial channels. All the Eurozone members are governed by the European Central Bank, which imposed the Single Supervisory Mechanism and other binds. This can be observed during the COVID-19 pandemic, where movements in financial indicators were synchronised for the countries in the panel regardless of their fundamentals. It is crucial to determine cross-sectional dependence as statistical tests may create spurious results if they are cross-sectionally dependent and the improper tests are applied.

How to test it? Outcomes and implications

Four tests are employed to confirm this dependency. These are Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and the Pesaran CD tests. The results of these tests confirm that there exist significant cross-sectional dependencies for the banking and sovereign risk variables in both the core and the peripheral countries.

4.3 Panel Stationarity Testing

Why test Stationarity?

Stationarity is the property that tells us whether a time series has a constant mean, variance, and autocorrelation remains constant over time. Such series don't demonstrate any long-term trends, and their behavior is predictable. A non-stationary series might have a trend or an ever-growing variance, and including this into a regression model will produce spurious results. This was first identified in a paper by Granger and Newbold (1974). The estimated coefficients may seem to be highly significant with abnormally large R-squared values, even if all variables are unrelated with each other. The null hypothesis for all stationarity tests indicates the presence of a unit root, indicating non-stationarity. Rejecting the null gives evidence for stationarity.

How to test it? Outcome and Implications

Detecting cross-sectional dependence has statistical implications as first-generation tests (such as Levin, Lin, and Chu) for stationarity are inaccurate if the panel units are cross-sectionally dependent. To resolve this problem, a second-generation stationarity test- Cross-sectionally augmented Im, Pesaran and Shin (CIPS*)* - will be employed.

The test indicates that banking risk is stationary in the panel of core countries, but the sovereign risk is not. Within the panel of peripheral countries, the sovereign risk is stationary in nature, but the banking risk index is not. The finding of a mix between stationary and non-stationary variables does not warrant testing when it comes to a cointegrating relationship (as stationary and non-stationary variables cannot be cointegrated), but will be done anyways as a robustness check.

4.4 Panel Cointegration Testing

Why test cointegration?

Cointegration is a property in econometrics where time series variables that are non-stationary might share an equilibrium relationship in the long run. If there are two individual time series that drift apart after some time, there exists a specific linear combination of them both that is stationary. In the context of the doom-loop, being cointegrated would imply that both sovereign and banking risks are bound to each other in a long-term equilibrium. Even if they do stray apart, they systematically return to said equilibrium over time. If the series are found to be cointegrated with each other, the Panel VAR methodology would be less appropriate than a Panel Vector Error Correction Model (PVECM) as it captures dynamics in both the long-run and the short-run.

How to test it? Outcome and Implications

Cointegration between both the variable series will be tested through the Kao cointegration test. It is a test suitable for panel data, and tests on residuals using the Augmented Dickey-Fuller approach. The test assumes that there exists a common cointegrating vector across all units in the panel. The null hypothesis states that there exists no cointegration. The alternative hypothesis states that there is cointegration between both the variables.

The Kao cointegration test fails to reject the null hypothesis at a significant enough level in both the panels. Hence, it can be confidently said that there exists no long-run relationship between sovereign risk and banking risk over the specified time period. Any further regressions that will be performed must be thought of as capturing associations in the short and medium run. Failure to detect cointegration confirms that a PVAR is a more suitable methodology than a PVECM framework.

4.5 Determining the optimal number of lags

It is vital to determine the optimal number of lags in a PVAR model, as including too many lags of the independent variable leads to overfitting, and the model has more noise than true signal. On the other hand, if not enough lags are included, then there is information being left on the table. The appropriate number of lags is determined through minimising several information criteria, and then choosing the number of lags that most criteria agree with.

The following methods will be tested:

- LR: Sequential modified LR test statistic (at the 5% level)
- FPE: Final prediction error
- AIC: Akaike information criterion
- SC: Schwartz information criterion
- HQ: Hannan-Quinn information criterion

All the information criteria agree that 2 is the optimal number of lags in both the core and the peripheral country panels.

4.6 Running a Panel regression

The model being specified to estimate a relationship between the sovereign and banking risk is an entity fixed effects panel vector autoregression model. There exist two symmetric equations that help capture the bidirectional nature of the potential doomloop. The primary equation with the sovereign risk as the dependent variable is as follows:

$$SR_{i,t} = \alpha_i^S + (\beta_1 * SR_{i,t-1}) + (\beta_2 * SR_{i,t-2}) + (\beta_3 * BR_{i,t-1}) + (\beta_4 * BR_{i,t-2}) + \varepsilon_{i,t}^S$$

The equation with the banking risk as the dependent variable is as follows:

$$BR_{i,t} = \alpha_i^B + (\beta_1 * SR_{i,t-1}) + (\beta_2 * SR_{i,t-2}) + (\beta_3 * BR_{i,t-1}) + (\beta_4 * BR_{i,t-2}) + \varepsilon_{i,t}^B$$

Where BR is the composite banking risk index, SR is the sovereign risk being proxied by the difference between the 10-year government bond yield and the main refinancing rate, $\varepsilon_{i,t}$ represents the usual error terms that can vary across individual countries and time, and α_i is the fixed intercept assigned to each country. The β represent the coefficients for each independent variable.

4.7 Panel Granger causality

Why panel Granger causality?

As the doom-loop is defined to be a dynamic mechanism, it follows that deterioration in past sovereign conditions generates banking stress in the future. Similarly, past banking stress can create future sovereign stress. Panel Granger causality tests whether values from one variable contain sufficient predictive power for the other variable. Finding Granger causality in either direction can help improve forecasting for these risks, and provide evidence for the sovereign-to-bank, or bank-to -sovereign transmission channels to exist. Finding the presence of bidirectional Granger causality points towards the doom-loop: each variable's present value is influenced by the other's past. It is imperative to point out that Granger causality, as a concept, does not define causation.

How to test it? Outcome and Implications

Dumitrescu and Hurlin's (2012) test of heterogeneous panel Granger causality will be used for testing. It is an extension of the Granger framework, making it suitable for a panel dataset. The Granger-causal relationship of each individual is allowed to be heterogeneous. For every country i, a VAR regression is run where the dependent variable is regressed using lags of its own, and the independent variables. If the past values of the individual variables are found to be statistically significant, then it can be considered Granger-causing. The regression is run again after switching the dependent and independent variables to test for Granger causality in the reverse direction. The null hypothesis states that all the coefficients for the lagged values of independent variables equal zero for all entities in the panel. The alternate hypothesis states that at least one such coefficient does not equal zero for at least one entity in the panel.

The number of lags chosen is 2, the same as Section 4.5.

4.8 Expected hypotheses/outcomes

In accordance with previously established literature, there exist 3 hypotheses that need to be tested:

1. H_0: There exists a bidirectional relationship between the sovereign and banking risk in the core countries.
2. H_1: There does not exist a bidirectional relationship between the sovereign and banking risk in the peripheral countries.
3. H_2: The link between the sovereign and banking risk is much stronger in the peripheral countries than their core counterparts.

Methodology Summary

Step	Procedure	Test / Estimator
4.1	PCA index construction	Standardisation, then Principal Component Analysis
4.2	Cross-Sectional dependence	Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, Pesaran CD tests
4.3	Panel unit root / Stationarity	Pesaran CIPS test
4.4	Panel cointegration	Kao cointegration test
4.5	Lag selection	LR, FPE, AIC, SC, HQ
4.6	Panel regression (both directions)	Entity fixed effects panel vector autoregression
4.7	Dynamic Granger causality	Dumitrescu-Hurlin panel test
4.8	Expected hypotheses/outcomes	Interpretation of the regression and Granger tests

Table 3: Methodology

Chapter 5: Econometric results

5.1 Core countries

5.1.1 Banking risk index via principal component analysis

Eigenvalues for each eigenvector

EV1	2.230621686386497
EV2	0.537358256155635
EV3	0.232020057457869

Table 4: Core countries - Eigenvalues for each eigenvector

The first eigenvector EV1 explains (2.23/3) * 100 = 74.3% of the total variation in the banking variables. This result is strong, as the Kaiser criterion recommends using eigenvectors with eigenvalues greater than 1. This ensures that the new variable holds greater information than any component variable could alone.

Loading matrix for Banking safety index

CET-1	0.529396623100925
Liquid	0.585116410607622
NPL	-0.61431099736777

Table 5: Core countries – Loading matrix

The table above shows how each component variable will load onto the PCA index. CET-1, and liquid assets load positively, while the NPL ratio loads negatively. This creates a bank safety index. Multiplying each of these by -1 transforms it into a banking risk index instead.

5.1.2 Cross-sectional dependence

Banking risk

Null hypothesis: No cross-section dependence (correlation)			
Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	213.8286	6	0.0000
Pesaran scaled LM	59.99494		0.0000
Bias-corrected scaled LM	59.94616		0.0000
Pesaran CD	14.61924		0.0000

Table 6: Core countries – Cross-sectional dependence for banking risk

Sovereign risk

Null hypothesis: No cross-section dependence (correlation)			
Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	246.7707	6	0.0000
Pesaran scaled LM	69.50451		0.0000
Bias-corrected scaled LM	69.45573		0.0000
Pesaran CD	15.70879		0.0000

Table 7: Core countries – Cross-sectional dependence for banking risk

Tables 6 and 7 test whether the countries in these groups move together when it comes to the variables. All tests demonstrate p-values of 0.0000, and hence the null can be rejected decisively. Both the sovereign and banking risks are correlated for Belgium, France, Germany, and the Netherlands. This makes sense as these countries are subject to the same ECB policies and are similar in macroeconomic conditions.

5.1.3 Panel Unit Root / Stationarity

Banking Risk

Null hypothesis: Unit root		
Statistic	**t-stat**	**p-value**
CIPS:	-3.33178	<0.01
Truncated CIPS:	-3.33178	<0.01

Table 8: Core countries – Stationarity for banking risk

Sovereign Risk

Null hypothesis: Unit root		
Statistic	**t-stat**	**p-value**
CIPS:	-1.10104	>=0.10
Truncated CIPS:	-1.10104	>=0.10

Table 9: Core countries – Stationarity for sovereign risk

We reject the null hypothesis for banking risk, and cannot reject it for sovereign risk. Banking risk is stationary, and hovers around a stable mean with a stable variance with no seasonal patterns. The same cannot be said about sovereign risk as it is non-stationary; it has a trend component. Cointegration between the two variables can be ruled out, but the tests are carried out for the purposes of robustness.

5.1.4 Panel cointegration test

Null Hypothesis: No cointegration		
Trend assumption: No deterministic trend		
Statistic	**t-Statistic**	**Prob.**
ADF	-1.452263	0.0732

Table 10: Core countries – Cointegration

The null hypothesis is not rejected, and the Kao cointegration test indicates that there is no cointegration between the variables; there exists no long-run equilibrium relationship. A persistent, stable link cannot be established between the variables in core countries.

5.1.5 Optimal number of lags

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-422.2366	NA	0.910562	5.582061	5.621849	5.598224
1	-139.6679	553.9834	0.023306	1.916683	2.036046	1.965172
2	-91.15664	93.83097*	0.012975*	1.331008*	1.529948*	1.411825*
3	-88.61771	4.844010	0.013228	1.350233	1.628748	1.463376

Table 11: Core countries – Optimal number of lags

The information criteria agree on 2 being the optimal number of lags to be included in the regression model.

5.1.6 Regression equations

Dependent Variable: BANKING_RISK_INDEX **Total panel (balanced) observations: 160**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BANKING_RISK_INDEX(-1)	0.726640	0.079771	9.109021	0.0000
BANKING_RISK_INDEX(-2)	0.159858	0.075093	2.128784	0.0349
SOVEREIGN_RISK(-1)	0.017586	0.085379	0.205980	0.8371
SOVEREIGN_RISK(-2)	0.046452	0.088951	0.522215	0.6023
C	-0.133542	0.032572	-4.099931	0.0001

Table 12: Core countries – Regression: Sovereign risk → Bank risk

The dependent variable here is the banking risk index, and the independent variables are two lags of its own and two lags of the sovereign risk. Banking risk is strongly autocorrelated (as indicated by both its lags being statistically significant), while past values of sovereign risk do not statistically affect current banking risk. There is a failure to detect a sovereign-to-bank risk transmission channel in core countries, and this is consistent with theory, as the banking systems in these countries have greater asset quality and liquidity cushion.

Dependent Variable: SOVEREIGN_RISK Total panel (balanced) observations: 160				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BANKING_RISK_INDEX(-1)	-0.040234	0.056002	-0.718445	0.4736
BANKING_RISK_INDEX(-2)	0.072547	0.052718	1.376138	0.1708
SOVEREIGN_RISK(-1)	1.484479	0.059939	24.76652	0.0000
SOVEREIGN_RISK(-2)	-0.707096	0.062447	-11.32320	0.0000
C	0.000609	0.022866	0.026619	0.9788

Table 13: Core countries – Regression: Bank risk → Sovereign risk

Now, the dependent variable is sovereign risk, and the independent variables are two lags of the banking risk and sovereign risk. Sovereign risk is highly autocorrelated, while banking risk has no statistically significant effect on the sovereign risk. Failure to detect a bank-to-sovereign risk transmission channel in core countries, is consistent with existing theory, as these countries have more robust institutions.

5.1.7 Dynamic Granger-causality

Pairwise Dumitrescu Hurlin Panel Causality Tests Lags: 2			
Null Hypothesis:	**W-Stat.**	**Zbar-Stat.**	**Prob.**
SOVEREIGN_RISK does not homogeneously cause BANKING_RISK_INDEX	1.10685	-0.90009	0.3681
BANKING_RISK_INDEX does not homogeneously cause SOVEREIGN_RISK	3.02444	0.80147	0.4229

Table 14: Core countries – Panel Granger causality

Both of the null hypotheses cannot be rejected. The results gained are in line with what the regression equations indicate: there does not exist a statistically significant causal relationship between sovereign risk and banking risk in core countries, in either direction.

5.2 Peripheral countries

5.2.1 Banking risk index via Principal Component Analysis

Eigenvalues for each eigenvector

EV1	2.31503065428017
EV2	0.6197149735439408

EV3	0.06525437217588883

Table 15: Peripheral countries - Eigenvalues for each eigenvector

The first eigenvector EV1 explains (2.31/3) * 100 = 77.16% of the total variation in the banking variables. This result is even stronger when compared to the core countries. Using the Kaiser criterion approves the use of EV1 to create a composite banking risk index for peripheral countries.

Loading matrix

CET-1	0.474960115
Liquid	0.628441818
NPL	-0.61601442

Table 16: Peripheral countries – Loading matrix

The factor loadings exactly mimic the directionality of the core countries (CET-1, Liquid assets load positively, whilst NPL ratio loads negatively). By multiplying these loadings by -1, we can capture the greater banking risk in peripheral countries which can be attributed to poorer asset quality and weaker capitalisation.

5.2.2 Cross-sectional dependence

Banking risk

Null hypothesis: No cross-section dependence (correlation)			
Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	211.3611	6	0.0000
Pesaran scaled LM	59.28265		0.0000
Bias-corrected scaled LM	59.23387		0.0000
Pesaran CD	14.52149		0.0000

Table 17: Peripheral countries – Cross-sectional dependence for banking risk

Sovereign risk

Null hypothesis: No cross-section dependence (correlation)			
Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	168.5037	6	0.0000
Pesaran scaled LM	46.91077		0.0000
Bias-corrected scaled LM	46.86199		0.0000
Pesaran CD	12.84581		0.0000

Table 18: Peripheral countries – Cross-sectional dependence for sovereign risk

All cross-sectional dependence tests help us reject the null hypothesis that these countries (Greece, Italy, Portugal, and Spain) are not correlated. All of their banking and sovereign risks are correlated as they are subject to similar macro and policy decisions.

5.2.3 Panel Unit Root / Stationarity

Banking Risk

Null hypothesis: Unit root		
Statistic	**t-stat**	**p-value**
CIPS:	-1.64172	>=0.10
Truncated CIPS:	-1.64172	>=0.10

Table 19: Peripheral countries – Stationarity for banking risk

Sovereign Risk

Null hypothesis: Unit root		
Statistic	**t-stat**	**p-value**
CIPS:	-3.05051	<0.01
Truncated CIPS:	-3.05051	<0.01

Table 20: Peripheral countries – Stationarity for banking risk

We cannot reject the null hypothesis for banking risk, but reject it for sovereign risk. Banking risk is non-stationary in nature, and has a trend component in its values across time. The sovereign risk, as it is stationary, has a stable mean with a stable variance and no patterns. Cointegration between the two variables can be ruled out, but the tests are carried out for the purposes of robustness.

5.2.4 Panel cointegration test

Null Hypothesis: No cointegration		
Trend assumption: No deterministic trend		
Statistic	**t-Statistic**	**Prob.**
ADF	-0.121351	0.4517

Table 21: Peripheral countries – Cointegration

The null hypothesis, stating that there is no cointegration, cannot be reliably rejected. Hence, we conclude that there does not exist a long-run cointegrating relationship between the sovereign risk and banking risk in peripheral countries as well.

5.1.5 Optimal number of lags

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-558.1197	NA	4.505361	7.181022	7.220122	7.196903
1	-117.5610	864.1729	0.016712	1.584115	1.701417	1.631758

2	-94.61772	44.41577*	0.013109*	1.341253*	1.536756*	1.420658*
3	-92.34790	4.335936	0.013404	1.363435	1.637140	1.474602

Table 22: Peripheral countries – Optimal number of lags

The information criteria agree on 2 being the optimal number of lags to be included in the regression model.

5.2.6 Regression equations

Dependent Variable: BANKING_RISK_INDEX **Total panel (balanced) observations: 160**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BANKING_RISK_INDEX(-1)	0.880016	0.079982	11.00274	0.0000
BANKING_RISK_INDEX(-2)	0.076906	0.078428	0.980593	0.3284
SOVEREIGN_RISK(-1)	0.109380	0.044915	2.435242	0.0160
SOVEREIGN_RISK(-2)	-0.096035	0.043871	-2.189017	0.0301
C	-0.131092	0.035101	-3.734654	0.0003

Table 23: Peripheral countries – Regression: Sovereign risk → Bank risk

Same as in the core countries, the dependent variable is the banking risk index, and the independent variables are the 2 lags for both sovereign and banking risk. The preceding lag for sovereign risk is statistically significant and increases the banking risk, but this is reversed at lag 2. This suggests that there exists a short-lived transmission of risk. The net impact of sovereign risk on banking risk is slightly positive in 2 periods. The model points towards the existence of a sovereign-to-bank risk transmission channel within peripheral countries.

Dependent Variable: SOVEREIGN_RISK **Total panel (balanced) observations: 160**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BANKING_RISK_INDEX(-1)	-0.060276	0.132670	-0.454327	0.6502
BANKING_RISK_INDEX(-2)	0.098615	0.130094	0.758032	0.4496
SOVEREIGN_RISK(-1)	1.275091	0.074504	17.11439	0.0000
SOVEREIGN_RISK(-2)	-0.369287	0.072772	-5.074572	0.0000
C	0.099920	0.058225	1.716096	0.0882

Table 24: Peripheral countries – Regression: Bank risk → Sovereign risk

The dependent variable is the sovereign risk, with 2 lags of each of the banking risk and sovereign risk being the independent variables. The sovereign risk is heavily autocorrelated,

determining its own path. Banking risk has no effect on the sovereign risk even after accounting for 2 lags, so the bank-to-sovereign part of the doom-loop remains entirely absent. It is a possibility that the implementation of policies and institutions may have severed this channel.

5.2.7 Dynamic Granger-causality

Pairwise Dumitrescu Hurlin Panel Causality Tests **Lags: 2**			
Null Hypothesis:	**W-Stat.**	**Zbar-Stat.**	**Prob.**
SOVEREIGN_RISK does not homogeneously cause BANKING_RISK_INDEX	3.68951	1.39162	0.1640
BANKING_RISK_INDEX does not homogeneously cause SOVEREIGN_RISK	3.20705	0.96351	0.3353

Table 25: Peripheral countries – Panel Granger causality

The null hypotheses cannot be rejected, and it can be concluded that neither risk Granger-causes the other in peripheral countries. This is in contradiction with the results from Table 23, where sovereign risk was statistically significant in determining banking risk. This might be because the coefficients of the two significant lags for sovereign risk (0.1093 and -0.096) almost cancel each other out, causing the method to find no Granger causality. However, the result is consistent with Table 24, stating that banking risk does not homogeneously cause sovereign risk in peripheral countries.

Chapter 6: Discussion

6.1 Core countries - An absence of doom-loop

The results are unambiguous in nature for the core countries– neither the panel VAR regressions nor the Granger-causality tests can detect statistically significant risk transmission in either direction. All the relevant coefficients are statistically insignificant, and the Granger causality null hypotheses are comfortably rejected at 5% significance levels. This finding remains consistent with what we know about the structure of these core-EU economies. They entered 2015 with better capital positions, higher amounts of liquid assets, and lower NPL burdens when compared to their peripheral counterparts. The CET-1 ratios were always comfortable above the Basel – III regulatory minimum. This would insulate their bank balance sheets from exposure to the sovereign-to-bank risk transmission channel. The bank-to-sovereign remains equally absent as well. Implementation of the Bank Recovery and Resolution Directive (BRRD) and other entities made sure that failing banks are handled appropriately, and that the burden of bailing them out does not fall upon the taxpayer. This would be crucial in severing the link that transmitted risk from the banking system to the sovereign.

6.2 Peripheral countries – An asymmetric transmission

Here, the Granger causality still failed to detect causation in either direction at a significant level. However, the regression equation told a different story. Inside the sovereign-to-bank regression, SOVEREIGN_RISK(-1) is statistically significant and positive, while SOVEREIGN_RISK(-2) is significant and negative. This implied that the sovereign-to-bank transmission would partially reverse itself within two quarters. It can be theorised that the initial negative shock is somewhat absorbed by the supervisory response and the ECB's liquidity provision, and starts returning towards its equilibrium level. The net cumulative effect would remain small yet positive.

The bank-to-sovereign direction is completely absent in peripheral countries as well. Both lags of the banking risk are statistically insignificant, and this is further confirmed by the Granger causality test. There exists an asymmetry, suggesting that the doom-loop was not complete and is insufficient to be a self-reinforcing spiral.

6.3 How does it relate to supervisory frameworks?

The results point towards the supervisory frameworks being effective in making the banking system more resilient in both core and peripheral countries, and weakening the risk transmission channels. The member countries improving their CET-1 ratios and reducing their NPLs could be the primary levers for reducing this interconnection between the sovereign and the bank. The one-way transmission in the periphery suggests that such stringent measures should not be relaxed. As these sovereign bonds carry a zero-risk weight (not caring about asset quality), it means that banks don't have to shore up additional capital for them. This incentivises and sustains the sovereign-to-bank channel. This could be mitigated by introducing a non-zero risk weighting to EU sovereign bonds.

Chapter 7: Conclusion

7.1 Summary of Findings

The aim of the thesis was to find out whether there existed a sovereign-bank doom-loop in European countries from 2015 to 2025. This was done through the use of a panel VAR with fixed effects model, and combined with Dumitrescu-Hurlin panel Granger causality tests for four core countries (Belgium, France, Germany, and the Netherlands) and four peripheral countries (Greece, Italy, Portugal, and Spain). The study did not find concrete evidence of a fully bidirectional doom-loop in either core or peripheral groups during the specified time period.

There were three hypotheses proposed in the methodology. H_0 predicted that there would be no significant bidirectional risk transmission amongst the core countries. H_1 predicted that there would be significant bidirectional risk transmission amongst the peripheral countries. H_2 predicted that the bidirectional feedback would be stronger in the peripheral countries when compared to their core counterparts.

H_0 is supported fully as risk transmission cannot be detected in either direction in core countries, using both regression and Granger-causality. H_1 is fully rejected as there exists a one-way transmission of risk (from sovereign to bank) inside the regression, but this does not extend to the Granger-causality framework. The bank to sovereign transmission channel is entirely missing, hence creating an incomplete looping mechanism. H_2 is partially supported since peripheral EU countries do show more evidence of risk transmission between the bank and the sovereign. However, it is not bidirectional.

7.2 Limitations

The study contains several limitations that need to be acknowledged when interpreting the econometric findings. The most integral limitation is one of the panel VAR framework as it struggles to differentiate between a doom-loop not happening because of the ECB's policies, or one not occurring because it was eliminated structurally. The estimation will show identical numbers in either case. Distinguishing the effect of ECB policies on the doom-loop would require the intervention to be modelled endogenously.

The sample is limited to only four countries per group, as there are still countries that do not cleanly fit into either the 'core' or the 'peripheral' groups. The limited cross-section constraints the statistical power of the Dumitrescu-Hurlin test.

The PCA index representing the banking risk solely relies on data gathered from the supervisory bodies. These datapoints are reported on an infrequent basis, and are thus ineffective at capturing high-frequency distress episodes in the banking sector. If there is a doom-loop/contagion operating at a weekly/monthly level, this model is incapable of detecting it.

The PVAR framework also assumes parameter stability across the entire sample period (2015-2025). There have been multiple financial 'anomalies' within the period, such as quantitative easing by the ECB (2015-2021), COVID (2020), and the interest rates hiking sharply (2022 onwards). It is likely that the doom-loop mechanism fluctuates across these periods, and reducing it to a single estimate can cover up nuances during these sub-periods.

7.3 Further research to be done

The topic can be explored in several directions for future research. The most obvious extension would be a temporal comparison between the pre-2015 EU, and post-2015 EU while using the same econometric methodology. In case there exists a significant bidirectional risk transmission in the peripheral countries pre-2015, that disappears post-2015, it would point towards the SSM and SRM and similar 'reforms' working well.

Another possible extension could be the use of higher frequency datasets to represent the banking risk. Having a daily or weekly variable that proxies the variable risk could help detect contagion at faster intervals. ECB's intervention could also be modelled endogenously within the study by using variables such as PSPP purchase volumes.

7.4 Closing remarks

The sovereign-banking nexus was at the core of the financial stability threat that was the Eurozone crisis. Multiple reformative measures – creation of the SSM, SRM, BRRD, ESM – were put in place to help break this feedback mechanism that almost dissolved the Eurozone in 2012. The study's findings demonstrate that during the 2015-2025 period, such reforms helped mitigate the doom-loop. No self-reinforcing cycle could be detected in either core or peripheral European countries.

However, this does not mean that financial and governmental bodies can grow complacent. The positive outcomes of these reforms are dependent on their continued successful operation. Detecting a risk transmission that is only one-way instead of being bidirectional, points towards the doom-loop having only been weakened and not completely removed. It is imperative to maintain financial stability in the region, and efficient policy-making and institutional design is a good step in that direction.

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