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Sovereign portfolio composition and bank risk: The case of European banks☆

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ABSTRACT

We extend the literature on the sovereign-bank nexus by examining the composition effects of sovereign portfolios on banks' risk profile, unlike previous studies which generally analyzed the determinants of banks' sovereign portfolios or the size effects of these portfolios. We also differ from previous studies with respect to the measures of risk considered and by covering a sample period that goes well beyond the Global Financial Crisis (2009–2018). Drawing on granular data from the European Banking Authority, we find that banks are riskier when their portfolio includes a higher proportion of securities that are issued by higher risk sovereigns or when they are themselves domiciled in a country with high sovereign credit risk. But we do not find concluding evidence that larger holdings of government securities of the country where the bank is incorporated increase bank risk *ex-post*. However, the risk profile is higher for banks that received government capital injections than for banks that did not receive capital support in the aftermath of the Global Financial Crisis. Banks that received government capital injections are less risky when their portfolio includes a higher proportion of securities that are issued by higher risk sovereigns. These results may indicate that regulatory arbitrage motives at these banks are particularly important.

1. Introduction

The global financial crisis brought to the forefront risks from sovereign-bank linkages, particularly in the European Union because banks held sovereign debt as part of their portfolio of securities. More than ten years later, banks still carry a significant amount of sovereign debt on their balance sheets.

Banks are vulnerable to episodes of sovereign distress by virtue of being important players in sovereign debt markets, holding on average approximately 1/3 of outstanding public debt in advanced economies and 45 per cent in emerging economies (Arslanap and Tsuda, 2014). But their sovereign portfolio is only one of several interacting channels in the sovereign-bank nexus, all of which operate simultaneously. These other channels include governments' financial safety net for banks and corporates (e.g. government bail-outs) as well as the macro-financial linkages resulting from the impact of the economic activity on the health of banks and non-financial firms (Podstawsk and Velinov, 2018; DellAriccia et al., 2018; Kirschennman et al., 2020).

This paper belongs to the extant literature on the management of the sovereign-bank nexus. Whether most papers have analyzed the determinants of sovereign portfolios of banks (De Marco and Macchiavelli, 2016; Ongena et al., 2016; Dreschsler et al., 2016; Altavilla et al., 2017), others have focused on the size effects of sovereign portfolios (Acharya and Steffen, 2015; Brůha and Kocěnda, 2018; DellAriccia et all. 2018; Bhöm and Eichler, 2020). We extend the latter strand of the literature by presenting evidence on the composition effects of sovereign portfolios on banks´ risk profile, which is a novelty in this paper. We are particularly interested in how the type of sovereign portfolios may affect banks' risk-taking behavior.

Our methods differ from previous studies with respect to the sample

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and period coverage, as well as the measures of risk considered. We use a large sample of banks incorporated in the euro area and the non-euro European Union (EU) countries plus Norway and Iceland, providing a more comprehensive picture about the importance of sovereign portfolio composition on bank risk. We also cover a ten-year period post Global Financial Crisis (2009–2018), which marked the return of distressed European sovereigns to the market, in contrast to previous studies that are generally limited to the global financial crisis period. Further, we use accounting measures of overall bank risk that are standard in the literature: the standard deviation of return on average assets (ROAA) and the Z- Score. We choose accounting measures of risk instead of market risk because the majority of banks in the EU, as is the case in our sample, are not publicly listed companies.[1] This choice allows us to capture a larger and more representative sample of banks compared with other related studies that use market measures of risk. Another advantage to using accounting measures of risk is that, during stress episodes, these indicators are less volatile and noisy than market measures of risk, as the latter might reflect information that is due to speculation by agents rather than to changes in bank risk per se. Indeed, market-based information about bank health could well embody investors' perception of sovereign risk, which is hard to disentangle from the banks' idiosyncratic risk-taking behavior. By using accounting measures of bank risk, our analysis complements research that employed market-based indicators of bank health, thereby helping provide a more comprehensive assessment of banks' risk profile ensuing from their holdings of sovereign bonds.

Our results indicate that banks are riskier when their portfolio includes a higher proportion of securities issued by more distressed sovereigns, or when they are themselves domiciled in a country with high sovereign credit risk. But we do not find concluding evidence that larger domestic holdings of government securities increase bank risk *ex-post*. However, our results indicate that the risk profile of banks that received government capital injections is higher than for banks that did not receive capital support in the aftermath of the great financial crisis. These banks are less risky when their portfolio includes a higher proportion of securities issued by more distressed sovereigns. These findings may indicate that regulatory arbitrage motives at these banks are especially important.

The rest of this paper is divided into five sections. Section 2 presents the relevant literature and Section 3 describes our data and variables included in the regression. Section 4 discusses the empirical approach and Section 5 analyses the regression results. The last section concludes and makes some policy considerations.

2. Relevant economic literature

The sovereign-bank nexus has received considerable attention in the financial literature. Since a deterioration of sovereign creditworthiness adversely impacts banks through their holdings of sovereign debt (BIS, 2011), a large body of research has investigated the determinants of banks' sovereign debt portfolios.

In this section, we develop the paper's hypotheses based on the extant literature on the sovereign-bank nexus. Our review of the literature focuses on the effect of sovereign credit risk ratings and the size of sovereign portfolios on different market-based measures of bank risk. We are not aware of studies that have investigated the composition effects of sovereign portfolios, which is the focus of our paper.

Most relevant to our paper is the sovereign-bank nexus literature that focuses on how the deterioration of sovereign creditworthiness acts as a bank risk amplifier. Previous studies have used a market measure of financial risk to that end. For example, Angeloni and Wolff (2012) analyze the link between holdings of sovereign debt and banks' stock market values, finding that investing in Italian, Irish and Greek debt had material adverse effect on banks' market value in 2011. Hence, we would expect large exposures to crisis sovereigns to increase bank risk (see Hypothesis 1 in Table 1). In their study of the euro area banking crisis, Acharya and Steffen (2015) analyze three channels through which banks' carry trade behavior can be explained: regulatory capital arbitrage and risk shifting by undercapitalized banks, home bias of peripheral banks, and suasion by domestic sovereigns for banks to maintain asset exposures. Using market-based measures of risk for EU banks (including daily stock returns), as well as sovereign credit default swaps (CDS) spreads and 10-year government bond yields that extend from March 2010 to June 2012, they find support for risk-shifting behavior and regulatory arbitrage motives at these banks: when sovereign yields rise, carry trade prevails and banks increase their holdings of sovereign debt. Dell'Ariccia et al. (2018) also find support for bank risk-shifting behavior. Using a sample of unconsolidated monthly data of euro area banks from the ECB, the authors report that the increase in exposure to domestic sovereigns in bank balance sheets took place against a backdrop of sovereign distress in some countries (March 2010 to December 2013). If such risk shifting exists via regulatory arbitrage, we should observe higher ex-post bank risk. Previously, Battistini et al. (2014) documented that most euro area banks respond to the common risk component of CDS spreads by raising their domestic exposures to sovereigns.[2] Hence, we would expect that banks located in high-risk sovereign countries and exposed to their own sovereign would be riskier (see Hypothesis 2 in Table 1).

Another strand of the sovereign-bank nexus literature focuses on the feedback loop from bank risk to the deterioration of sovereign creditworthiness. Using CDS spreads as the measure of sovereign risk in the EU during 1999–2014, Brůha and Kočenda (2018) find that bank characteristics (such as loan portfolio quality, capital adequacy, and size) matter for sovereign risk. Podstawsk and Velinov (2018) analyze the impact of exogenous changes in bank exposure on the risk positions of the sovereigns and conclude that rising bank exposures increase default risk for EMU periphery, but they decrease credit risk for the core EMU countries. This effect is particularly pronounced during phases of financial turmoil, and it supports their hypothesis that bank exposure to the sovereign is a key ingredient in the diabolic sovereign-bank loop mechanism. More recently, Bhöm and Eichler (2020) find a statistically

Table 1
Hypothesized effect of sovereign portfolio composition on banks' risk and links to the literature.

Composition Type of the Sovereign Portfolio	Hypothesis	Expected Sign on Bank Risk	Financial Literature
Larger share of sovereign securities of euro area countries in crisis.	Hypothesis 1	(+)	Angeloni and Wolff (2012) Dell'Ariccia et al. (2018)
Larger shares of domestic holdings of sovereign securities in crisis countries.	Hypothesis 2	(+)	Battistini et al. (2014) Acharya and Steffen (2015)
Larger exposure of bailed-out banks to sovereigns in crisis.	Hypothesis 3	(+)	De Marco and Macchiavelli (2016) Acharya and Steffen (2015)

[1] In our sample of EU banks, less than 3 % are publicly listed.

[2] The authors decompose CDS spreads in a country specific and a common risk component via a dynamic factor model.

and economically significant effect of instrumented banking sector distress on sovereign distress for nine Eurozone countries in the period 1999–2016. These authors conclude that banking sector distress was therefore a major cause of deteriorating sovereign creditworthiness during the crisis and not just a by-product or a correlation.

Relevant to our paper is the strand of literature that focuses on the economic rationale of the sovereign bail-out bank nexus. Acharya and Steffen (2015) provide evidence that bailed-out EU banks increase their domestic sovereign debt holdings significantly, which, in turn, increases their risk profile. De Marco and Macchiavelli (2016) have found that euro area banks with significant government ownership or politically appointed directors feature more home-biased sovereign portfolios than privately owned banks through the 2010–2013 period. If government ownership is the result of a bail-out in crisis countries, we would expect bailed-out banks' exposure to home-biased sovereign portfolios to increase banks' ex-post risk in crisis countries (see Hypothesis 3 in Table 1).

Although not directly related to our research, yet another strand of the literature focuses on the economic rationale of the sovereign-bank nexus. Banks' holdings of sovereign debt portfolios are mostly the result of economic developments rather than carry-trade or risk-shifting strategies by those institutions. Castro and Mencía (2014) defend the view that macroeconomic factors play a central role in explaining the link between sovereign debt and bank balance sheets rather than banks engaging in carry-trade strategies, particularly in times of stress. A similar conclusion is reached by Lamas and Mencia (2018) using granular data on Spanish banks. The authors additionally observe that financial fragmentation at the peak of the sovereign debt crisis explains increased holdings of the Spanish sovereign debt by domestic banks. Their findings are in line with Angelini et al. (2014) who analyze the different channels through which sovereign risk affects bank risk, concluding that the expansion of banks' sovereign holdings is a consequence, not a cause, of the sovereign debt crisis. The authors find that the correlation between the CDS premia of sovereigns and banks is not stronger than the association between sovereigns and domestic non-financial corporations, both before and after June 2011—around the peak of the European debt crisis. Their findings suggest that the self-reinforcing negative spiral involving sovereign difficulties, bank fragility, and economic recession has a key underlying factor which is country risk.

3. Variables and data description

3.1. Variables description

3.1.1. Bank financial variables

All bank accounting variables are sourced from Fitch over the study period 2009–2018. We use banks' consolidated statements and, only where not available, unconsolidated statements. We give priority to financial statements that are reported according to the International Financial Reporting Standards (IFRS), considering statements prepared in line with Generally Accepted Accounting Principles (GAAP) only when IFRS financials are not available. Regardless of the consolidation level and reporting standard, we are consistent in the use of financial data for each bank, i.e., using the same reporting standards and consolidation status throughout the study period.

3.1.2. Bank risk measures

Our two proxies of ex-post risk are the standard deviation of ROAA and the Z–score. ROAA is an indicator of bank profitability measured by net income generated from average total assets of the bank, with the latter calculated as the arithmetic mean of total assets at the end of the current year and the one preceding it. More precisely, for each bank-year observation, the standard deviation of ROAA is time varying, calculated over a rolling 3-year window (*3yr rolling ROAA-SD*), i.e., over (t-1, t, t + 1). The realized volatility of returns is an ex-post measure of bank risk and a noisy measure of the ex-ante risk. Although profits can be subject to number of discretionary accounting practices, high profit volatility can be interpreted as a source of instability and risk for the bank (Carbó-Valverde et al., 2013). While imperfect due to the limited number of data points to compute volatility, *3yr rolling ROAA-SD* shows some significant variation across banks.

Our second proxy of ex-post bank risk, the *Z–score*, is calculated for each bank-year pair as the ratio of the sum of current period ROAA and equity to total assets to the standard deviation of ROAA. The *Z-score* is widely used in the literature to proxy for the distance-to-default probability, as it measures the number of standard deviations that bank returns may drop to before bank capital is depleted (Berger et al., 2009).[3] Despite being a widely used indicator, the Z-score could fall short of being a good measure of distance-to-default, particularly for listed institutions where asset value and profitability may show larger variations and can be related to unspecified market and industry features (Carbó-Valverde et al., 2013).

3.1.3. Exposure to sovereigns

To capture the composition effect of banks' sovereign portfolios on balance sheet risk outcomes, we use sovereign exposure data provided by the European Banking Authority. The data are detailed at the bank-sovereign level, allowing us to identify sovereign holdings on the bank's balance sheet at year end.[4] In particular, we are interested in the risk impact of holding higher exposures to euro area crisis (*C*) countries, which we define as the group of Cyprus, Greece, Ireland, Italy, Malta, Portugal and Spain, in our study as the ratings of those sovereigns were downgraded below AA after the onset of the sovereign debt crisis (see footnote 3 in Dreschsler et al., 2016). This group of crisis (*C*) countries remains constant over our study period, though banks' exposures to these countries varies over time. We consider two variants of the first ratio—sovereign exposures to the crisis countries in the euro area (EA)—normalized by the total portfolio of euro area (*Exposure_C_EA*) and European Union (EU) (*Exposure_C_EU*) sovereign exposures.

The second ratio looks at the share of the bank's own country (*O*) sovereign exposure—which we define as the sovereign where the bank is legally incorporated—again normalized by the total portfolio of euro area (*Exposure_O_EA*) and EU (*Exposure_O_EU*) sovereign exposures.

3.1.4. Macroeconomic variables

To capture country-specific macroeconomic developments that may impact sovereign portfolio composition (as demonstrated in the previous literature), we control for the annual real GDP growth rate from year 't-1′ to 't′ (GDP %) for the country where a bank is legally incorporated. We source the data from the International Monetary Fund, World

[3] Hesse and Čihák (2007) and Lepetit and Strobel (2013) find that using mean and standard deviation estimates of the return on assets that are calculated over the full sample/study period and combining these with current values of the capital-asset ratio, is a straightforward measure to assess individual bank insolvency risk and financial stability more broadly. Furthermore, this measure displays a fairly low level of intertemporal volatility at the bank level for all G20 countries, stressing the importance of avoiding the introduction of potentially "spurious" volatility in construction of such time-varying bank insolvency risk measures more generally.

[4] The Basel risk-weighted capital framework prescribes minimum capital requirements for sovereign exposures related to the underlying risk. However, at national discretion, a lower weight may be applied to domestic sovereign debt, provided it is denominated and funded in domestic currency. (see International Convergence of Capital Measurement and Capital Standards: A revised Framework Comprehensive Version" Basel Committee of Banking Supervision, June 2006 https://www.bis.org/publ/bcbs128.pdf). This discretion was widely applied including in the EU and the euro area. The International Convergence of Capital Measurement and Capital Standards provided for a transitional period, to be phased out in 2020, during which a zero -risk weight is applied to sovereign exposures denominated and funded in the currency of any member state.

Table 2
Number of banks per country.

Country	Number of Banks
Austria	10
Belgium	8
Bulgaria	1
Cyprus	4
Denmark	5
Estonia	1
Finland	2
France	11
Germany	26
Greece	5
Hungary	1
Iceland	3
Ireland	7
Italy	14
Latvia	1
Luxembourg	3
Malta	2
Netherlands	8
Norway	1
Poland	6
Portugal	6
Slovenia	4
Spain	17
Sweden	5
United Kingdom	5
Total banks	***156***

Economic Outlook Database, April 2020.

3.1.5. Dummy variables

As the literature has documented the importance of sovereign developments on bank risk, we distinguish between high- and low-risk sovereign environments where the bank is legally incorporated. We first collect information on the monthly CDS for European countries from Thompson Reuters and calculate their annual average. Quoted in USD, a CDS price is the cost to either buy or sell sovereign exposures, considering the possibility of a sovereign defaulting or restructuring its debt. Next, for each year, we calculate the median CDS price for each of the EA and the EU samples (see Section 3.2), splitting them at the relevant median.[5] The resulting CDS dummy variables (*CDS* > *Median*) for each of the EA and EU samples are, for each year, set to one if the CDS price of the country where the bank operates falls above the median of each sample, and zero otherwise. Whereas the CDS for some countries in our sample (e.g., Bulgaria, Cyprus, Greece, Hungary) are always higher than the median, other countries never register CDS spreads above the median in a given year (e.g., Norway, Sweden) whereas other countries may be riskier than the median in some years but not across the entire sample period (e.g., Spain, Ireland).[6]

The CDS dummy allows us to gauge the relative riskiness of countries in which the banks are incorporated, which are not necessarily crisis countries. We treat countries whose CDS are above the median as riskier sovereigns than other countries in the sample.[7] While the EA CDS median is on average lower than that of the total sample median over the entire study period, it is higher than that of the EU during the EA sovereign crisis and its immediate aftermath (2011–2014).

Finally, we account for two additional bank- and banking sector-specific factors as they could signal access to higher amounts of liquidity, which could impact the composition of the sovereign portfolio. First, using BIS data, we include a dummy variable (*GovtCap*) that equals one if a bank received a capital injection during or after the financial crisis and zero otherwise. We also complete the analysis by controlling for short-term lending facilities extended by central banks as a part of their unconventional monetary policies with a dummy, as they could potentially impact banks' sovereign portfolio holdings. These facilities include short term loans in Sweden, long-term refinancing operations (LTROs) in euro area countries, and facilities shorter than 18 months in the UK, all of which were in place for the entire duration of a calendar year in the countries in our sample.

3.2. Data description

Our sample consists of 156 banks incorporated in the EU countries, including the euro area, as well as non-EU countries such as Norway and Iceland.[8] Table 2 shows the number of banks per country over our study period. 129 banks are in the EA and 27 institutions are non-euro area banks. For the purpose of the regression analysis, we focus on the full sample (referred to *Total Sample* and including all EU countries and Norway and Iceland as members of the European Economic Area) and the euro area subsample of banks (*Euro Area*). All major bank institutions are considered. The coverage in terms of total assets (TA) varies from year to year but it is approximately 80 % of TA of the EU banking system as reported by the EBA.

We focus on banks for which sovereign exposure information is available, resulting in an unbalanced panel dataset of approximately 1000 bank-year observations. This extended coverage of banks' sovereign exposures sets our dataset apart from other empirical research. However, it comes at a cost of relatively fewer number of bank observations that report sovereign exposures over the study period. As such, we refrain from using bank-year level interacted controls in our regressions.

Table 3 Panel A presents summary statistics for all variables used in our empirical analysis. Without being an entirely reliable guide to multicollinearity, the correlations do not show extremely high correlations among the variables, as no correlation between any of the right-hand side variable with our measures of risk exceeds 0.39. Panel B presents medians of our groups of banks (crisis vs non crisis; euro vs non euro).

Over our study period, on a cumulative basis, the largest volume of holdings of sovereign portfolios of the EA countries are held by banks in the EA (Fig. 1). Outside the EA, only the UK banks hold a significant amount of EA sovereign securities in their portfolios, which is nearly equal to non-euro area sovereign exposures. Also, it is worth noting that most banking systems are focused on holdings of domestic sovereigns, concentrating sovereign-banking system linkages and risks within countries (Fig. 2).[9] Holdings of sovereign portfolios of the euro area crisis countries are concentrated in banks in the euro area, with Spain and Italy holding the largest volumes over the study period (Figs. 3 and 4). Fig. 5 shows the different patterns of crisis and non-crisis euro area banks' holdings of government securities over time.[10] During our study

[5] In the remainder of the paper, we use the acronym EU to refer to the total sample which is the EU augmented with Norway and Iceland.

[6] We underscore that the variable *CDS* > *Median* is different from the share of sovereign exposures to the euro crisis countries in the EA or the EU. For example, the riskiness of some important banks in the United Kingdom or the Netherlands increased significantly during the financial crisis despite being located in countries where the CDS were consistently below the median for all years during the sample period.

[7] Since Luxembourg does not have a CDS value associated with its sovereign securities, for the purpose of our analysis, we assign an epsilon value to it to classify it as below the median in both cases, considering that the country was not subject to sovereign debt distress

[8] Due to sovereign exposure data availability from the European Banking Authority, our final sample does not have banks from Croatia, Czech Republic, Lithuania, Romania, and Slovakia. As such, data from these countries are not included in the calculation of EU and EA CDS medians.

[9] Along similar lines, see Figure B.1 of the IMF GFSR, April, 2019, which shows that most banking systems are focused on holdings of domestic sovereigns.

[10] Data are from Fitch.

Table 3

Panel A. Summary statistics of total sample.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	N	mean	sd	median	min	max	p5	p95
CDS	240	516	3001	113	18	29083	31	620
GDPgrowth	250	1.39	3.69	1.84	-14.43	25.12	-5.11	6.19
Z-score	1369	41.10	106.17	18.14	-4.40	1338.26	1.50	112.30
sd(ROAA)	1257	0.65	1.15	0.22	0	11.30	0.02	2.97
Total Assets	1403	11.40	1.62	11.30	5.17	14.90	8.60	14.24
Exposure_C_EA	1403	0.09	0.25	0	0	1	0	0.96
Exposure_O_EA	1403	0.82	10.62	0	0	328.50	0	0.97
Exposure_C_EU	1403	0.08	0.24	0	0	1	0	0.93
Exposure_O_EU	1403	0.17	0.75	0	0	20.81	0	0.95
Lending Facility	1403	0.24	0.43	0	0	1	0	1
GovtCap	1403	0.03	0.16	0	0	1	0	0
Crisis	1403	0.32	0.47	0	0	1	0	1

Panel B. Medians, euro area (EA) vs non-euro area (non-EA) and EA crisis vs EA non-crisis

	Non-EA	**EA**	Non-Crisis EA	Crisis EA
SD ROAA	0.4	0.3	0.2	0.8
SD ROAA 3-yr rolling	0.2	0.3	0.1	0.7
SD ROAA 5-yr rolling	0.2	0.3	0.2	0.8
Z-Score	20.4	17.6	25.1	8.4
Z-score rolling	37.5	27.6	41.4	13.4
Log Assets	11.1	11.3	11.5	11.1
Domestic exposures / Equity	0.1	0.2	0.1	0.3
Total exposures / Equity	0.2	0.4	0.4	0.4
Equity / TA	6.8	5.8	4.9	6.6
NII / TA	1.5	1.3	1.1	1.5
ROAA	0.5	0.1	0.3	-0.3
Loans / Deposits	114.1	95.6	90.5	100.8

Note: sd(ROAA) refers to the three year rolling standard deviation of ROAA. Total assets refer to natural logarithmic of the total assets of the bank. Lending facility, government capitalization and crisis are dummy variables. The high values in the share of own exposure relative to European sovereigns belong to a few number of countries; largest Exposure_O_EA belongs to Denmark and Sweden; largest Exposure_O_EU correspond to Iceland and Norway.

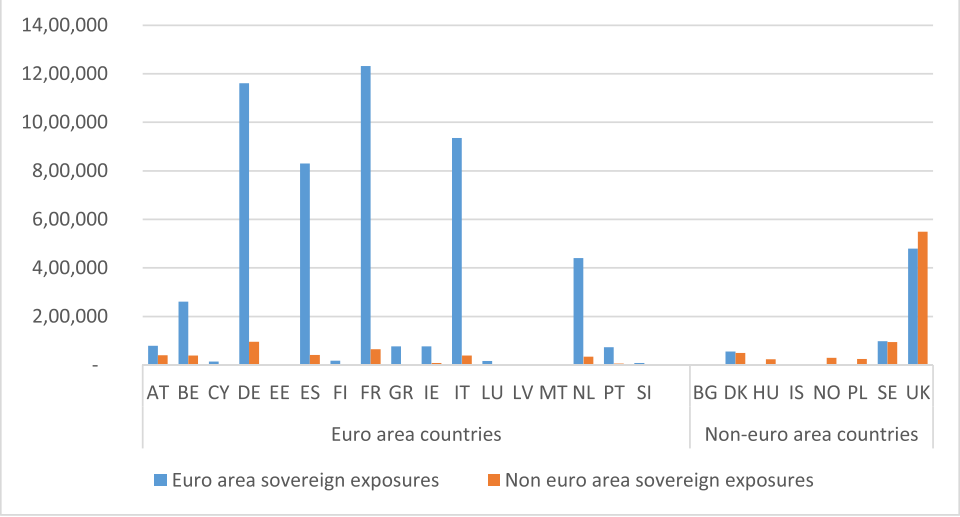

Fig. 1. Accumulated holdings of sovereign exposures to the euro area and non-euro area countries (mln euros).
Source: European Banking Authority.

period, euro area banks´ holdings of government securities over total assets fluctuate between approximately 6 % and 14 % of total assets. From 2008, the largest holdings correspond to banks in crisis countries.

Also relevant to our paper is the classification of sovereign exposures by accounting treatment, which has evolved with changes in accounting principles. Broadly speaking, sovereign exposures can be grouped into portfolios whose accounting valuation is sensitive to changes in bond pricing (trading and available for sale portfolios –AFS–),[11] and those that are insensitive to bond price changes (held to maturity).[12] As reflected in Figure B.1 of the IMF GFSR, April, 2019, , Italy, Portugal and

[11] Book values respond to changes in underlying prices that reflect either changes in the broad interest rate environment or changes in the riskiness of specific bonds.

[12] The balance sheet values of bonds in 'held to maturity' accounts do not respond to changes in the yield on those instruments.

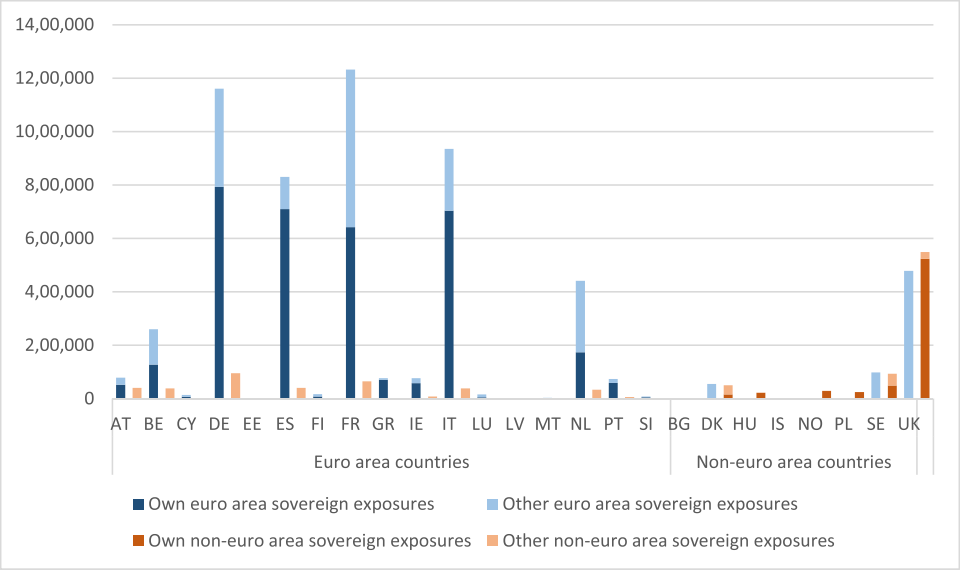

Fig. 2. Banks' exposure to own country sovereign: Accumulated holdings of banks in the euro area countries and non-euro area countries (mln euros).
Source: European Banking Authority.

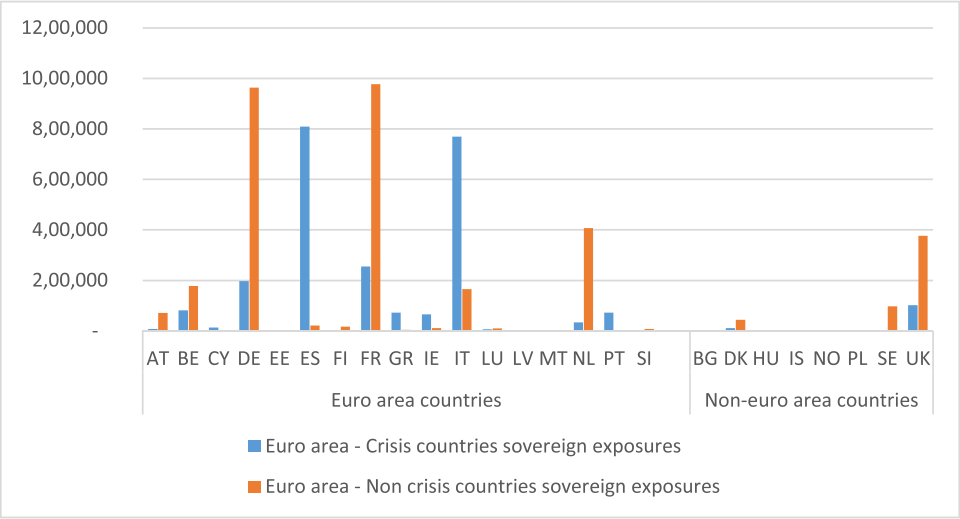

Fig. 3. Accumulated holdings of euro area sovereign exposures to crisis and non-crisis countries: Banks in the euro area vs banks in the non-euro area countries (mln euros).
Source: European Banking Authority.

Ireland and to lesser degree Spain have a higher percentage of sovereign exposures booked in price sensitive asset categories. Since changes in prices of the AFS portfolio are reflected in the bank's own funds (unlike the trading portfolio whose price changes are recognized through the Profit and Loss –P&L–), the revaluation of such a portfolio of sovereign securities will not translate into variability of net income of the P&L.

4. Empirical approach

We test the hypotheses shown in Table 1 using four baseline regressions over the study period 2009–2018 for the *Total Sample* (EU countries including Norway and Iceland) and for the *Euro Area Sample* (smaller subset of EA countries). The dependent variable in all regressions is ex-post risk measured for bank i at time t as either the standard deviation of ROAA σ_{it} or the Z–score as defined in Section 3.

In all regressions, we include an indicator for government capitalization $GovtCap_i$ and real GDP growth rate of banks' countries of operation at time t, as well as the natural logarithmic function of total assets lagged by one year to condition the estimation on the initial asset size of the bank, as bank size could have an impact on the sovereign portfolio. In our specifications, the estimated parameters are α and β_i; τ_t denotes time fixed effects; and the error term is ε_{it}..

Our four main regressions are grouped by two potential risk factors: the country-level time-varying proxy of high sovereign risk $(CDS > Median)_t$ and the bank-level government capitalization indicator $GovtCap_i$. We are interested in the interaction of each of these factors with the share of sovereign exposures, to better understand the implications of sovereign portfolio composition on bank risk under more distressed sovereign and bank conditions, respectively, relative to less-distressed sovereigns and viable banks. All regressions control for the business cycle using real GDP growth as deteriorating macroeconomic conditions result in an increase in doubtful exposures (bad loans),

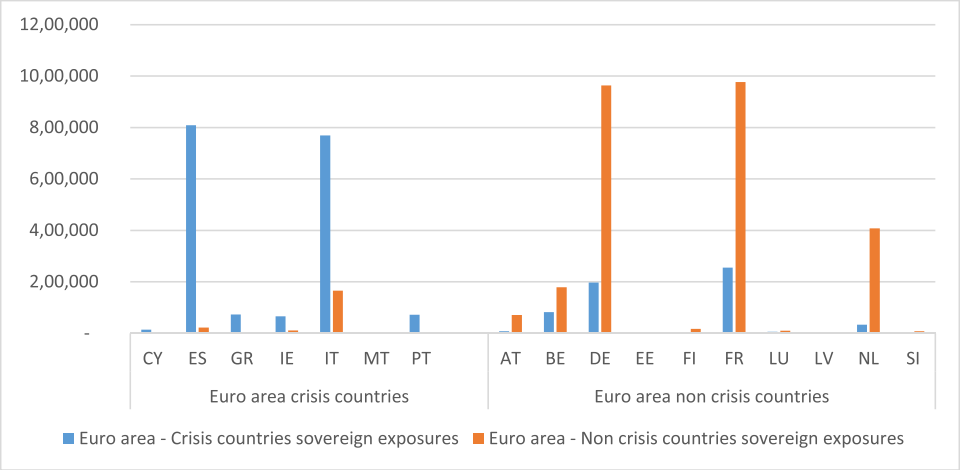

Fig. 4. Accumulated holdings of euro area crisis sovereigns and euro area non-crisis sovereigns: Banks in the euro area crisis countries vs banks in the euro area non-crisis countries (mln euros).
Source: European Banking Authority.

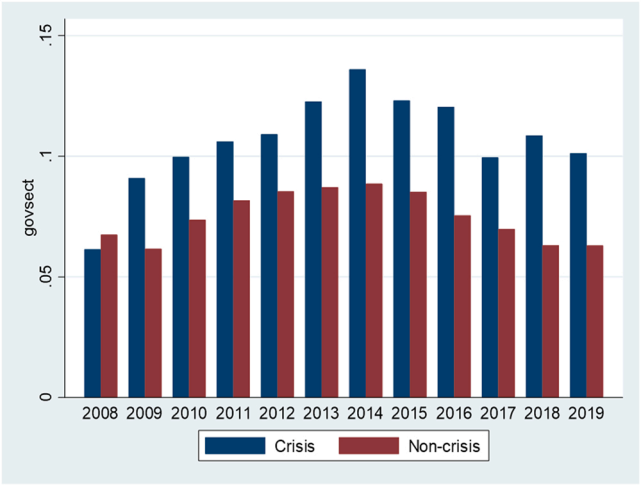

Fig. 5. Banks' holdings of government securities over total assets (2008–2018) (%): euro area banks in crisis countries vs euro area banks in non-crisis countries.
Source: Fitch.

leading to an increase in bank risk.[13]

First Approach using High Sovereign Risk as Potential Risk Factor: Two regressions are estimated under this approach. In the first specification, we include the share of crisis sovereigns' exposures as a proportion of the total euro area sovereign exposures of banks $(Exposure\_C\_EA)_{it}$, the measure of high sovereign risk $(CDS > Median\ EA)_t$ of banks' countries of incorporation, and the interaction of both variables at time *t*.

$$\begin{aligned}\sigma_{it} =& \alpha + \beta_1(Exposure\_C\_EA)_{it} + \beta_2(CDS > MedianEA)_t \\ &+ \beta_3(Exposure\_C\_EA)_{it}(CDS > MedianEA)_t + \beta_4(GovtCap)_i \\ &+ \beta_5(TA)_{it-1} + \beta_6(RealGDP\%)_t + \beta_7(LendingFacility)_t + \tau_t + \varepsilon_{it}\end{aligned} \quad (1)$$

We also estimate a variant of Eq. (1), replacing $(Exposure\_C\_EA)_{it}$ with $(Exposure\_O\_EA)_{it}$, which is the share of the bank's own country sovereign.

In the second specification, we change the reference frame that is considered to calculate the shares of sovereign exposure from the EA to the EU, replacing $(Exposure\_C\_EA)_{it}$ with $(Exposure\_C\_EU)_{it}$ and $(CDS > Median\ EA)_t$ with $(CDS > Median\ EU)_t$ as follows:

$$\begin{aligned}\sigma_{it} =& \alpha + \beta_1(Exposure\_C\_EU)_{it} + \beta_2(CDS > MedianEU)_t \\ &+ \beta_3(Exposure\_C\_EU)_{it}(CDS > MedianEU)_t + \beta_4(GovtCap)_{it} \\ &+ \beta_5(TA)_{it-1} + \beta_6(RealGDP\%)_t + \beta_7(LendingFacility)_t + \tau_t + \varepsilon_{it}\end{aligned} \quad (2)$$

Here again, we estimate a variant of Eq. (2) by replacing $(Exposure\_C\_EU)_{it}$ with $(Exposure\_O\_EU)_{it}$. We are particularly interested in the interaction term in Eqs. (1) and (2), "$(Exposure\_\ C\_EA\ C_EA)_{it}$ $(CDS > Median\ EA)_t$" and "$(Exposure\_C\_EU)_{it}(CDS >\ Median\ EU)_t$", respectively. The parameter estimate of β_3 in each equation conveys the *differential impact* (on bank risk) of carrying a high share of public debt issued by risky sovereigns if the bank is located in a high sovereign risk country, compared with a bank that is headquartered in a low-risk country. This difference-in-difference approach is different from a policy experiment where the sample of banks is split into affected and non-affected, and where a pre-post cut-off date is chosen, which is the approach by Popov and Van Horen (2015).[14]

Second Approach using Government Capitalization as Potential Risk Factor: Here, we replicate Eqs. (1) and (2) by replacing $(CDS > Median)_t$ indicators with $GovtCap_i$. In the third specification, we include the concentration of crisis sovereigns' exposures as a proportion of the total euro area sovereign exposures of banks, as in Eq. (1):

$$\begin{aligned}\sigma_{it} =& \alpha + \beta_1(Exposure\_C\_EA)_{it} + \beta_2(GovtCap)_i + \beta_3(Exposure\_C\_EA)_{it} \\ &(GovtCap)_i + \beta_4(TA)_{it-1} + \beta_5(RealGDP\%)_t + \beta_6(CDS > MedianEA)_t \\ &+ \beta_7(LendingFacility)_t + \tau_t + \varepsilon_{it}\end{aligned} \quad (3)$$

Similar to before, we estimate a variant of Eq. (3) by replacing $(Exposure\_C\_EA)_{it}$ with $(Exposure\_O\_EA)_{it}$.

The last specification is similar to Eq. (3), but where we expand the reference frame for the sovereign exposures from the EA to the EU:

$$\begin{aligned}\sigma_{it} =& \alpha + \beta_1(Exposure\_C\_EU)_{it} + \beta_2(GovtCap)_i + \beta_3(Exposure\_C\_EU)_{it} \\ &(GovtCap)_i + \beta_4(TA)_{it-1} + \beta_5(RealGDP\%)_t + \beta_6(CDS > MedianEA)_t \\ &+ \beta_7(LendingFacility)_t + \tau_t + \varepsilon_{it}\end{aligned} \quad (4)$$

[13] We thank an anonymous referee for making this comment. This paper does not aim to distinguish between the real channel and the sovereign channel in driving bank risk.

[14] This paper does not confront the challenge to identify the causal effect of holding risky sovereign debt on bank risk.

Table 4
Total sample, sovereign risk and sovereign exposures as a share of EA portfolio.

	Panel A						Panel B					
Dependent Variable:	sd(ROAA)						z-score					
	1	2	3	4	5	6	1	2	3	4	5	6
Exposure_C_EA	0.600 * **	0.280 * *	1.080 * **				-21.855 * **	-5.364	-42.473 * *			
	[0.129]	[0.136]	[0.379]				[5.664]	[5.877]	[16.653]			
Exposure_O_EA				-0.001	0	-0.001				-0.061	-0.099	-0.098
				[0.003]	[0.003]	[0.003]				[0.118]	[0.115]	[0.115]
CDS>MedianEA		0.475 * **	0.509 * **		0.525 * **	0.519 * **		-24.234 * **	-25.699 * **		-25.241 * **	-25.194 * **
		[0.071]	[0.072]		[0.066]	[0.067]		[2.950]	[3.008]		[2.774]	[2.793]
Exposure_C_EA * CDS>MedianEA			-0.871 * *						40.280 * *			
			[0.386]						[16.918]			
Exposure_O_EA * CDS>MedianEA						0.022						-0.167
						[0.025]						[1.112]
GovtCap	1.434 * **	1.262 * **	1.289 * **	1.580 * **	1.303 * **	1.300 * **	-17.732 * *	-10.82	-11.085	-18.442 * *	-10.722	-10.724
	[0.434]	[0.426]	[0.426]	[0.436]	[0.427]	[0.427]	[8.722]	[8.547]	[8.532]	[8.769]	[8.546]	[8.549]
TA	-0.232 * **	-0.177 * **	-0.181 * **	-0.224 * **	-0.167 * **	-0.168 * **	2.388 * **	-0.476	-0.309	2.133 * **	-0.633	-0.63
	[0.019]	[0.020]	[0.020]	[0.019]	[0.020]	[0.020]	[0.799]	[0.853]	[0.855]	[0.800]	[0.834]	[0.834]
Real GDP %	-0.134 * **	-0.115 * **	-0.121 * **	-0.141 * **	-0.116 * **	-0.116 * **	0.904	0.039	0.328	1.169 * *	0.068	0.068
	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.596]	[0.591]	[0.602]	[0.596]	[0.590]	[0.591]
Constant	3.220 * **	2.434 * **	2.440 * **	3.262 * **	2.367 * **	2.371 * **	5.625	43.203 * **	43.332 * **	10,507	45.642 * **	45.590 * **
	[0.256]	[0.278]	[0.277]	[0.259]	[0.276]	[0.276]	[10.739]	[11.428]	[11.407]	[10.723]	[11.092]	[11.102]
Obs	1194	1194	1194	1194	1194	1194	1304	1304	1304	1304	1304	1304
R-squared	0.2086	0.2378	0.2410	0.1943	0.2350	0.2355	0.0284	0.0768	0.0809	0.0174	0.0768	0.0768
Adj.R-sq	0.1999	0.2287	0.2314	0.1854	0.2259	0.2258	0.0179	0.0661	0.0694	0.0068	0.0660	0.0653

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

Table 5
Total sample, sovereign risk and sovereign exposures as a share of EU portfolio.

	Panel A						Panel B					
Dependent Variable:	sd(ROAA)						z-score					
	1	2	3	4	5	6	1	2	3	4	5	6
Exposure_C_EU	0.631 * **	0.265 *	1.547 * **				-21.768 * **	-3342	-47.378 * *			
	[0.134]	[0.141]	[0.495]				[5.879]	[6.143]	[21.846]			
Exposure_O_EU				0012	0006	-0002				0203	0423	0434
				[0.040]	[0.039]	[0.039]				[1.757]	[1.704]	[1.726]
CDS>MedianEU		0.496 * **	0.529 * **		0.545 * **	0.509 * **		-24.711 * **	-25.742 * **		-25.303 * **	-25.257 * **
		[0.071]	[0.072]		[0.066]	[0.073]		[2.970]	[3.007]		[2.771]	[3.021]
Exposure_C_EU * CDS>MedianEU			- 1.340 * **						45.962 * *			
			[0.497]						[21.884]			
Exposure_O_EU * CDS>MedianEU						0184						-0.246
						[0.148]						[6.413]
GovtCap	1.443 * **	1.257 * **	1.286 * **	1.581 * **	1.289 * **	1.264 * **	-17.843 * *	-10.791	-11.168	-18.415 * *	-10.698	-10.700
	[0.433]	[0.426]	[0.425]	[0.436]	[0.426]	[0.426]	[8.725]	[8.545]	[8.536]	[8.770]	[8.544]	[8.548]
TA	-0.231 * **	-0.176 * **	-0.183 * **	-0.224 * **	-0.168 * **	-0.171 * **	2.343 * **	-0.477	-0.26	2.114 * **	-0.589	-0.585
	[0.019]	[0.020]	[0.020]	[0.019]	[0.020]	[0.020]	[0.798]	[0.849]	[0.854]	[0.802]	[0.832]	[0.838]
Real GDP %	-0.134 * **	-0.114 * **	-0.122 * **	-0.141 * **	-0.114 * **	-0.113 * **	0.892	-0.003	0.304	1.165 *	0.016	0.014
	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.014]	[0.597]	[0.592]	[0.609]	[0.596]	[0.591]	[0.595]
Constant	3.219 * **	2.416 * **	2.465 * **	3.260 * **	2.351 * **	2.371 * **	5.958	43.278 * **	42.374 * **	10.683	44.912 * **	44.837 * **
	[0.256]	[0.276]	[0.276]	[0.259]	[0.275]	[0.275]	[10.740]	[11.387]	[11.380]	[10.733]	[11.060]	[11.239]
Obs	1194	1194	1194	1194	1194	1194	1304	1304	1304	1304	1304	1304
R-squared	0.2090	0.2404	0.2451	0.1942	0.2382	0.2391	0.0276	0.0772	0.0803	0.0172	0.0770	0.0770
Adj.R-sq	0.2003	0.2314	0.2355	0.1853	0.2291	0.2295	0.0170	0.0664	0.0689	0.0066	0.0662	0.0655

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

Table 6
Total sample, government capitalization and sovereign exposures as a share of EA portfolio.

	Panel A				Panel B			
Dependent Variable:	sd(ROAA)				z-score			
	1	2	3	4	1	2	3	4
Exposure_C_EA	0.280 * *	0.336 * *			-5.364	-5.473		
	[0.136]	[0.137]			[5.877]	[5.945]		
Exposure_O_EA			0	0			-0.099	-0.099
			[0.003]	[0.003]			[0.115]	[0.115]
CDS>MedianEA	0.475 * **	0.465 * **	0.525 * **	0.526 * **	-24.234 * **	-24.225 * **	-25.241 * **	-25.240 * **
	[0.071]	[0.071]	[0.066]	[0.066]	[2.950]	[2.952]	[2.774]	[2.776]
GovtCap	1.262 * **	2.449 * **	1.303 * **	2.351 * **	-10.82	-11.179	-10.722	-10.68
	[0.426]	[0.597]	[0.427]	[0.598]	[8.547]	[9.026]	[8.546]	[9.009]
Exposure_C_EA * GovtCap		-2.399 * **				3.478		
		[0.848]				[28.014]		
Exposure_O_EA * GovtCap				-2.122 * *				-0.419
				[0.850]				[27.981]
Total Assets	-0.177 * **	-0.179 * **	-0.167 * **	-0.167 * **	-0.476	-0.471	-0.633	-0.633
	[0.020]	[0.020]	[0.020]	[0.020]	[0.853]	[0.855]	[0.834]	[0.834]
Real GDP %	-0.115 * **	-0.115 * **	-0.116 * **	-0.116 * **	0.039	0.04	0.068	0.068
	[0.014]	[0.014]	[0.014]	[0.014]	[0.591]	[0.591]	[0.590]	[0.591]
Constant	2.434 * **	2.443 * **	2.367 * **	2.363 * **	43.203 * **	43.218 * **	45.642 * **	45.634 * **
	[0.278]	[0.277]	[0.276]	[0.276]	[11.428]	[11.433]	[11.092]	[11.109]
Obs	1194	1194	1194	1194	1304	1304	1304	1304
R-squared	0.2378	0.2429	0.2350	0.2390	0.0768	0.0768	0.0768	0.0768
Adj.R-sq	0.2287	0.2333	0.2259	0.2294	0.0661	0.0654	0.0660	0.0653

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

Table 7
Total sample, government capitalization and sovereign exposures as a share of EU portfolio.

	Panel A				Panel B			
Dependent Variable:	sd(ROAA)				z-score			
	1	2	3	4	1	2	3	4
Exposure_C_EU	0.265 *	0.319 * *			-3.342	-3.405		
	[0.141]	[0.143]			[6.143]	[6.208]		
Exposure_O_EU			0.006	0.009			0.423	0.424
			[0.039]	[0.039]			[1.704]	[1.705]
CDS>MedianEU	0.496 * **	0.487 * **	0.545 * **	0.546 * **	-24.711 * **	-24.705 * **	-25.303 * **	-25.302 * **
	[0.071]	[0.071]	[0.066]	[0.066]	[2.970]	[2.972]	[2.771]	[2.773]
GovtCap	1.257 * **	2.367 * **	1.289 * **	2.279 * **	-10.791	-10.997	-10.698	-10.663
	[0.426]	[0.593]	[0.426]	[0.593]	[8.545]	[9.019]	[8.544]	[9.003]
Exposure_C_EU*GovtCap		-2.421 * **				2.151		
		[0.904]				[30.055]		
Exposure_O_EU*GovtCap				-2.170 * *				-0.369
				[0.907]				[30.079]
TA	-0.176 * **	-0.177 * **	-0.168 * **	-0.168 * **	-0.477	-0.474	-0.589	-0.589
	[0.020]	[0.020]	[0.020]	[0.020]	[0.849]	[0.850]	[0.832]	[0.833]
Real GDP %	-0.114 * **	-0.113 * **	-0.114 * **	-0.114 * **	-0.003	-0.002	0.016	0.016
	[0.014]	[0.014]	[0.014]	[0.014]	[0.592]	[0.592]	[0.591]	[0.592]
Constant	2.416 * **	2.427 * **	2.351 * **	2.348 * **	43.278 * **	43.286 * **	44.912 * **	44.906 * **
	[0.276]	[0.276]	[0.275]	[0.274]	[11.387]	[11.392]	[11.060]	[11.075]
Obs	1194	1194	1194	1194	1304	1304	1304	1304
R-squared	0.2404	0.2450	0.2382	0.2418	0.0772	0.0772	0.0770	0.0770
Adj.R-sq	0.2314	0.2354	0.2291	0.2322	0.0664	0.0657	0.0662	0.0655

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

As for other regressions, we also replace exposures to crisis countries with own sovereign exposures in a variant to Eq. (4).

We estimate Eqs. (1) to (4) using the entire sample first, or *Total Sample*, and then for the *Euro Area*. The parameter estimates of the interaction term "$(Exposure\_C\_EU)_{it}(GovtCap)_i$" indicates the *differential impact* (on bank risk) of carrying a high share of risky sovereigns if the bank has received government capitalization, compared with a bank that has not received government capitalization.

Here again, we estimate variants of these joint tests by replacing$(Exposure_C_EA)_{it}$ with $(Exposure\_O\_EA)_{it}$, $(Exposure\_C\_EU)_{it}$, and $(Exposure\_O\_EU)_{it}$.

5. Regression results

Tables 4 to 7 present the estimated coefficients of Eqs. (1) to (4) *Total Sample* and Tables 8 and 9 present the results for EA relevant Eqs. (1) and (3) using the smaller *Euro Area* sample. In all tables, we present the results when using the standard deviation of ROAA as dependent variable in Panel A and the Z-score in Panel B.

In particular, Table 4 presents the results for the investigation of sovereign risk and crisis sovereign exposures as a share of the EA portfolio. Table 5 presents the same results but with crisis sovereign exposures expressed as a share of the bank's EU portfolio including Norway and Iceland. Tables 6 and 7 rely on the second regression approach, that is, the interaction of government capitalization and the composition of

Table 8
Euro Area sample, sovereign risk and sovereign exposures as a share of EA portfolio.

	Panel A						Panel B					
Dependent Variable:	sd(ROAA)						z-score					
	1	2	3	4	5	6	1	2	3	4	5	6
Exposure_C_EA	0.638 * **	0230	1.493 * **				-22.871 * **	-3.093	-43.969 * *			
	[0.146]	[0.156]	[0.475]				[6.336]	[6.649]	[20.638]			
Exposure_O_EA				0.262 *	0073	0015				-2.395	6575	10,069
				[0.151]	[0.148]	[0.192]				[6.541]	[6.399]	[8.285]
CDS>MedianEA		0.562 * **	0.609 * **		0.604 * **	0.587 * **		-27.236 * **	-28.594 * **		-28.373 * **	-27.436 * **
		[0.084]	[0.085]		[0.078]	[0.086]		[3.451]	[3.506]		[3.237]	[3.532]
Exposure_C_EA * CDS>MedianEA			-1.340 * **						43.232 * *			
			[0.476]						[20.668]			
Exposure_O_EA * CDS>MedianEA						0106						-6.183
						[0.218]						[9.311]
GovtCap	1.423 * **	1.221 * **	1.249 * **	1.535 * **	1.242 * **	1.231 * **	-20.827 * *	-13.008	-13.362	-21.658 * *	-12.781	-12.713
	[0.471]	[0.462]	[0.460]	[0.474]	[0.462]	[0.463]	[9.744]	[9.523]	[9.509]	[9.802]	[9.519]	[9.522]
TA	-0.270 * **	-0.222 * **	-0.231 * **	-0.266 * **	-0.217 * **	-0.217 * **	1.872 *	-0.432	-0.172	1.57	-0.73	-0.742
	[0.024]	[0.025]	[0.025]	[0.024]	[0.025]	[0.025]	[1.016]	[1.030]	[1.036]	[1.031]	[1.029]	[1.030]
Real GDP %	-0.140 * **	-0.112 * **	-0.123 * **	-0.145 * **	-0.112 * **	-0.111 * **	0.881	-0.453	-0.101	1.112	-0.436	-0.483
	[0.015]	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]	[0.688]	[0.689]	[0.709]	[0.690]	[0.689]	[0.693]
Constant	3.793 * **	3.049 * **	3.149 * **	3.776 * **	2.986 * **	2.988 * **	14.675	48.923 * **	46.280 * **	18.099	52.631 * **	52.490 * **
	[0.291]	[0.306]	[0.307]	[0.295]	[0.304]	[0.304]	[12.146]	[12.578]	[12.621]	[12.309]	[12.521]	[12.526]
Obs	975	975	975	975	975	975	1061	1061	1061	1061	1061	1061
R-squared	0.2107	0.2459	0.2521	0.1976	0.2444	0.2446	0.0281	0.0827	0.0865	0.0161	0.0834	0.0838
Adj.R-sq	0.2008	0.2357	0.2412	0.1876	0.2342	0.2336	0.0160	0.0704	0.0734	0.0039	0.0712	0.0707

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

the sovereign portfolio as a share of the EA and EU portfolios, respectively.

Tables 8 and 9 present regression results similar to those in Tables 4 and 6 but for the subsample of EA countries only using the equations with EA ratios. These subsample estimations are motivated by the fact that banks within the EA may have had a particular approach to portfolio diversification during the EA sovereign crisis.

5.1. *Sovereign holdings and bank risk: total sample*

Our baseline results show that banks that are located in countries with above median sovereign risk are riskier than banks in low sovereign risk countries. The positive and significant signs on *CDS* > *Median EA* (Table 4) and *CDS* > *Median EU* (Table 5) variables using the 3-year standard deviation of ROOA in Panel A indicates higher ex-post bank risk when banks operate in a high-risk environment. The same result holds using the Z-score (Panel B) where the negative sign on those variables points to shorter distance to default. These estimates are not trivial, with around a 50 % increase in the standard deviation of ROAA if a bank is located in a country with sovereign risk above the median of our total sample of countries. The findings are also intuitive. When the sovereign is riskier, the government's ability to assist the banking system if it runs into trouble is lower, thereby hurting banks (Dell'Ariccia et al., 2018). Also, in the case of a fiscal crisis that raises sovereign CDS spreads, governments adopt austerity measures that, at least in the short term, depress economic activity, hurting the banking system via higher default rates and a lower demand for credit (Dell'Ariccia et al., 2018).

Another key finding is that holding a higher share of securities from crisis sovereigns also increases bank risk (positive sign on *Exposure_C_EA* using the standard deviation of ROAA and negative sign when using the Z-score). These results are statistically significant at the highest level. They are also in line with Angeloni and Wolff (2012) who find that investing in periphery sovereign securities lowered bank market value.

However, banks with higher concentration of their national sovereign in their sovereign portfolio (*Exposure_O_EA*) are not significantly riskier than their peers, and these results are consistent using both accounting measures of bank risk as shown in Tables 4 and 5. This finding seems to confirm that banks increased holdings of domestic sovereign debt in order to hedge against the risk of a break-up in the European Monetary Union (EMU) by preventing currency mismatches in assets and liabilities by nation (Lamas and Mencia, 2018). Such evidence of risk-shifting is documented by Battistini et al. (2014) and Acharya and Steffen (2015).

As for the parameter estimate of the interaction term "*Exposure_C_EA * CDS> Median EA*", it points to a statistically lower differential risk impact of carrying a high share of crisis sovereigns if the bank is located in a high sovereign risk country compared with a bank that is headquartered in a low-risk country. This finding may actually suggest that the ECB and, more broadly, euro area policy makers (e.g., reforms of the institutional framework such as the Banking Union) were successful in mitigating the risk of high-risk sovereigns in the past and stabilizing bank risk, in line with the findings of Kataryniuk, Mora-Bajén, and Pérez (2021)). These results are consistent using both accounting measures of bank risk as shown in Tables 4 and 5.

Tables 6 and 7 indicate that banks that received capital injections by the government (*GovtCap*) are generally riskier than banks that did not receive such support, though the risk impact is somewhat smaller statistically if we consider the distance to default risk measure (Panel B). Furthermore, we find a similar pattern for the effect of the composition of sovereign portfolios on one accounting risk measure (the standard deviation of the time varying ROAA), with higher exposure to crisis sovereigns increasing bank risk.

Our results show that accounting measures of bank risk are countercyclical. Real GDP growth is important for the riskiness of banks measured by the standard deviation of the time varying ROAA. This result is not maintained in the case of the Z-score, which could be

Table 9
Euro Area sample, government capitalization and sovereign exposures as a share of EA portfolio.

	Panel A				Panel B			
Dependent Variable:	sd(ROAA)				z-score			
	1	2	3	4	1	2	3	4
Exposure_C_EA	0.230	0.289 *			-3.093	-3.278		
	[0.156]	[0.157]			[6.649]	[6.724]		
Exposure_O_EA			0.073	0.118			6.575	6.576
			[0.148]	[0.149]			[6.399]	[6.445]
CDS>MedianEA	0.562 * **	0.551 * **	0.604 * **	0.601 * **	-27.236 * **	-27.217 * **	-28.373 * **	-28.373 * **
	[0.084]	[0.084]	[0.078]	[0.078]	[3.451]	[3.454]	[3.237]	[3.238]
GovtCap	1.221 * **	2.382 * **	1.242 * **	2.328 * **	-13.008	-13.646	-12.781	-12.774
	[0.462]	[0.647]	[0.462]	[0.648]	[9.523]	[10.116]	[9.519]	[10.105]
Exposure_C_EA * GovtCap		-2.342 * *				5.648		
		[0.918]				[30.090]		
Exposure_O_EA* GovtCap				-2.206 * *				-0063
				[0.926]				[30.255]
TA	-0.222 * **	-0.224 * **	-0.217 * **	-0.218 * **	-0.432	-0.421	-0.730	-0.730
	[0.025]	[0.024]	[0.025]	[0.024]	[1.030]	[1.032]	[1.029]	[1.031]
Real GDP %	-0.112 * **	-0.112 * **	-0.112 * **	-0.111 * **	-0.453	-0.451	-0.436	-0.436
	[0.016]	[0.016]	[0.016]	[0.016]	[0.689]	[0.690]	[0.689]	[0.690]
Constant	3.049 * **	3.068 * **	2.986 * **	2.997 * **	48.923 * **	48.842 * **	52.631 * **	52.631 * **
	[0.306]	[0.305]	[0.304]	[0.304]	[12.578]	[12.591]	[12.521]	[12.531]
Obs	975	975	975	975	1061	1061	1061	1061
R-squared	0.2459	0.2510	0.2444	0.2489	0.0827	0.0827	0.0834	0.0834
Adj.R-sq	0.2357	0.2401	0.2342	0.2379	0.0704	0.0696	0.0712	0.0703

Note: TA refers to natural logarithmic of the total assets of the bank, from the previous year. All other variables are contemporaneous. All columns include year controls. The results are obtained via panel OLS, with short term lending facility used as the absorbed control variable. * $p < 0.10$, * * $p < 0.05$, * ** $p < 0.01$

explained by the fact that the standard deviation of ROAA in the denominator is calculated over the entire study period, somewhat muting variation over the cycle.

As for the control variable $(TA)_{t-1}$, it bears a negative relationship with bank risk measured by the standard deviation of the time varying ROAA. This result does not seem broadly in line with the findings of Popov and Van Horen (2015). However, these authors focus only on lending in the syndicated market by large EU banks from July 2009–2011.

5.2. Sovereign holdings and bank risk: Euro area sample

Euro area banks that are located in countries with above euro area median sovereign risk are riskier than other banks in the euro area, as measured in terms our two accounting measures of bank risk (Table 8). The parameter estimates are generally of larger magnitude than in the case of the *Total Sample*. Ex-post risk measured by the time-varying standard deviation of ROAA increases by around 60 % if a bank is located in a euro area country where sovereign risk is above the median of the euro area countries. Also, where the share of crisis sovereigns is larger in sovereign portfolios, euro area banks are riskier. In parallel, euro area banks with higher concentrations of their national sovereign in banks' sovereign portfolio are not statistically riskier using any of the two measures of risk as shown in Table 8 Panels A and B. This pattern is the same one that was observed for *Total Sample*.

As for the parameter estimate of the variable "*Exposure_C_EA * CDS>Median EA*", our results are similar as for the entire sample as shown above.

In Table 9, euro area banks that received government capitalization show a similar risk pattern according to the composition of their sovereign portfolios as in *Total Sample*.

6. Conclusions

This paper belongs to the extant literature on the management of the sovereign-bank nexus. We extend the latter strand of the literature by presenting evidence on the composition effects of sovereign portfolios on banks' risk profile, which is a novelty in this paper. Our methods differ from previous studies with respect to the sample and period coverage (2009–2018), as well as the measures of risk considered. Previous studies were generally limited to the crisis period. Further, we use accounting measures of overall bank risk that are standard in the literature. Using sovereign exposure data from the European Banking Authority for a large number of European banks, we find that banks that are domiciled in countries with higher sovereign risk are riskier, lending support to the balance sheet channel for the sovereign-bank nexus. Also, banks with higher share of sovereigns of crisis countries in their sovereign portfolio exhibit higher risk than other banks. This is in line with the findings of Angeloni and Wolf (2012) and Dell'Ariccia et al. (2018). However, we find a statistically lower differential risk impact of carrying a high share of crisis sovereigns if the bank is located in a high sovereign risk country compared with a bank that is headquartered in a low-risk country. This finding may actually suggest that the ECB and, more broadly, euro area policy makers (e.g., reforms of the institutional framework such as the Banking Union) were successful in mitigating the risk of high-risk sovereigns in the past and stabilizing bank risk, in line with Kataryniuk et al. (2021). After all, no country exited the euro area or defaulted on its debt.

Our results indicate that banks with higher concentrations of their national sovereign in their sovereign portfolio are not riskier than other banks with less exposure to their own sovereign. This finding seems to confirm that banks increased holdings of domestic sovereign debt in order to hedge against the risk of a break-up in the European Monetary Union (EMU) by preventing currency mismatches in assets and liabilities by nation (Lamas and Mencia, 2018).

We also find that banks that received capital injections by the government have higher risk. However, when those banks hold a higher proportion of crisis sovereigns, their ex-post risk is lower (in contrast with Acharya and Steffen, 2015). These results may indicate that regulatory arbitrage motives at these banks were more important than for banks that did not receive capital injections by the government.

Since EU banks hold the largest proportion of their sovereign portfolios in the AFS category, revaluations of the sovereign portfolio are not reflected in banks' P&L and this can be interpreted as an underestimation of the true variability of ROAA (our dependent variable) as a bank risk measure.

Finally, our findings indicate that banks carrying a higher share of crisis sovereigns are not necessarily riskier when they are located in a high sovereign risk country, suggesting that ECB policies were effective in mitigating bank risk.

Data Availability

Data will be made available on request.

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