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Carlos Alberto Piscarreta Pinto Ferreira

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1249-078 Lisboa,
Portugal

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Rua Miguel Lupi, 20
1249-078 LISBOA
Portugal

Telephone: +351 - 213 925 912
E-mail: rem@iseg.ulisboa.pt

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DRIVERS OF SOVEREIGN BOND DEMAND – THE CASE OF JAPAN

by Carlos Alberto Piscarreta Pinto Ferreira[1]

KEYWORDS

Sovereign Debt, Portfolio Choice, Banks, Monetary Policy, Panel Data.

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ABSTRACT

The aim of this empirical paper is to understand the portfolio decisions of banks regarding their asset allocation to sovereign bonds applied to the case of Japan, over the period 2002-21. The issue is relevant because globally central banks are moving to a passive holder or even net seller stance, raising the question of whether banks can be counted among the investors which will replace them. Japan makes an interesting case since Japanese banks are among the banks in advanced economies with a larger share of non-official holdings of domestic sovereign debt, their mean ratio of gross claims on the central government to total assets is about three times above average values in the United States or in the Euro Area, and government portfolios are relatively more homogeneous. We contribute to the existing literature by exploring the impact of unconventional monetary policy on sovereign bond bank demand and putting to test the significance of risk on banks´ asset portfolio decisions using a dynamic rather than a static setting. Our results show that banks struggling to grow, more diversified, better capitalized, or larger banks during expansion periods tend to hold relatively fewer sovereign bonds. On the contrary, past higher profitability, higher economic volatility and funding risk encourage relatively greater holdings. Though less clearly, data also suggests that banks facing weaker loan performance and regional banks with more significant need of collateral hold a higher proportion of sovereign bonds. Quantitative and Qualitative Monetary Easing had a major disruptive effect over banks' government bond demand. Excess reserves at the Bank of Japan became a low risk/low return alternative to government bonds, as banks with relatively higher excess reserves have relatively less government bond holdings in their assets. Going forward, only a reversion of the monetary base expansion may help government bonds regain their role of the single riskless asset for Japanese banks.

[1] ISEG - Lisbon School of Economics & Management, Universidade de Lisboa; REM/UECE. R. Miguel Lupi 20, 1249-078 Lisbon, Portugal. Email: cpferreira@phd.iseg.ulisboa.pt; cferreira@iseg.ulisboa.pt. The views expressed are the author's and all errors are his responsibility. I am very grateful for comments from Miguel St. Aubyn and José Cardoso da Costa.

1. Introduction

Banks hold a significant amount of sovereign debt outside official holdings. Bank holdings represent on average 30% of non-official holdings and 16% of total holdings at the end of the fourth quarter of 2021, according with the latest update of the IMF database "Sovereign investor base estimates by Arslanalp and Tsuda (2014)". Among advanced Economies (AE), Japanese banks have been one of the largest non-official investors in domestic sovereign debt over the period 2004-21 with a mean share of 45%, only behind German banks 46%.

But how relevant are government bonds for banks portfolios? The data collected by the IMF in the Monetary and Financial Statistics does not distinguish government bonds from other claims on the central government. Over the period 2001-21, Japan stands out. Gross claims on the central government have an average weight on bank total assets of 14.5%, well above 5.2% in the Euro Area (EA) and 4.5% in the US. Within the EA the cases of France (2.4%) and Italy (11.4%) illustrate well member's heterogeneity. The most recent figures tend to be lower than the average. This reflects the impact of central banks' Asset Purchase Programmes (APP), but as the case of the US (10.7%) and Italy (15%) illustrate, the general trend does not apply to all countries.

The Covid-19 epidemic prompted a new round of government debt net purchases programmes in most advanced economies, increasing already elevated domestic official holdings even further. In this regard, Japan seems to have been a remarkable exception, as Bank of Japan's (BOJ) "Special Funds-Supplying Operations to Facilitate Financing in Response to the Novel Coronavirus" centres on short-term loans collateralized by corporate debt, not additional government debt purchases.

However, since mid-2021, domestic central banks stopped government debt net purchases, as disruptions in supply-chains, war, demand and supply imbalances, and higher commodity prices, namely energy, propelled inflation for levels not seen for decades. The Fed ended purchases in March 2022 and announced in May the details of a plan for reducing the size of its balance sheet starting on 1 June 2022. The phase-in of the reduction in reinvestments started with a monthly value of $30 billion in Treasuries and $17.5 billion in Agencies Mortgage-Backed Securities (MBS), values to be stepped-up to the double of these monthly figures at cruise speed from September onwards. At this rhythm, the Fed's $8.5 trillion portfolio should be halved by second quarter 2027. Although outright sales were no envisaged, they were also not excluded for Agencies MBS, as the Fed seems eager to avoid distortions in the allocation of credit among economic sectors. The ECB Governing Council decided to end net asset purchases under its asset purchase programme as of 1 July 2022, but to continue to reinvest principal repayments of APP for an "extended period" and those of the pandemic emergency purchase programme (PEPP) at least until the end of 2024. The BOJ is again an exception, as it seems more concerned with its multi-decade fight to totally de-anchor Japanese deflation expectations. Thus, in its Monetary Policy Meeting of July 2022, the BOJ kept unchanged its Quantitative and Qualitative Easing with Yield Curve control policy, continuing to target negative short-term rates (-0.1%) and 0% for 10-year government bond yields. Although asset purchases have remained in place throughout 2022, recent episodes of heavy buying of government bonds became mostly related with the need to counteract expectations that Japan would follow other AE in changing their monetary policy stances. After strong buying in June 2022, BOJ holdings surpassed more than 50% of total government debt holdings.

Domestic central banks net buyers' stance seems to be changing, even if at different paces, to either passive holders or net sellers of government bonds. This change in sovereign bond market dynamics begs the question of which type of investors will replace central banks. In most countries, central banks displaced domestic investors. Thus, can we expect rational domestic banks in their line of business to step in? To answer this question, we need to understand banks' portfolio decisions. The aim of this empirical paper is precisely to explore the drivers of sovereign bond demand.

We focus on Japan because of two main factors. First, the relative homogeneity of Japanese banks sovereign debt portfolio almost entirely composed of Japanese government bonds (JGBs). In the US, government agencies bonds are a very important part of the securities' portfolio of banks, with several of them having from time to time zero holdings of Treasuries. In the EA, the single currency drove away the exclusivity of domestic sovereign bonds in banks´ portfolios and the recent trend is tainted by the EA sovereign debt crisis, all factors that make more difficult to identify the expected behaviour of banks in "normal" times. Second, the relatively higher importance of sovereign bond holdings on Japanese bank total assets and its widespread presence on banks' balance sheets.

In the theoretical literature, the answer to the question why banks invest in sovereign bonds is embedded in the more general problem of the optimal composition of banks' balance sheet in order to maximize the expectation of some utility function of their financial net worth subject to certain conditions, namely minimum capital requirements. Banks' sovereign bond holdings are typically linked to liquidity management, as a buffer asset (Prisman, et al., 1986), to funding management, as collateral for interbank loans (Bolton & Jeanne, 2011), to portfolio diversification (Pyle, 1971; Hart & Jaffee, 1974), and to the level of bank capital (Rochet, 1992).

Our analysis, departing from a portfolio allocation model specification, is most closely related to the empirical literature on the determinants of banks' sovereign bond holdings such as the work of Affinito et al. (2022), Buch et al. (2016), Ogawa & Imai (2014) and Rodrigues (1993). This paper contributes to the existing literature by exploring the impact of unconventional monetary policy on sovereign bond bank demand and putting to test the significance of risk on banks´ asset portfolio decisions in the context of a dynamic instead of the more often seen static panel data model. It also updates the period coverage of previous work on Japanese banks' sovereign bond demand and introduces new bank-specific variables.

Our granular analysis of a sample of 130 Japanese banks over 20 years shows that banks struggling to grow, more diversified, better capitalized banks, or larger banks during expansion periods tend to hold relatively fewer sovereign bonds. On the contrary, past higher profitability, higher economic volatility and funding risk encourage relatively greater holdings. Though less clearly, data also suggests that banks facing weaker loan performance seek refuge in government bonds and regional banks with more significant need of collateral for repo and security lending operations also hold a higher proportion of sovereign bonds. Structural shocks, such as credit crisis and unconventional monetary policies, are probably behind the difficulty in identifying consistently the influence of the loan rate spread over government bond yields and of bank efficiency. Banks' adjustment to the sovereign bond portfolio in response to shocks is rather slow, a result not entirely surprising given the findings of studies on other corporate targets such as the leverage ratio.

The BOJ Quantitative and Qualitative Easing monetary policy and the following addition of a yield curve control target had a major impact on banks government bond demand. BOJ asset purchases to the non-official sector drove an accumulation of excess reserves in the accounts of Japanese banks at the central bank. We find that those excess reserves at the BOJ became a low risk/low return alternative to JGBs, as banks with relatively higher excess reserves have relatively less JGBs in their assets.

The most recent developments of Japanese monetary policy in 2019 show BOJ loans rather than asset purchases continuing to feed banks' excess reserves. Although the resultant increase in the debt-to-equity ratio lessened the negative impact of higher excess reserves on JGBs holdings, it also indicates that it would require an end in the expansion of the monetary base rather than a simple passive asset holder stance from the BOJ to encourage banks to step up their holdings of government bonds.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature, addressing first the theoretical approach to banks´ asset portfolio allocation and then covering the empirical studies that focus on the drivers of sovereign bond bank demand. In Section 3 we introduce the base portfolio allocation model. Section 4 introduces the data and offers some descriptive statistics. Section 5 details the empirical strategy and presents the results. Section 6 sums up the main findings and conclusions. An Appendix provides more comprehensive information.

2. Literature Review

Literature focusing on bank demand of sovereign bonds perceived as riskless in advanced economies is sparse, although the EA sovereign debt crisis encouraged an array of initiatives to address the joint dynamics of sovereign and bank behaviour in situations of government debt distress, namely in the specific case of a single currency area, such as those of Bolton & Jeanne (2011), Uhlig (2014), Farhi & Tirole (2018), Gennaioli et al. (2014) and Ari (2018), among others. Explicit theoretical models are also seldom found, liquidity demand models being their closest proxies.

In the next sub-sections, we present first the theoretical foundations of our modelling approach followed by a review of the most relevant empirical literature.

2.1 Theoretical Approach

In the theoretical literature, the rational of banks' investment in sovereign bonds is embedded in the more general problem of what is the optimal composition of banks' balance sheet that maximizes the expectation of some utility function of their financial net worth subject to certain conditions, namely minimum capital requirements.

In most microeconomic approaches to banking the main bank allocation decision involves loans and deposits, with government bonds taking a buffer role. Such is the case of Prisman et al. (1986) adaptation of the Monti-Klein model[2] to the presence of liquidity risk. In their model, reserves (that may be invested in the riskless asset) are simply the difference between deposits and loans volumes resulting from the deposit and loan rates set by the bank and random shocks to both loan and deposit demand. The yield of reserves is a given and its volume is affected by the penalty rate associated with liquidity shortages. The volume of reserves grows with increases in the liquidity shortage penalty rate and with the volatility of the random shocks to deposits or loans. In this model, the demand for liquidity drives investment in sovereign bonds.

Pyle (1971) and Hart & Jaffee (1973) model bank management of market risk using a Capital Asset Pricing Model (CAPM) mean-variance framework, where banks take a portfolio decision comprising an allocation to a riskless asset and a set of risky financial products (loans and deposits). The amount to be invested in reserves or the riskless asset is simply the difference between total wealth and the amounts allocated to each risky financial product. The riskless asset yield is a given. In this setting both loans and deposits are an increasing function of lending and deposit margins (measured against the riskless rate) but react negatively to increased volatility of loan and deposit rates, respectively. Under this CAPM mean-variance framework, diversification is the determinant of government bonds bank demand.

Banks' portfolio decision is constraint by regulatory solvency requirements since the introduction of the Cooke ratio by the Basle Convergence Accord between G10 countries in 1988 and enacted through the Bank for International Settlements. Although it is a well-established result that the probability of a bank failure is a decreasing function of their capital ratio, Rochet (1992) shows that when the limited liability clause is considered banks' shareholders indirect utility function is no longer a monotonic decreasing function of risk. As a result, for low levels of capital, banks will deviate from the efficient portfolio and choose a maximal risk and minimum diversification alternative allocation. Under this setting, we would expect a link between the capital position and sovereign bond holdings, more precisely lower riskless asset holdings at low levels of capital.

Bolton & Jeanne (2011) introduce collateral as another driver of sovereign bond bank demand. They derive an implicit bank demand schedule for sovereign bonds where equilibrium bond yields are function of the probability of repayment times the sovereign bonds extra value as collateral, termed the "collateral premium", in a model where

[2] Klein (1971) and Monti (1972).

banks use government bonds to raise collateralized interbank loans to fund investment opportunities. The "collateral premium" is a decreasing function of the outstanding quantity of bonds, falling to zero once a critical threshold is reached.

To sum up, bank holdings of sovereign bonds are linked to liquidity management, as a buffer asset between loans and deposits, to funding management, as collateral for interbank loans, to portfolio diversification and to bank capital in its role of cushion against unexpected risks, as the riskless asset.

2.2 Empirical Studies

We cover next the most relevant empirical studies of sovereign bond bank demand by geography. We start with the US, given the importance and benchmark role of the US government bond market, followed by our country of interest, Japan. We then briefly review Europe whose analysis is complicated by the presence of a single currency area that by eliminating exchange rate risk made the government of all member countries closer substitutes and promoted a diversification away from the national sovereign, even if the process was later reverted with the EA sovereign debt crisis. Moreover, much of the available literature focus on the degree of home bias, the possible underlying factors, and on the interaction of sovereign and bank default risks. These issues, though important, are less relevant for the case at hand. Examples of such literature include Ongena et al. (2016), Altavilla et al. (2017), Lamas & Mencía (2018), Lamers et al. (2022), and Campos et al. (2019). We conclude with the review of a study with a broad geographical approach.

In the empirical literature, Krishnamurthy & Vissing-Jorgensen (2007) attribute banks' US government bond demand to short-term liquidity needs and to the effect of regulatory capital requirements that favour "the liquidity/low risk of Treasury securities over other assets". They estimate a demand price -semi-elasticity close to one, a value between the more inelastic demand of the official sector and the more elastic demand of households and long-term investors. In the authors' view banks' relative position validates the liquidity motive as their fundamental driver of demand. However, the fact that banks' holdings dropped from an impressive 42% of total Treasury securities in 1945 to 3% in 2005, as well as the use of time trends in their regressions, suggest the possible presence of other structural drivers. In fact, Neuberger (1993) point out that bank portfolios have changed substantially along the years (see Figure A - 1), as banks replaced securities first by business loans and, particularly after the 1980s, by mortgage loans.

Different researchers investigated US commercial banks' securities demand out of concern with the impact that a surge in holdings could have on the transmission of monetary policy and the recovery after the economic through in March 1991. Typically banks purchase safer government securities during recessions and early economic recoveries while waiting for more attractive loan opportunities to re-emerge. In this instance, instead, commercial banks built-up the portfolio of securities, including US government securities, although part of that growth was driven by an already in motion trend for higher holding of MBS issued or guaranteed by US agencies.

Regulatory changes following the credit crunch of the 1980s (an overview can be found in Wall & Peterson (1996)) affected developments in the early 90s, namely the end of the Regulation Q ceiling on deposits and the phase-in of the risk-based capital standards agreed in 1988 (Basle I). The first meant that the exit of deposits of the banking system usually observed in previous cycles when interest rates move above Reg Q ceiling did not occur, leaving banks with liquidity that may have been invested in government securities. Regarding the second, Furfine (2000) argues that the effects observed in 1989-92 in fact reflect the increase of both risk-based and non-risk based (leverage ratio) capital requirements. Shrieves & Dahl (1995) computations of mean target capital ratios in 1985-89 and 1990-91 confirm higher capital targets in the second period. Furthermore, it seems that regulators used stricter criteria to evaluate the quality of bank loans in the early 1990s than they had in the 1980s, effectively raising minimum capital requirements (Bizer, 1993).

Rodrigues (1993) combines time-series and cross-section analysis. Using quarterly data between 1979 Q1 – 1989 Q4, he regresses the change in the ratio of government securities' holdings to total bank assets on current and lagged output growth (demand factor), several lags of the spread of the effective loan rate over 5-year Treasuries (market factor), and the fourth lag of the dependent variable to account for seasonality in the data. His results point to weak demand and low lending rate spreads - due to the unusual steep interest rates' term structure - as partial explanatory factors of banks' build-up of securities' portfolios. However, model forecasts over 1990-92 underestimate government securities' increase, suggesting other factors have an important role in explaining the observed change. His cross-section partial adjustment model over 10,042 banks focus on the role of credit quality and capital requirements as possible additional drivers of bank holdings of securities in the 1990-92 period. The model assumes banks have an unobserved target for the share of government securities in their total assets that relates with bank features, namely loan performance, bank size, asset growth over 1990-92 and dummy variables describing banks' capital position appraised at the beginning of 1990 which rated each institution in three categories: well-capitalized, adequately capitalized, and undercapitalized. Separate models are estimated for Treasuries and Agencies securities. The share of both Treasuries and Agencies rises with higher loan loss provisions. Undercapitalized banks have a higher target share of both types of securities in comparison with well-capitalized ones. The change in holdings is negatively related with initial holdings. In the case of Agencies, smaller banks have a higher target share and there is a positive relation with the initial holdings of Treasuries. Haubrich & Wachtel (1993) regress changes in the ratio of government securities to total assets with loan performance proxied by net charge-offs and dummies for size and different capital classes reaching similar conclusions: poorly capitalized banks make larger portfolio adjustment from credit to government securities[3]. Hancock et al. (1995)

[3] The size effect is statistically significant, but no detail of its impact is provided. Furlong (1992) using panel data in the period 1985-91 finds that at large banks loan growth has a greater sensitivity to the capital position and that credit at smaller banks started reacting to the capital position only later in the period (1990-91). These results suggest, on the one hand, that capital regulation has effectively shifted for small banks and, on the other hand, that capital regulation tends to be in general more binding for larger banks.

use impulse response functions for securities of a 9 variables VARX to show that a positive response to a negative capital shock prevails for 3 quarters before partially reversing. The response is larger and has a different pattern than the one observed in the 1980s (1986 Q1 – 1989 Q3). Response from banks with capital shortfalls is larger and persists positive for one more quarter, probably because they rely more in the re-composition of assets in favour of less capital-intensive alternatives since raising capital is usually more expensive for smaller banks. Thus, it seems that stiffer capital requirements did lead undercapitalized banks to increase their securities holdings beyond the amounts implied by their loan performance vis-à-vis their peers. Berger & Udell (1994) dissent. They test the relation of bank asset categories' growth rates with five[4] variables reflecting banks assessment of their risk position including risk-based measures of capital (RBC). Their findings suggest that the RBC credit crunch hypothesis fares the worst of all the alternative explanations of the bank credit reallocation of the 1990s. They also find that the effects of the RBC ratios on lending did not get consistently stronger in the early 1990s, and that the RBC ratios generally acted to counteract each other in their effect on credit allocation. However, the other credit crunch theories examined even if somewhat more consistent with the data, do not show substantial quantitative effects.

Keeton (1994) starts by confirming the unusual size of banks' security holdings once adjusted for inflation and long-term economic growth by taking its ratio to potential GDP. The proposed explanation for this development includes temporary and permanent factors. Temporary factors include the slowdown in economic activity, the unprecedent fact that the Fed continued to ease after the recession ended which possibly rose deposits demand faster than loan demand, and a temporary decline in loan demand and supply, as overborrowing in the 80s made firms and households reluctant to borrow and heavy losses in the late 80s and regulators pressure to avoid risk made banks more risk-averse (Bernanke & Lown (1992); Cantor & Wenninger (1993); Johnson (1991)). Permanent explanations are twofold: the impact of risk-based capital standards and a more pessimistic view on long-term prospects for bank lending. To determine whether the increase in bank security holdings is temporary or permanent, Keeton (1994) uses regression analysis to estimate how much of the increase can be attributed to the three temporary factors cited above. All the empirical results are based on a VAR estimated with quarterly data over the 1960-89 period on four lags of three macro variables (the federal funds rate, the ratio of actual GDP to potential GDP, and the GDP deflator) and four bank balance sheet variables (securities, loans, core deposits and large time deposits measured as a ratio to potential GDP). Variance decomposition for 1960-89 show that shocks to the three macroeconomic variables and loans account for 80% of the variation on ratio of securities to potential GDP. The decomposition of unexpected changes in the securities ratio between 1989-93 leave a significant proportion to shocks

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As previous authors had found, a substantial proportion of the slower loan growth is not accounted for by changes in the capital position or by changes in capital regulation.

[4] Tier 1 and total capital risk-based capital ratios, the leverage capital ratio, the ratio of nonperforming loans to total assets and commercial real estate loans to total assets.

to securities rather than to the different explanatory variables, namely after 1992, one year into the economic recovery. This leads the author to conclude that, save eventual structural breaks in the variables' relationships, the unexplained increase in the security ratio could reflect a permanent shift in bank portfolio preferences from loans to securities.

Ogawa & Imai (2014) investigate the determinants of the demand for Japanese Government Bonds (JGB) by commercial banks as their proportion in the financial portfolio of commercial banks increased from 4% in 1990 to 15.7% by 2012. They use a portfolio selection model between loans and government bonds based on the Monti-Klein model of a monopolistic banking sector, taking liabilities and capital as predetermined. This assumption allows to estimate government bonds by subtracting loans from total assets. Thus, besides total assets, all other explanatory variables of JGBs are identical to the explanatory variables of loans but with the opposite sign. The explanatory variables used are: (1) a measure of real activity, the real gross regional product of the prefecture where the head office of the financial institution is located; (2) the ratio of the lending rate and the 10-year JGB yield; (3) a proxy for the price-cost lending margin that includes the ratio of interests on loans to total costs, Non-performing loans (NPLs) and Write-offs; (4) the leverage ratio defined as debt to net worth. All variables are in logs and balance sheets figures are deflated by the GDP deflator and taken from unconsolidated financial statements. Dummy variables control the type of bank – city bank, regional bank, second regional banks – as well as time and bank specific effects. According with the results of a Hausman specification test, a fixed-effects model is estimated first, with a panel of 128 commercial banks over the period FY 1998 – FY 2010. In face of possible endogeneity problems of loan rates and thereby interests on loans, an instrumental variables (IV) estimation method with random-effects[5] is used taking the determinants of the loan rate as instruments (log of the interest rate on deposits, the sum of operating costs and the expenses for raising funds divided by the stock of loans and bills discounted in the previous year and the ratio of the loan-loss reserve to the stock of loans and bills discounted in the previous year). Their results point to the importance of supply factors rather than weak loan demand in explaining commercial banks' holdings of government bonds. In fact, besides the loan rate spread and asset size[6], the main drivers of holdings are reported to be the price-cost margin and leverage. The latter, however, loses statistical significance once the loan quality variables are added. The authors emphasize the contribution of the price-cost margin to explain JGB holdings which is particularly high for the second regional banks, a segment that experienced a substantial drop in efficiency during the period. A recognized possibly missing explanatory variable regards the impact of the BOJ in the JGB market.

[5] According with the results of the Hausman specification tests. Given this model Sargan statistics are used to test the overidentifying restrictions. The validity of the instruments is not rejected in 4 out of 6 cases.

[6] The parameter estimate of the variable is above 1 but no test is reported that allow us to understand if is statistically different from 1. Hancock et al. (1995) argues in favour of using levels since it allows adjustments to shocks in bank size.

Buch et al. (2016) focus on the drivers of sovereign bond holdings of 1,970 German banks during the period 2005 Q4 – 2013 Q3. Sovereign bonds are defined as general government bonds rather than central government bonds for reason of comparability with studies using EBA stress test data. Their descriptive analysis reveals that only two thirds of all banks have a sovereign bond portfolio, participation rates in the sovereign bond market are lower for commercial banks compared to mortgage, savings and cooperative banks, and a large share of the portfolios is composed of EA bonds, particularly in smaller banks. The decision to hold sovereign bonds is modelled using a Heckman selection model that first asserts whether the bank invests altogether in government bonds and then explains the size of the exposure. Besides country specific variables such as the sovereign bond yield, GDP (logs), inflation rate, and the sovereign debt ratio, a host of bank specific variables are used. These include size (log of total assets), cash-to-assets as a measure of liquidity, customer loans-to-total loans and securities portfolio-to-total assets to control for different business models, core capital-to-total assets, retail deposits-to-total assets as a measure of funding vulnerability, collateralized liabilities-to-total assets as a proxy for the demand of collateral, return on equity and cost-to-income as indicators of profitability, and fee over interest income to account for different revenue structures. Oddly, no measure of loan performance is used. It is also unclear whether sovereign bonds are included or not in the measure of securities portfolio which would risk rendering the regression results tautological. Their results indicate that macroeconomic fundamentals only became relevant with the advent of the Global Financial Crisis (GFC). Higher liquidity, greater securities portfolio and collateralized liabilities, weaker capital position, greater profitability and larger size all determine both a higher probability of holding sovereign bonds and a larger sovereign bond portfolio.

Affinito et al. (2022) look at the bank-level determinants' of the ratio of net purchases of domestic general government securities to its previous quarter stock. The sample covers 520 banks and banking groups in Italy over the period 2007 Q3 – 2013 Q4. Italian banks participation in the government bond market is higher than their German counterparts. In June 2015, only 13.3% of banks held no sovereign debt securities in their portfolios, a group which was comprised mostly (83.8%) by foreign banks. Their econometric analysis using bank and time fixed effects excludes foreign banks, and considers two sub-periods, the first covering the impact of the GFC and the second the EA sovereign debt crisis. The results for the entire sample link purchases to a lower loan spread, lower profitability, higher central bank funding, worse loan performance, larger bank size and lower weight of sovereign debt on the overall portfolio of securities. However, only the last two explanatory variables are statistically significant in the first sub-period. Balance sheet conditions become truly significant during the EA sovereign debt crisis. Besides the variables already mentioned, a weaker capital position and a larger funding gap also become significant drivers of banks' investment in government bonds during this latter period. When they compare the behaviour of the top 5 groups with small and minor banks in the second phase it seems that the capital position, loan performance and central bank liquidity are only relevant for the latter institutions, while large groups display a higher response to the funding gap, profitability, the loan spread, and size. These results are mostly in line with the findings of Buch et al. (2016) with the notable exception of the impact of profitability. A closer look indicates that in Italy the variable only turns negative in the more stressful period of the EA sovereign debt crisis and is probably driven by small and minor banks. Investment in government securities of the top 5 groups exhibits a positive significant relation with the variable in the first sub-period and the negative coefficient of the second period is only statistically significant at a 10% level. In fact, smaller banks are the ones that increase the most their sovereign debt holdings following a deterioration of their balance sheets. Thus, the authors conclude that banks' government debt purchases have represented a much-needed mean to support balance sheet conditions at a time of deteriorating liquidity and credit risk brought about by the sovereign debt crisis.

Gennaioli (2018) analyses sovereign bond holdings by banks in 29 to 157 countries over the years 1998–2012, providing a broad geographical overview. Main results from pooled OLS regressions over 29 countries regarding the determinants of banks' government bond holdings in normal times show that the ratio of bond holdings to total assets is decreasing in outstanding loans-to-total assets and is also decreasing in the expected sovereign bond return, suggesting a countercyclical behaviour by banks. Financial development variables are either non statistically significant or have an unexpected sign, as is the case with private credit, suggesting higher holdings are associated with greater financial development which contradicts data showing that average bank holdings in advanced economies are lower than in emerging markets. Size is not statistically significant. Sovereign defaults reduce the importance of government bond holdings in total assets by 1.5% but its interactions with other variables have a counteracting positive effect. This positive effect is greater in larger banks, and in countries with higher private credit to GDP and higher GDP per capita, hence more advanced economies. The simultaneous occurrence of a banking crisis also contributes to higher holdings of government securities. The expected bond return interaction parameter takes a positive sign and is larger than the parameter of the variable on its own. Thus, holdings only increase under the expectation of positive returns during a sovereign default, suggesting a cyclical behaviour by banks during such periods. When the analysis is extended to 157 countries only outstanding loans-to-assets seems to remain statistically significant in normal times. Sovereign default lowers bond holdings but by much less than in the 29 countries regression and is counteracted only by the effect of size.

To sum up, we remark first that sovereign bonds holdings are accounted for in different ways by the empirical literature: levels, growth rates, ratio to assets, change in the ratio to assets or the ratio to potential GDP. On this subject we follow Hancock et al. (1995) and depart from the variable in levels. Sovereign bond holdings correlate positively with assets when measured in levels with the relation being less clear when a ratio to assets or its change are used. The relation to loans is negative, indicating it is an alternative asset. Higher holdings are usually associated with weaker capital positions, worse loan performance, greater importance of collateralized liabilities, higher profitability, and larger pool of liquid assets. On the other hand, the relationship is negative regarding the loan rate spread. The association with efficiency or the share of fees in the income revenue is less clear as results for Japan and Germany point in opposite directions. In the reviewed empirical literature indicators of risk accounting for liquidity of capital shocks that may have a precautionary effect on sovereign bond demand seem to be missing. An example of the introduction of risk variables is the use of the coefficients of variation of the ratio of cash-to-deposits and output-to-trend output as a proxy of volatilities in the study of the determinants of excess liquid assets in several East Asia countries by Agénor et al. (2004).

3. The Portfolio Allocation Model

Our empirical analysis departs from a log-linear model inspired on the one presented by Ogawa & Imai (2014), itself an adaptation of the classical Monti-Klein model of a monopolistic banking system. The portfolio selection model assumes:

(i) Banks make allocation decisions regarding the amounts to lend and to invest in government bonds;
(ii) Each bank faces a downward sloping loan demand curve;
(iii) The lending production technology is linearly homogeneous thus unit lending costs do not depend on the quantity of loans;
(iv) The government bond market is perfectly competitive hence government bond yields are a given for each bank;
(v) Banks maximize profits in respect of their asset allocation subject to a total assets' constraint and minimum capital adequacy requirements regarding lending;
(vi) Debt and equity finance total assets and are assumed to be predetermined in regard the asset allocation decision;
(vii) The unobserved lending margin is proxied by a relation comprising the margin (defined as the ratio of interest on loans to interest and general expenses), total assets and quality measures of the loan portfolio) .

The demand for government bonds is given by:

$$(1)\ \log G_{it} = \alpha + \beta_0 \log A_{it} + \beta_1 \log \frac{R_{it}^L}{R_{it}^G} + \beta_2 \log MG_{it} + \beta_3 \log NPL_{it} +$$
$$\beta_4 \log LEV_{it} + \beta_5 \log \frac{Y_t}{Y_t^P} + \beta_6 \log \frac{Y_t^R / Y_{t-1}^R}{Y_t / Y_{t1}} + \vartheta_{it} \quad , i = 1, \dots, N; t = 1, \dots, T,$$

where i and t denotes each bank and time period, respectively, G_{it} represents bank holdings of government bonds, $\frac{R_{it}^L}{R_{it}^G}$ stands for the relation between the bank loan rate and government bond yields, MG_{it} is the margin, an efficiency measure, defined as the relation between loan interest revenues and the sum of interest and general and administrative expenses, NPL_{it} is the ratio of non-performing loans to total loans, a measure of credit quality, LEV_{it} is a non-risk based measure of leverage, A_{it} represent bank assets, $\frac{Y_t}{Y_t^P}$ is the relation between output and potential output, a measure of the cyclical position of the economy, $\frac{Y_t^R / Y_{t-1}^R}{Y_t / Y_{t1}}$ indicates the relation between regional and national real output growth rates, ϑ_{it} is the random disturbance term. We differ from Ogawa & Imai (2014) on the treatment of output. We do not use the regional real output, as this variable tends to be strongly correlated with bank assets, preferring instead a relative measure of real output growth.

Besides different alternatives to above mentioned variables, we also consider: (i) the return on assets (ROA), admitting that lower ROA prompts banks to take more risk and therefore less GG bonds; (ii) the ratio of derivatives and repo/security lending in relation with assets, to capture demand of collateral; (3) the ratio of 'due from banks'-to-assets, the balance sheet item that is driven and best reflects the accumulation of excess reserves at the BOJ. Excess reserves are mainly determined by monetary policy and therefore exogenous to banks – a regression of the median value of the ratio (in logs) on the central bank holdings of government debt (in logs) has a slope not statistically different from 1 and an adjusted R^2 of 0.927[7] . With the introduction by the BOJ of the "Quantitative and Qualitative Monetary Easing" (QQE) monetary policy in 2013, excess reserves became an equally low risk/low return alternative to JGBs. We prefer to use the bank specific ratio instead of the BOJ holdings because the latter alternative would introduce a bank-invariant variable. This would require us to reduce the number of time-fixed effects used to control for unobserved shocks over time that have an impact on banks' GG bond holdings to avoid collinearity.

A second set of additional variables aims at capturing the impact of size (as measured by assets), relative asset growth, relative capital position in term of equity-to-assets ratio and relative refinancing risk proxied by the loans-to-deposits ratio using dummies. These variables are introduced affecting the slope or in interaction with other variables, namely the loan rate spread and the output gap.

A last group of variables is introduced to test empirically the impact of uncertainty suggested by the theory, a novelty, since these variables are often absent from empirical studies. The rationale is that precautionary motives would lead to higher allocation to safe assets to safeguard against shocks on output, loan-to-assets, and deposit-to-assets. Shocks to the loan rate were dropped due to the high correlation with the loan rate spread and the resulting risks of collinearity between the two variables if both were present in the same regression.

[7] The test on the unity value for the slope has F statistic = 0.13 (p-value = 0.7201). The cumulative sum test for parameter stability showed no signs of structural breaks (Test statistic = 0.4743 vs 10% critical value of 0.85) and the Breusch-Godfrey LM test no signs of AR (1) serial correlation (F Stat. = 1.293 p-value = 0.2734).

4. Data and Descriptive Statistics

4.1 Data Description

The Japanese dataset spans 20 years covering the period fiscal year 2002 to fiscal year 2021. However, the information regarding regional GDP is only available up to 2018. The main sources of our Japanese data are the Japanese Bankers Association (JBA) from where we retrieved banks financial statements for each fiscal year; the Bank of Japan from where we sourced the output gap quarterly data; the OECD for annual data on the output gap and regional GDP; Bloomberg for information regarding 10-year JGB yields; the IMF for data on central bank holdings of government debt and aggregated balance sheet data of Other Depositary Corporation; and the ECB for data on 10-year zero coupon yields. The 130 Japanese banks are classified in six bank types: (1) City-banks; (2) Regional banks; (3) member banks of the Second Association of Regional Banks; (4) Trust banks; (5) Other banks, including namely former long-term credit banks. During the sample period several banking institutions went through merger or acquisition processes. In those cases, we retain only the data pre-merger or -acquisition for those institutions for which individual data is no longer available after those operations and discard the pre-operation information for those banks under which the post-merger or -acquisition data is reported. Operations at the very beginning or end of the sample period in most cases are just removed from the dataset as there is little information on pre or post operation institutions.

The government bond yield is an average of 10-year JGB yields over each fiscal year. In 2016 and 2019 yields are negative, making impossible the use of those years in our base model specification. To take advantage of the entire dataset, we make a parallel increment in all yields so that the minimum value of the series becomes an arbitrary small value (0.001%). Overall, the Japanese panel data is unbalanced and characterized by both a long N (130 banks) and a smaller but relatively long T (up to 20 years).

The margin is computed as the ratio of interest on loans and discounts to the sum of interest expenses and general and administrative expenses. The NPL ratio is the ratio of non-performing loans to total gross loans. Leverage is the ratio of total liabilities to total shareholders' equity. The output gap is the ratio of actual to potential output in real terms. In regressions with time fixed effects the variable is taken in interaction with bank total assets. The relation of regional to nationwide output growth rates is the ratio of the respective ratios of current and previous period output.

As additional variables we include return on assets, computed as the ratio of net income to total assets, and a proxy of excess reserves at BOJ for which we make use of the ratio due from banks to total assets in the absence of more granular information. As proxies for the demand of collateral we use for derivatives the item trading account – financial derivatives in relation to total assets and for repo and security lending the sum of securities sold under repurchase agreements and cash collateral received for securities lent in relation with total assets. As these markets are relatively concentrated in a few banks we consider for financial derivatives only the volumes of the 10 major players with derivatives to assets above 0.5%, setting the volumes of all other banks to zero. This allows to use the variable without losing observations. Regarding repo and securities lending, we consider different specifications. As a standalone variable we use the original data with 97 market participants. When interacted with the loan rate spread a dummy variable is used. The indicator variable has two variants: it takes the unity value for those 26 banks with a ratio to assets above 2%; or just for the most significant 10 banks with a ratio to assets above 4%.

For size, asset growth, capital position and refinancing risk we use quartile dummies except for the loans-to-deposits ratio, the proxy for refinancing risk, where we consider a simple threshold of 100. Quartiles composition is computed each year, which allows bank to move quartiles across time and permits the use of this variable in regressions with bank-fixed effects. In the specific case of size and due to the considerable asymmetry between the largest institutions and the rest of the banks we define a specific group for the 8 major banks and compute quartiles for all the other institutions.

As uncertainty measure, we considered the standard deviation. The standard deviation of our output gap variable is computed over the four quarters of each fiscal year, and the standard deviations for loans- and deposit-to-assets over the banks present in the sample in each fiscal year. All these variables are bank-invariant. Hence, to avoid collinearity with time fixed effects they are interacted with banks assets, sample mean loan-to-assets, and the deposits-to-assets ratio, respectively. All variables are used in logs with the sole exception of the uncertainty measures.

4.2 Descriptive Statistics

Japanese banks total assets grew at an annual average rate of 3.1% between 2000 and 2021, while loans and bills discounted grew at a more moderate pace of 1.5%.

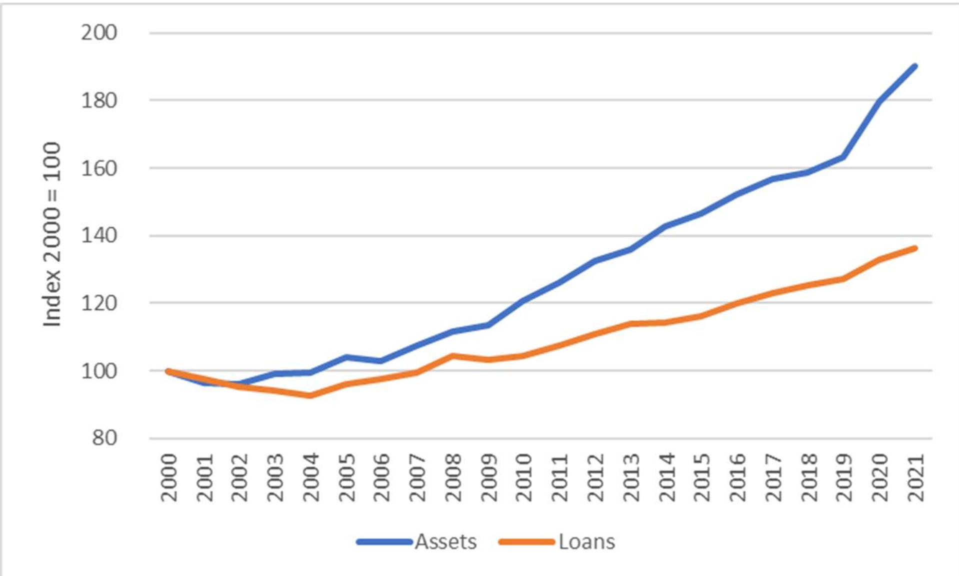

FIGURE 1– JAPANESE BANK ASSETS AND LOANS AT CONSTANT PRICES

Source: Bank of Japan. Author's calculations. Note: Data for domestically licensed banks for each fiscal year deflated using the corresponding fiscal year GDP deflator.

Japanese bank holdings of general government bonds started the sample period slightly above 11% of total bank assets, reached a peak of 16.5% in the aftermath of the GFC in 2011[8] and subsequently fell to a historical minimum of 7% in 2021 (see Figure 2).

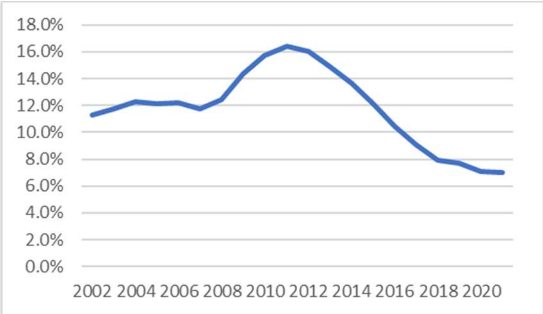

FIGURE 2 – GG BONDS TO BANK ASSETS
Source: JBA - Bank Financial Statements. Author's calculations.

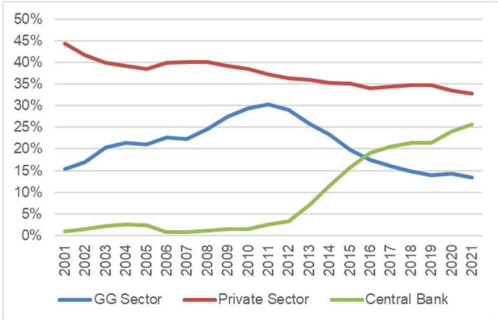

FIGURE 3 – BANK ASSETS (% OF TOTAL)
Source: IMF – IFS. Author's calculations.

FIGURE 4 – 10-YEAR JGB YIELDS
Source: Bloomberg. Author's calculations.

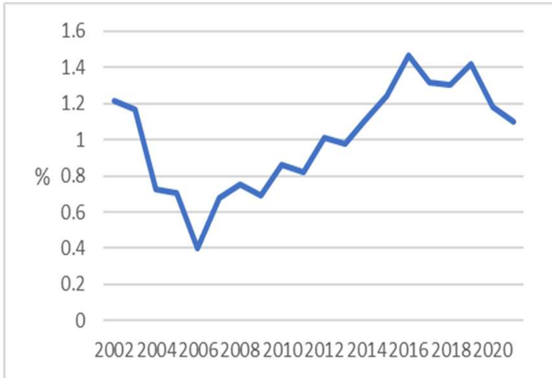

FIGURE 5 – MEAN LOAN RATE SPREAD OVER 10-YEAR JGB YIELDS
Source: JBA - Bank Financial Statements, Bloomberg. Author's calculations.

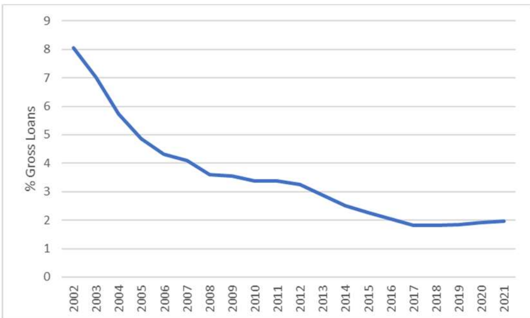

FIGURE 6 – NON-PERFORMING LOANS
Source: JBA - Bank Financial Statements. Yearly simple average values. Author's calculations.

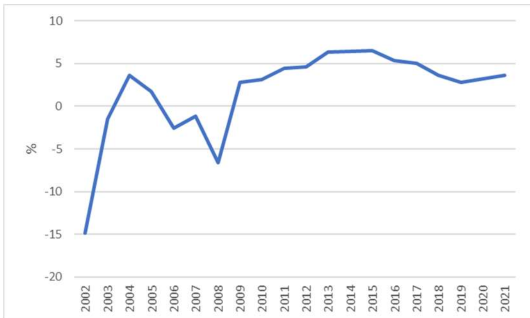

FIGURE 7 – RETURN ON EQUITY
Source: JBA - Bank Financial Statements. Yearly simple average values. Author's calculations.

Up to 2011, the rise in banks' exposure to the general government replaces private sector lending (see Figure 3). In 2013, the BOJ launches its QQE under which it commits to double the monetary base through assets purchases and to bring inflation to 2 percent within two years. The fall in claims on the general government in the 2013-16 period mainly matches the unprecedent build up in central bank reserves (see Figure 3). Despite the fall of JGB yields and the peak in the spread of loan rates to JGBs (Figure 4

[8] A previous peak had been observed around 2000 following the Asian Crisis.

and Figure 5), the loan-to-assets downward trend proceeded unabated. In September 2016, with JGB yields at the zero low bound, the BOJ introduced a new monetary policy framework "QQE with Yield Curve Control" aiming and succeeding at keeping yields around zero. Banks' general government claims continued to fall, now in response solely to quantitative measures as JGB yields remained virtually unchanged. Reserves kept piling up at the BOJ even if "(…) net interest payments to the Bank have become a normal situation" (Assessment for Further Effective and Sustainable Monetary Easing - BOJ, 2021), a condition affecting mainly trust and other banks. Despite the fall in interest rates, the loan-to-assets ratio relentlessly persisted its downward movement. This evidence suggests that, so far, the 'risk-taking channel' transmission mechanism of monetary policy (Adrian & Shin, 2009; Borio & Zhu, 2008), according to which a long period of low interest rates leads to an increase in banks' 'risk appetite', has not been at work in Japan. Over most of the sample period the loan margin shrunk, even adjusted for the falling loan-to-assets ratio but seems to have started recovering since 2019.

Non-performing loans were high at the beginning of the sample period, with an average value close to 8%, but trended down with just a small plateau around the GFC. The trend most probably reflects the general positive impact of low interest rates in the overall quality of loan portfolios documented by Altunbas et al. (2012) and Jiménez et al. (2014). Write-offs followed the same downward movement as NPLs but spiked in 2008. Its peak led the ROE to fall into negative territory around the GFC after having been improving since 2002, a period still negatively affected by the East Asian Crisis. From then on, the ROE recovered up to 2016, when it stated weakening with the yield curve at the Zero Lower Bound (ZLB). This is in line with Borio et al. (2017) findings that a change in (short) interest rates have a non-linear impact on net interest income which is stronger at the ZLB. It improved again with the Covid-19 pandemic, mainly at regional banks, as BOJ loans decreased the equity-to-assets ratio and ROA stayed stable.

TABLE I – GG BONDS TO BANK ASSETS DESCRIPTIVE STATISTICS

	2002-21		2002-11		2012-21	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Overall	0.1188	0.0585	0.1306	0.0553	0.1069	0.0593
Between		0.0439		0.0472		0.0457
Within		0.0404		0.0309		0.0387
Decomposition SS						
Between		52.4%		68.7%		57.4%
Within		47.6%		31.3%		42.6%

Notes: SS = Sum of squares of deviations regarding the mean. The between standard deviation measures variation of the variable's means across banks and is calculated as the square root of SSDB/(T_i(N-1)) where SSDB = $\sum_{i=1}^{N} T_i \left(\bar{X}_i - \bar{\bar{X}}\right)^2$, T_i is the sample period of each bank i, $\bar{X}_i$ is the bank mean, $\bar{\bar{X}}$ is the total sample mean, and N is the number of banks. The within standard deviation measures variation of the variable in each bank over time and is calculated as the square root of SSDW/(NT_i-N), where SSDW = $\sum_{i=1}^{N} \sum_{t=1}^{T_i} (X_{it} - \bar{X}_i)^2$ and X_{it} is the value of the variable of bank i at time t. Because the computation of the different standard deviations uses distinct degrees of freedom the sum of between and within standard deviations do not add up to total standard deviation. Thus, the decomposition is carried out over the sum of squares of deviations regarding the means Source: JBA - Bank Financial Statements. Author's calculations.

Table I shows descriptive statistics for the ratio of GG Bonds to Total Assets across the entire data sample and for the two sub-periods of upward and downward trends. The overall mean of GG bond holdings stands at 11.9%. The mean for the two sub-periods area statistically different (t-stat = -13.6; p-value = 0), being smaller in the sample's second half.

The overall standard deviation of 5.85% is also statistically different between the two sub-periods (χ^2-stat = 1300; p-value = 0.0006), being lower in the first half. The overall decomposition of variability between variability across banks and variations over time within each bank is almost even. However, in the sample's first half, variability across institutions predominates, representing about 2/3 of total variability.

TABLE II – GG BONDS TO BANK ASSETS DESCRIPTIVE STATISTICS

Bank Type	Obs	Median	Mean	Std	Skew	Kurt
1 - City	97	10.8%	12.5%	6.8%	1.10	3.94
2 - Regional	1232	12.7%	13.2%	5.8%	0.42	3.15
3 - 2nd Association	825	9.3%	9.8%	4.6%	0.35	2.83
4 -Trust	80	13.7%	14.3%	9.2%	0.56	2.84
5 - Other	95	10.1%	9.8%	6.3%	0.33	2.48

Source: JBA - Bank Financial Statements. Author's calculations over the period 2002-21

Across banks, the ratio of GG bonds to assets is higher at trust banks, but the mean values are not statistical different from city and regional banks. Second association regional banks and other banks share a smaller average ratio of GG bond holdings.

TABLE III – DIFFERENCE-IN-MEANS T-TEST

H_0: Equal Means of bank type i and j

Period: 2002-21

Bank Type i	Bank Type j	t-stat	df	p-value
City	Regional	-1.04	107.4	0.3014
Regional	2nd Association	14.60	2001.3	0.0000
Regional	Trust	-1.04	83.1	0.3024
City	Other	3.76	173.8	0.0002
2nd Association	Other	1.45	87.9	0.1501

Notes: df = Satterthwaite's degrees of freedom. Source: Author's calculations.

The examination of the correlation coefficients among the main explanatory variables in Table A - I does not suggest potential multicollinearity problems as their value is below 0.8 (Studenmund, 2005; Kennedy, 2008)) with one exception, the standard deviation of loan rates. This variable has a correlation coefficient of 0.82 with the loan rate spread. Therefore, we refrain from using it in our Japanese base model specification.

Banking institutions operating in the same national market face common shocks. Hence, we would expect panel variables to exhibit contemporaneous correlation. Since the presence of cross-sectional dependence affects the estimation of the variance-covariance of parameters' estimates, we perform the tests suggested by Pesaran (2004) and Pesaran (2015) with a null hypothesis of strict cross-sectional independence and weak cross-sectional dependence, respectively. Results are presented in Table A - II. In both tests, we reject the null hypothesis for all variables, pointing to the expected presence of cross-sectional dependence. In face of these results, we make use of Driscoll & Kraay (1998) standard errors which are robust to general forms of cross-sectional dependence.

5. Empirical Strategy and Results

Our approach can be outlined as follows. We will start by taking the base model and conduct a preliminary analysis to ascertain residuals' properties. We also test whether the assets' coefficient is equal to one, which would allow us to work with the ratio of GG bonds to assets and reduce the number of regressors. Based on the results, we will proceed using the aforementioned ratio and introducing a partial adjustment mechanism. Then, we will check the presence of fixed effects, alternative definitions of the model variables and introduce a few others to get a panel of exogenous variables that allow us to test the possible endogeneity of both the loan rate spread and the margin using an IV estimator. Having confirmed the endogeneity of these variables, we will use a system-GMM estimator that instruments those variables and corrects the bias introduced by the presence of a lagged dependent variable to arrive at the final estimates of our empirical model.

A preliminary analysis to determine the possible presence of heteroskedasticity and serial correlation in the log-linear portfolio allocation model of equation (1) is conducted with a pooled OLS regression.

To identify the variance-covariance process in the panel we perform a Breusch-Pagan (1979) / Cook-Weisberg (1983) test for heteroskedasticity where its 'F-stat' version drops the assumption that the regression disturbances are independent draws from a normal distribution with variance σ^2. We also carry out White (1980) test for homoskedasticity. In all cases the null is rejected at a 5% significance level, pointing to residuals' heteroskedasticity (see Table A - III). Levene (1960) and Brown & Forsythe (1974) tests on equality of variances robust to nonnormality clearly reject the null hypothesis of constant variance across banks and across time, further confirming residuals heteroskedasticity.

To test the presence of serial correlation we use a version of the Cumby-Huizinga (1992) test for autocorrelation robust to heteroskedasticity and within-cluster autocorrelation. The test confirms residuals to be autocorrelated (see Table A - IV).

We re-run the regression using Driscoll-Kraay (1998) standard errors – see Table IV - since Driscoll-Kraay standard errors assume the error structure to be heteroskedastic, autocorrelated up to some lag and possibly correlated between banks. Then, we test the restriction of a unit coefficient for the log of total assets through a Wald test. Its result - F statistic of 3.49, p-value = 0.064 – does not reject the null of a unit coefficient at the 5% level. This brings the model closer to a specification more often found in the literature, where the dependent variable is the ratio of GG bond holdings to total assets.

The very strong presence of serial correlation suggests that banks may face frictions in the adjustment to their target GG bond holdings and, therefore, the adjustment does not take place instantaneously. As in Rodrigues (1993), we specify a partial adjustment process. If we designate as Y the dependant variable and as X the vector of independent variables for the sake of conciseness, we have that:

(2) $Y_{it}^{*} = AX_{it}^{\beta}$ and a partial adjustment motion process $\left(\frac{Y_{it}}{Y_{it-1}}\right) = \left(\frac{Y_{it}^{*}}{Y_{it-1}}\right)^{1-\gamma} e^{\vartheta_{it}}$

Combining the two and taking logs:

(3) $\log Y_{it} = \alpha(1-\gamma) + \gamma \log Y_{it-a} + \beta(1-\gamma) \log X_{it} + \vartheta_{it}$

Where $\beta(1-\gamma)$ denote the short-run elasticity, β the long-run elasticity associated with the independent variables and γ the adjustment parameter.

The adjusted initial model is then:

$$(4) \log \frac{G_{it}}{A_{it}} = \alpha + \beta_0 \log \frac{G_{it-1}}{A_{it-1}} + \beta_1 \log \frac{R_{it}^{L}}{R_{it}^{G}} + \beta_2 \log MG_{it} + \beta_3 \log NPL_{it} +$$

$$\beta_4 \log LEV_{it} + \beta_5 \log \frac{Y_t}{Y_t^P} + \beta_6 \log \frac{Y_t^R / Y_{t-1}^R}{Y_t / Y_{t1}} + \vartheta_{it} \quad , i = 1, \ldots, N; t = 1, \ldots, T.$$

The results of the regressions with a lagged dependent variable - (2) in Table IV- show that residuals no longer exhibit serial correlation, suggesting an improved model specification. Furthermore, the absence of serial correlation in the presence of a lagged dependent variable reassures that OLS remains an efficient and consistent estimator.

The variable used to measure the different degrees of regional lending opportunities has proved so far not statistically significant. Most likely because the relevant information is better captured by the national output gap measure. The fact that regional GDP available data ends in 2018 constraints the usable sample size. Considering a regional level of aggregation instead of the prefecture level used so far does not change in any meaningful way the results obtained. In Ogawa & Imai (2014), their measure of regional real GDP is also not statistically significant in any of their specifications of the demand equation for JGBs. Therefore, we drop this variable.

Having adjusted the preliminary base specification and taking stock that ignoring heterogeneous intercepts leads to bias in pooled slopes as illustrated by Hsiao (2003), we include bank fixed effects to control for unobserved time-invariant bank heterogeneity and time fixed effects to capture bank-invariant time-specific shocks affecting all banks (e.g., regulatory changes, market specific shocks, or more broad macroeconomic shocks). In Table IV we present two alternative specifications that distinguish themselves by the way margin enters the model. In (3) the base specification is retained. Henceforth, we will designate this specification as Model 1. In (4) the margin enters in first differences. This specification will be named Model 2. The models' main differences regard the loan rate spread and the margin. In (3) the former is statistically significant but has the "wrong" sign[9], as we would expect that a higher loan rate spread would entice banking institutions to lend more and therefore reduce their GG bond holdings. The price-cost margin carries the "right" negative sign but is not statistically significant. On the other hand, in (4) the loan rate spread is no longer statistically significant, but the change in the margin is, and carries the expected negative sign. Although both the loan rate spread and margin are influenced by the loan rate, the pairwise correlation between the two variables is very low (-0.06).

TABLE IV – INITIAL MODEL SPECIFICATIONS

Variables		(1)		(2)		(3)		(4)	
		Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat
Constant	α	-3.9373 ***	-9.72	-0.435 ***	-3.24	-1.880 ***	-9.31	-1.748 ***	-8.75
Total assets	β_0	1.0654 ***	30.41						
GG bonds to Total Assets (t-1)	β_0			0.853 ***	11.32	0.754 ***	9.21	0.759 ***	9.31
Loan rate to 10y JGB avg yield	β_1	-0.1733 ***	-5.34	-0.064 ***	-3.49	0.172 ***	3.95	0.090	1.50
Margin	β_2	-0.2861 ***	-3.66	-0.018	-0.72	-0.121 *	-1.68		
ΔMargin	β_2							-0.321 ***	-5.68
NPL ratio	β_3	0.0361	0.67	0.017	0.81	0.070 ***	3.88	0.068 ***	4.40
Debt-to-equity	β_4	0.2818 **	2.55	0.043 **	2.52	0.150 ***	4.23	0.149 ***	4.30
GDP to potential GDP	β_5	-0.0314 *	-1.74	-0.028 ***	-4.99	-0.017 ***	-7.39	-0.017 ***	-6.86
Regional to National GDP growth rates	β_6	0.0006	0.06	0.002	0.83				
F Stat		5613.18 ***		1730.61 ***		13.3×10^6		1.69×10^6	
df		(7,129)		(7,129)		(23,129)		(23,129)	
No bank effects F stat						2.2900 ***		2.2100 ***	
df						(129,1896)		(129,1894)	
No time effects F stat						2.7×10^6 ***		1.2×10^6	
df						(17,129)		(17,129)	
Adj. R^2		0.8479		0.8315		0.8603		0.8609	
Root MSE		0.5465		0.2471		0.2389		0.2385	
AIC		3035.7		85.518		-165.164		-171.7	
$\chi^2(4)$ Stat.		37.507 ***		5.112		4.302		4.920	
df		4		4		4		4	
Number of banks		130		130		130		130	
Number of observations		1858		1837		2049		2047	
Dependent Variable		GG bonds		GG bonds / Assets		GG bonds / Assets		GG bonds / Assets	
Estimation		OLS DK SE		OLS DK SE		FE DK SE		FE DK SE	
Period		2002-18		2002-18		2002-21		2002-21	

Notes: GDP to potential GDP is interacted with total assets in the fixed-effects regressions; DK SE - Driscoll-Kraay (1998) standard errors; FE – fixed-effects; MSE - Mean squared error; AIC – Akaike information criteria; all variables in logs; estimates of coefficients associated with time and bank fixed effects are omitted; F Stat. is the statistic of the F-test of overall significance; $\chi^2(4)$ is the statistic of the Cumby-Huizinga test of serial correlation up to lag 4 with a null hypothesis of no serial correlation robust to within-cluster arbitrary correlation and between-cluster heteroskedasticity. The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

The estimates of the loan rate spread in (3) seem to be affected by the presence of time-fixed effects that have embedded the change in monetary policy from 2013 on. If we remove the time dummies of this period, the coefficient of the loan rate spread turns negative and becomes statistically significant. The other variables in both specifications carry the expected sign and coefficient estimates are close. In both specifications growth above potential has a negative impact on bank holdings of GG bonds, which is greater in larger banks. Higher levels of non-performing loans and higher leverage[10] bring about higher levels of less risky government bonds in both specifications. In both cases, bank

[9] The same result is found by Ogawa & Imai (2014) in several of their random-effects regressions.

[10] Leverage here is not to be confused with the regulatory 'leverage ratio' as it is measured by the debt-to-equity ratio, hence capital is in the denominator and not in the numerator as is the case of the leverage ratio. Hence an increase in this measure of leverage is commensurate with a lower leverage ratio.

fixed effects and time fixed effects are statistically confirmed. Quality of adjustment indicators favour very slightly specification (4). In both cases, robust Hausman tests[11] reject the random-effects alternative specification.

The results obtained using as alternative measures of government bond returns the 10-year JGB yield at the end of the FY, and the annual holding period return computed from compounded monthly returns on 10-year zero coupon JGBs using the procedure described in Lamers et al. (2022), are qualitatively similar to the ones obtained with the average 10-year JGB yield over the FY – see Table A - V. Since those alternatives imply the additional loss of one or three years of data, respectively, we retain the variable in our base specification.

Alternative variables to the debt-to-equity ratio are considered in Table A - VI. Both debt-to-net assets and equity-to-assets provide similar results to the original leverage variable and in most cases with a worse Akaike Information Criteria. Thus, again, we retain the debt-to-equity ratio.

We also tested as alternatives to the NPL ratio, the write-offs ratio, the ratio of allowances to loan losses to loans, and the ratio of provisions for loan losses to loans ratio. Results are presented in Table A - VII. Only the write-offs ratio is statistically significant, but the quality of the adjustment is inferior and there is a substantial loss of observations dues to zeros, negative values, or simply lack of information. Hence, we keep the NPL ratio as an indicator of the loan book quality.

To improve the base specification, we further test the addition of new variables. The ROA is an indicator of profitability often used in the literature - e.g., Gennaioli (2008) or Campos et al. (2019). Profitability is influenced by asset allocation; hence the variable is contemporaneously endogenous. Since the model has a lagged dependent variable, we consider the ROA with a two-year lag. The expectation is that a lower ROA would press banks to take more risk in their balance sheet and reduce the amount invested in low-risk GG bonds. Results confirmed this expectation of a positive relationship and the statistical significance of the variable.

In the case of Japan, as we have already illustrated, since 2013 BOJ's asset purchases translated not in an increase in loans-to-assets but in the accumulation of excess reserves at the BOJ. Once JGB yields reached the ZLB, the impact of monetary policy is no longer visible in bond yields but in the expansion of banks' excess reserves. In our model, the loan rate spread no longer reflects the impact of monetary policy after 2015. To capture that effect, we add the ratio of due from banks to assets as an additional

[11] A robust Hausman test is employed since in the presence of heteroskedasticity the variance of the estimators of fixed-effects and random-effects models are invalid, and the traditional Hausman test statistic based on its difference is inappropriate. The test uses a cluster-robust bootstrap with 200 repetitions. Two other tests confirm the robust Hausman tests' results. The first, tests the overidentifying restrictions imposed by the random-effects model - regressors are uncorrelated with the panel-specific error term - using the heteroskedasticity robust Hansen J statistic. The second, tests the statistical significance of panel means in a correlated random-effects model under the null of all of them being zero, which would correspond to the random-effects model (Mundlak, 1978).

independent variable. The dynamics of the variable is mainly determined by monetary policy and therefore exogenous to each bank. An unexpected shock affecting one bank is not expected to sufficiently relevant to affect the course of monetary policy. The variable is statistically significant, has the expected negative sign, and improves the Akaike information criteria.

A distinct factor that may drive the demand of government bonds is its use as collateral in derivative transactions and on repo operations and security lending where the bank receives cash. To account for this specific driver, we tested the introduction of two variables. The variable derivatives-to-assets fails to be significant and carries an unexpected negative sign. The repo and security lending liabilities on a standalone basis have a positive impact on GG bond holdings but the number of observations drops for less than half. So, we introduce a different specification relying on a lower response of the main users of repos and security lending to movements in the loan rate spread. The interaction variable is statistically significant, but carries an unexpected sign, although correctly the inverse of the also "wrong" positive sign of the loan rate spread.

TABLE V – FULL MODEL SPECIFICATIONS

Variables	Model 1 (1)		Model 1 - All years (2)		Model 2 (3)		Model 2 - All years (4)	
	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat
Constant	-1.902 ***	-9.31	-1.847 ***	-8.17	-1.811 ***	-9.78	-1.899 ***	-8.07
GG bonds to Total Assets (t-1)	0.748 ***	8.92	0.750 ***	10.11	0.753 ***	9.11	0.756 ***	10.34
Loan rate to 10y JGB yield/return	0.172 ***	3.57	0.173 ***	2.98	0.124 *	1.94	0.128 **	2.04
Margin	-0.086	-1.25	-0.100 ***	-2.98				
ΔMargin					-0.492 ***	-6.02	-0.521 ***	-6.34
NPL ratio	0.074 ***	4.18	0.088 ***	4.52	0.075 ***	5.28	0.086 ***	5.48
Debt-to-equity	0.163 ***	4.73	0.161 ***	3.84	0.162 ***	4.71	0.159 ***	3.79
GDP to potential GDPxAssets	-0.016 ***	-6.08	-0.014 ***	-5.56	-0.015 ***	-4.77	-0.014 ***	-4.89
ROA (t-2)	0.010 **	2.30	0.011 **	2.33	0.014 ***	4.83	0.015 ***	5.49
Due from banks / Assets	-0.047 ***	-8.47	-0.047 ***	-8.94	-0.047 ***	-8.61	-0.048 ***	-8.83
Loan Rate Spread x Repo Mkt Major Players	-0.045 ***	-3.01	-0.022 **	-2.36	-0.040 ***	-3.55	-0.020 **	-2.32
Loan Rate Spread x Top Banks by Assets	0.059 ***	3.80	0.019 *	1.88	0.063 ***	5.51	0.019 *	1.95
Qtle 1 Banks by Asset Growth	-0.052 ***	-4.46	-0.047 ***	-4.13	-0.053 ***	-4.07	-0.047 ***	-3.84
Qtle 2 Banks by Asset Growth	-0.015 **	-2.18	-0.014	-1.65	-0.014 **	-2.44	-0.012	-1.53
Loan Rate Spread x Qtle 3 Banks by Leverage	0.021 ***	2.82	0.025 ***	6.26	0.021 ***	2.77	0.026 ***	6.05
Qtle 3 Banks by Leverage	-0.022 *	-1.89	-0.019 **	-2.31	-0.021 *	-1.80	-0.019 **	-2.25
Std GDP to potential GDP x Assets	0.017 ***	2.83	0.024 ***	3.78	0.024 ***	3.60	0.027 ***	5.32
Std (log) deposit-to-assets x Deposit-to-assets	-0.039	-0.99	-0.036	-0.96	-0.041	-0.97	-0.038	-0.94
Std (log) loan-to-assets ex trust banks x Mean loan-to-assets	-0.264 **	-1.98	-0.118	-0.87	-0.335 *	-1.85	-0.207	-1.39
F Stat	$365*10^3$ ***		$865*10^3$ ***		$917*10^3$ ***		$164*10^3$ ***	
df	(34,129)		(37,129)		(35,129)		(36,129)	
No bank effects F stat	2.3200 ***		2.5300 ***		2.3000 ***		2.5100 ***	
df	(129,1859)		(129,2084)		(129,1859)		(129,2084)	
No time effects F stat	$0.55*10^6$ ***		$84*10^3$ ***		$33.5*10^3$ ***		$0.37*10^6$ ***	
df	(17,129)		(18,129)		(17,129)		(19,129)	
Adj. R^2	0.8639		0.8676		0.8655		0.8692	
Root MSE	0.2349		0.2372		0.2335		0.2357	
AIC	-223.37		-190.45		-247.71		-218.19	
$\chi^2(4)$ Stat.	6.686		7.310		5.547		5.912	
df	4		4		4		4	
Number of banks	130		130		130		130	
Number of observations	2023		2250		2023		2250	
Period	2002-21		2002-21		2002-21		2002-21	
Gaps in Period	2016,19				2016,19			

Notes: Dependent variable (log) GG bonds-to-assets; Estimation method – fixed-effects with Driscoll-Kraay (1998) standard errors; MSE - Mean squared error; AIC – Akaike information criteria; all variables in logs but the standard deviations; estimates of coefficients associated with time and bank fixed effects are omitted; F Stat. is the statistic of the F-test of overall significance; $\chi^2(4)$ is the statistic of the Cumby-Huizinga test of serial correlation up to lag 4 with a null hypothesis of no serial correlation robust to within-cluster arbitrary correlation and between-cluster heteroskedasticity. The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Another group of variables is used to verify if the institution profile has an impact on the GG bond demand schedule. Banks that are growing their assets the least tend to reduce more their portfolio of the GG bonds to finance alternatives with higher expected return. Banks adequately capitalized (3rd quartile by equity-to-assets ratio) seem to hold a relatively smaller fraction of assets invested in GG bonds. However, the evidence is weak, as statistical significance lies in the borderline of rejection of the null hypothesis, and the banks with the best capitalization do not exhibit the same type of behaviour. In the case of banks in the 3rd quartile of capital positions and top banks by assets increases in the loan rate spread have a positive impact on the fraction of assets invested in GG bonds. This evidence is difficult to interpret since the loan rate spread in this specification does not have the expected negative sign. If that was the case, largest and banks with good capital positions would be less responsive to relative rate changes between loans and JGBs.

Lastly, we introduce uncertainty in the specification. The expectation is that precautionary motives would lead to higher allocation to safe assets to safeguard against unexpected shocks on output, loans, and deposits. Evidence is consistent across specifications and concur that risk has a positive impact on GG bond holdings, on what concerns shocks on output (demand factor). Shocks on loans are never statistically significant, and shocks to deposits carry an unexpected negative sign and lose statistical significance once we include the year 2016 and 2019 by parallel shifting yields to be able to cope with negative values while using logs.

Hitherto, we have treated all bank variables in the model as exogenous or predetermined. We pretend to address now possible endogeneity issues.

In the event of a bank-specific shock, the affected banking institution would adjust its asset allocation and by changing its loan supply would also affect its own and the market loan rate. Note that the inverse demand curve is given by the following expression of the market loan rate (R_L) on the total loan demand (L_T), the factors that shift loan demand (B) and the interest elasticity of loan demand (η): $R_L = BL_T^{\frac{-1}{\eta}}$, and total loans is simply the aggregation of loan supply (L_i) across the market N bank institutions: $L_T = \sum_{i=1}^{N} L_i$. Since the loan rate affects both the loan rate spread and the margin, we may have correlation between these variables and the random disturbance term.

To test the endogeneity of these variables we make use of an IV estimator. Considering that the instruments should affect the loan rate but not directly GG bond holdings or the loan supply, we employ proxies for the three factors that underly the loan rate. The cost of funding, that we proxied by the (log) deposit rate, since the loan-to-deposits ratio is generally below 100%; non-interest expenses, represented by the lagged ratio of general and administrative expenses to loans; and expected loan losses, proxied by the lagged ratio of allowances for loan losses to loans. Since the margin enters one of the models in first differences, we also experiment with the first difference of these instrumental variables. We further consider the degree of business diversification by using the (log) lagged ratio of interest to ordinary income.

Endogeneity tests reject the null hypothesis that the presumed endogenous regressors are indeed exogenous. On the other hand, tests on the exogeneity of the 'included' instruments confirm that the other model variables are exogenous (see Table A - IX).

TABLE VI – ENDOGENEITY TESTS

	Model 1		Model 2	
	Base	All years	Base	All years
Ho: Presumed endogenous regressors are actually exogenous				
$\chi^2(2)$ Stat.	11.707	14.241	6.683	2.39
(p-value)	0.0029	0.0008	0.0354	0.3028

Notes: the test statistic is defined as the difference of two Hansen statistics: one for the equation with the smaller set of instruments, where the suspect regressors are treated as endogenous, and one for the equation with the larger set of instruments, where the suspect regressors are treated as exogenous.

The within-estimator demeaning process in the presence of a lagged dependent variable among the regressors creates a correlation between this regressor and the disturbance term. This correlation produces a negative bias ("Nickell bias" after Nickell (1981)), in the estimate of the coefficient of the lagged dependent variable, meaning persistence and long-run elasticities are underestimate. Using both Nickell's approximation of the bias for large values of T (time) and N (panel units) and Hahn and Kuersteiner (2002) bias-correction of the estimator, we come up with a bias estimate slightly below 13% of the estimated coefficient value, yielding a coefficient value around 0.85.

To address this issue, we make use of the "system" GMM estimator developed for dynamic panel models with 'small T, large N' by Arellano and Bover (1995) and Blundell and Bond (1998) that allows for endogenous regressors. This estimator is efficient and consistent if the models are not subject to serial correlation of order two, the instruments used are valid, and there is no cross-sectional dependence. To overcome the latter constraint Roodman (2009) suggests the introduction of time dummies to prevent contemporaneous correlation, the most likely form of cross-sectional dependence. Given that our panel is unbalanced, the first difference transformation enlarges the gaps in the dataset. This motivates the alternative use of the forward orthogonal deviations' [12] transformation, proposed by Arellano & Bover (1995). The number of instruments produced by the GMM estimator[13] is quadratic on T. Since our T is large, we do not have enough number of observations for all the instruments. Furthermore, GMM is known to have poor finite sample properties when using many overidentifying restrictions. To overcome this problem, we collapse the instruments' matrix into a single column, as in standard IV estimation, and restrict the number of past lags used as instruments. To make estimates as efficient as possible a two- step estimator is used, with the Windmeijer (2005) finite-sample correction applied to covariance matrix to avoid downward biased standard errors.

[12] The forward orthogonal deviations' transformation subtracts the average of all available future observations from the current value, thereby dropping the last observation for each panel unit.

[13] The estimator uses a different number of instruments for each time-period with the number increasing as we move to the latter time-periods.

All specifications take as endogenous variables the lagged dependent variable, the loan rate spread and the (change in) margin.

TABLE VII – DPD SYSTEM GMM ESTIMATES

Variables	Model 1						Model 2					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat
Constant	-1.175 ***	-3.84	-0.793 ***	-4.44	-1.783 ***	-4.96	-0.947 ***	-4.07	-0.800 ***	-4.45	-1.189 ***	-4.57
GG bonds to Total Assets (t-1)	0.875 ***	20.59	0.909 ***	19.31	0.921 ***	17.21	0.887 ***	23.21	0.905 ***	20.72	0.906 ***	18.97
Loan rate to 10y JGB yield/return	0.072	0.48	0.004	0.10	0.073	1.08	0.034	0.44	0.007	0.13	0.049	0.90
Margin	-0.189	-1.18	-0.122	-1.40	-0.198 **	-2.18						
ΔMargin							-0.319	-0.84	0.017	0.03	0.006	0.01
NPL ratio	0.056 *	1.75	0.054 ***	2.58	0.061 ***	2.65	0.026	0.88	0.036 *	1.80	0.027	1.40
Debt-to-equity	0.108 ***	3.81	0.083 ***	3.60	0.080 ***	3.29	0.075 ***	3.35	0.082 ***	3.37	0.079 ***	3.11
GDP to potential GDP x Assets	-0.012 ***	-3.29	-0.007 *	-1.92	-0.007 *	-1.93	-0.012 ***	-3.46	-0.008 **	-2.05	-0.007 **	-2.02
ROA (t-2)	0.012 *	1.93	0.014 *	1.69	0.024 **	2.26	0.015 ***	2.59	0.016 **	2.21	0.019 ***	2.61
Due from banks / Assets	-0.032 ***	-4.29	-0.029 ***	-4.12	-0.025 ***	-3.73	-0.035 ***	-4.87	-0.030 ***	-4.58	-0.028 ***	-4.51
Loan Rate Spread x Repo x Mkt Major Players	0.000	0.00	0.005	0.31	-0.003	-0.17	0.038	1.17	0.007	0.36	0.009	0.55
Loan Rate Spread x Top Banks by Assets	0.012	0.40	0.006	0.28			0.020	0.73	0.016	0.62		
Qtle 1 Banks by Asset Growth	-0.054 ***	-3.37	-0.045 ***	-3.01	-0.040 ***	-2.82	-0.047 ***	-3.59	-0.038 ***	-2.69	-0.033 **	-2.47
Qtle 2 Banks by Asset Growth	-0.012	-1.20	-0.011	-1.04			-0.010	-1.04	-0.009	-0.85		
Loan Rate Spread x Qtle 3 Banks by Leverage	0.013	1.38	0.024 ***	2.90	0.018 **	2.14	0.015 *	1.81	0.024 ***	2.86	0.022 ***	2.66
Qtle 3 Banks by Leverage	-0.005	-0.35	-0.018	-1.49	-0.016	-1.26	-0.016	-1.22	-0.019	-1.57	-0.020	-1.61
Std GDP to potential GDP x Assets	0.022 ***	2.83	0.022 ***	3.66	0.025 ***	4.08	0.017 ***	2.29	0.019 ***	2.61	0.022 ***	2.90
Std (log) deposit-to-assets x Deposit-to-assets	0.004	0.29	0.011	1.37	0.014 **	2.09	-0.004	-0.40	-0.001	-0.06	0.003	0.32
Std (log) loan-to-assets ex trust banks x Mean loan-to-assets	0.260	1.17	0.134	0.78	-0.104	-0.91	-0.083	-0.70	-0.083	-0.93	-0.211 **	-1.74
Loan-to-deposits (t-2)					0.146 **	2.14					0.018	0.33
Interest Income/ Ordinary Income (t-2)					0.068 ***	3.37					0.068 ***	3.30
Wald χ2	180047 ***		237781 ***		251289 ***		218002 ***		261781 ***		262643 ***	
df	31		35		35		34		35		35	
Arellano-Bond test for AR(2) in first differences (p-value)	0.572		0.112		0.128		0.745		0.128		0.128	
Hansen J test of over-identifying restrictions (p-value)	0.759		0.648		0.445		0.248		0.267		0.290	
Number instruments	40		46		46		43		48		48	
Number of banks	130		130		130		130		130		130	
Number of observations	2023		2143		2143		2023		2143		2143	
Period	2002-21		2002-21		2002-21		2002-21		2002-21		2002-21	
Gaps in Period	2016,19						2016,19					

Notes: Dependent variable (log) GG bonds-to-assets; Estimation method – Two-steps 'System' GMM of Arellano & Bover (1995) and Blundell & Bond (1998) with forward orthogonal deviations and bank-clustered standard errors with Windmeijer's correction to allow for intra-institution correlation; endogenous variables: lagged dependent variable; loan rate spread and the (change in) margin; regression 1 uses as additional instrument the ratio of general and administrative expenses to ordinary income; regression 2 uses the same variable but lagged and as additional instruments in the level equation the deposit rate, the lagged ratio of allowances to loans losses to loans and the lagged ratio of general and administrative expenses to loans; regression 4 uses as additional instruments in the level equation the deposit rate, the lagged ratio of allowances to loans losses to loans and the lagged ratio of general and administrative expenses to loans; all variables in logs but the standard deviations; the coefficients estimates associated with time fixed effects are omitted; Wald Stat. is the statistic of the χ^2-test of overall significance. Arellano-Bond test for AR(2) reports the p-value, failure to reject the null indicates that lags of the dependent variable (and any other variables used as instruments that are not strictly exogenous), are in fact endogenous, thus inappropriate instruments; Hansen J reports p-values of the null hypothesis that the instruments used are not correlated with the residuals The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Results in Table VII confirm a large autoregressive coefficient, but statistically different from unity. Values are slightly above our previous 'back-of-the-envelope' bias estimate, possibly due to the combined use of forward orthogonal deviations and system GMM.

The coefficient value implies a slow speed of adjustment (SOA) of Japanese banks' sovereign bond holdings of around 11.9% per year, meaning a half-life of about 5.5 years for the adjustment to a shock. This "glacial" managerial response suggests large frictions and adjustment costs relative to the benefits of the adjustment. This finding is not entirely surprising given Rodrigues (1993) option to use the change in the securities-to-assets ratio instead of the ratio itself as a dependent variable in his study of US banks. The same slow pace of response is also found in studies on other corporate targets such as capital or the leverage ratio. Furlong (1992) finds a SOA of around 7.5% for US banks. Iliev & Welch (2010) report a SOA of 9-15% for different measures of corporate leverage using a constant sample of US firms on Compustat from 1963–2007 and the system GMM estimator. This figure is half-way the most prominent estimates published in the literature, which include such low SOA as 7-18% (Fama & French, 2002) or even practically zero (Welch, 2004). Iliev & Welch (2010) contend that standard panel estimators are not designed for applications in which the dependent variable is censored, as is the case of a ratio, and possibly the best inference regarding the slow SOA found is that the average manager does not move back towards a target ratio.

To overcome the bias stemming from a censored dependent variable Elsas & Florysiak (2015) propose the dynamic panel data with a fractional dependent variable estimator (DPF estimator), a doubly censored Tobit specification that allows for corner observations, with a lagged dependent variable and unobserved heterogeneity. The DPF estimator builds on the model of Loudermilk (2007) and changes her specification of the presumed fixed effects distribution, such that it allows for unbalanced panel data with a lagged dependent variable. However, the DPF estimator does not allow for other endogenous covariates than the lagged dependent variable and is documented the inaccuracy of the quadrature approximation used by the estimator in the presence of large correlations within panel units as is our case. The use of logs also reduces the data censorship as the dependent variable is only right censored with an upper limit of zero.

Notwithstanding, running the DPF estimator over the earlier and simpler specifications we find the coefficient of the lagged dependent variable to be revised up about 7.5%, below our estimates of the Nickell bias and below the system GMM estimates. The corresponding SOA is 18.5% per year. The half-life for the adjustment to a shock is 3.4 years, indicating a more active but far from quick managerial action.

The loan rate spread is not statistically significant indicating the market factor has no direct impact on government bond bank demand over the sample period. This result holds when we run the regression over 2002-11, before the BOJ commitment to QQE, suggesting it is not driven by the change in monetary policy. A possible explanation for the absence of a link between demand and relative return rates is the unexpected behaviour of each component of the loan rate spread in two sub-periods of our sample. Up to 2012, GG bond holdings move according to expectations with loan rates, but not with JGB yields. The reason for the broken relation may lie with risk management. First, we observe a shedding of GG bond holdings built up during the Asian crisis, possibly accentuated by bank mergers/acquisitions. Then, an increase in GG bond holdings in response to the GFC also unrelated with yields. After 2012, GG bond holdings and JGB yields display the expected relation. However, holdings show no response to the fall in loan rates, as JGBs seem to have been replaced in its role of an alternative asset by banks´ excess reserves at the BOJ. Thus, occasional runs for safety and the changes brough about by BOJ’s QQE seem to be behind the difficulties in identifying the relationship between GG bond holdings and the loan rate spread. This same relationship had already shown a volatile statistical significance across specifications in the work of Ogawa & Imai (2014).

On what regards supply factors, the margin has the ‘right’ negative sign but is never statistically significant. The negative relation between the two variables seems to have been broken in 2012-16 with QQE monetary policy and the associated heavy purchase of JGBs by the BOJ, making difficult its identification over the sample period. Thus, our results do not support the significant relationship found by Ogawa & Imai (2014). Buch et al. (2016) using as efficiency measure the cost-to-income also failed to find a statistically significant relationship with GG bond holdings. Surprisingly, given previous estimates, the change in the margin seldom is statistically significant, and the respective sign is dependent on the instruments used and timeframe. Overall, the results point to the absence of a meaningful role for this price-cost efficiency measure among the drivers of GG bonds bank demand.

The NPL ratio exhibits the expected positive impact on GG bond holdings, but statistical significance is more consistent under model 1 and when we use the all sample. Elasticities estimates, both short- and long-run, are higher under model 1. Running the same models over the sub-sets of regional banks and 2nd association of regional banks, we find that only the demand of the less diversified 2nd association banks is driven by loan performance. This finding mirrors a similar result from Affinito et al. (2022) for Italy, where only small and minor banks' government bond demand respond to loan performance.

Leverage, another supply factor, confirms consistently its positive impact, indicating that banks under a 'negative capital shock' boost their relative holdings of government bonds. The capital position measured by the relative leverage ratio proves to be meaningful for the response of 3rd quartile banks to changes in the loan rate spread. The associated positive coefficient indicates that these institutions would be less responsive to changes in the loan rate spread if those changes had the expected negative sign. A possible explanation may be a concern of these banks on taking further risk that may compromise their current capital position as it is perceived by both the market and regulators. Being closer to the median, these banks may fear a non-linear response to negative changes in their leverage ratio. The relative capital position of the 3rd quartile banks, by itself, fails to be statistically significant, except for the 2nd association banks, and even then, not consistently across models.

To test the proposition of Rochet (1992) that at low levels of capital shareholders limited liability clause drives banks to hold lower levels of the riskless asset we replaced the non-statistically significant dummy representing the 3rd Quartile of banks ranked by the leverage ratio with a dummy for the 1st Quartile or the least capitalized banks in regressions (1) and (3), covering both models[14]. In both cases the coefficient is negative, hence in line with the theoretical proposition, but clearly non-statistically significant (z statistics of -0.69 and -0.77, respectively). Thus, in the case of Japan, we are unable to confirm the above stated proposition.

Our demand factor, the output gap interacted with size, is always statistically significant confirming that larger banks tend to adjust their asset portfolio more intensely to the economic cycle than their smaller counterparts.

[14] Results not presented but available upon request.

The impact of monetary policy is clear across all regressions in the role of excess reserves at the BOJ as a substitute of JGBs in bank assets This effect, already visible before 2012[15], is intensified with QQE. The short-run elasticity of excess reserves about triple in 2012-21 in comparison with the previous period.

Profitability proves to be significant, and the elasticity estimates are consistent across specifications. A past reduction in the ROA encourages banks to divert assets away from the portfolio of low-risk government bonds into riskier activities. Likewise, banks striving to expand their asset base tend to have lower mean GG bond holdings and therefore a riskier asset portfolio.

Other characteristics of banks' business models such as the loan-to-deposit ratio, use of collateralized liabilities or the degree of diversification of the sources of revenue are also relevant (see specifications 3 and 6). The former, an indicator of funding vulnerability, is statistically significant under model 1. Its positive coefficient indicates that banks safeguard against funding risk by holding a larger proportion of GG bonds that can easily be used as collateral in the wholesale market. Regressions on the sub-set of regional banks show that collateral use by major market players in the repo and security lending markets are also significant. This demand driver would make institutions less responsive to changes in the loan rate spread if those changes had the expected negative sign. The positive response regarding revenue diversification reveals that a bank with a more diversified source of revenues (less weigh of interest income in ordinary income) holds relatively less GG bonds, a result in line with the findings of Buch et al. (2016) for German banks.

A novelty in the literature is the finding that precautionary motives associated with the volatility of the economic cycle also play a role in bank demand of government bonds. Higher volatility translates into higher GG bond holdings, with larger banks displaying a greater reaction. On the other hand, volatility of loans or deposits seldom prove significant. These empirical results partially validate the theoretical contributions on the significance of risk.

6. CONCLUSIONS

The aim of this paper is to provide empirical insights on the drivers of sovereign bonds bank demand in Japan. Our analysis shows that such demand is driven by several different factors.

Leverage, a supply factor, is one of the most consistent drivers. According with the results found for this variable, weakening capital positions prompt banks to increase their holdings of GG bonds, most probably to reduce risk, in line with the findings of Altunbas et al. (2012). The results are in line with Acharya & Steffen (2015), who find

[15] The earlier QE programme in Japan began in March 2001 and allowed the BOJ to expand the monetary base by about 60% before coming to a halt in March 2006. It was then partially reversed, and reactivated following the GFC, only to be further reinforce with the QQE in 2013. We take 2012 as the cut-off date between the two periods as assets purchases had already been stepped up before the official commitment to QQE.

that banks with lower capital ratios invest more in sovereign bonds, as well as the result of Buch et al. (2016) for German banks. Furthermore, it parallels the strong significance of this variable in the IV estimates of Ogawa & Imai (2014). If we link higher holdings of government bonds to lower risk, then results reflect a positive relationship between bank capital and risk, which the literature links to agency problems between management and shareholders or external (regulatory or market) pressure over weaker banks to build up capital (Altunbas, et al., 2012). In our Japanese data, we failed to find support for Rochet (1992) proposition that, at low levels of capital, shareholders limited liability clause drives banks to hold lower levels of the riskless asset. The relative capital position, as measured by the leverage ratio, is found relevant for 3rd Quartile banks in its interaction with the loan rate spread. These group of banks that tend to have lower mean GG bond holdings and whose capital position is close to the median may fear a non-linear response of markets or regulators if they take more risk. Therefore, they seem to be less responsive to changes in the loan rate spread if those changes had the expected negative sign.

The role and impact of unconventional monetary policy that in Japan began in March 2001 is also clear in our results. Excess reserves at the BOJ became a low risk/low return alternative to JGBs. This finding is very different from the conclusion of Buch et al. (2016) for German banks that higher holdings of liquid assets make more likely the investment in sovereign bonds.

The impact of demand is subsumed in banks response to the economic cycle and its volatility. Expansion periods, offering plenty higher return alternatives to banks, are associated with a reduction of GG bond holdings in total assets. However, periods of higher economic volatility cause banks to take a more cautious stance, increasing the relative size of their sovereign bond portfolio. Banks take the same prudent approach to safeguard against funding risk, as measured by the loans-to-deposits ratio.

In our set up, these two factors are interacted with size, making size also relevant. Thus, larger banks in terms of assets tend to reduce more their government bond holdings during expansions, and to react more negatively to increases in economic volatility. Since we are working with the ratio of GG bonds to assets as our dependent variable, it is implicit a unity coefficient linking numerator and denominator, and therefor that larger banks have larger GG bond holdings. It is this 'result' that is comparable with identical findings of Ogawa & Imai (2014), Acharya & Steffen (2015), and Buch et al. (2016) that larger banks hold more GG bonds. Thus, our findings highlight an additional channel for the impact of size on sovereign bond demand, besides providing empirical support to the importance of risk in bank's asset allocation decisions.

Asset growth is also meaningful. Banks struggling to expand their balance sheet have a lower mean exposure to government bonds as they explore more attractive growth opportunities. Profitability matters too. Theory is ambiguous on the expected sign of the relationship between the variable and GG bond holdings, but in the case of Japan our results suggest more profitable banks preserve their resilience to unexpected risks by holdings more government bonds. Or put differently, less profitable banks are more prone to search for yield and prefer more risky investments over low return sovereign bonds. The same relationship is found, but using ROE, by Buch et al. (2016) for Germany. Empirically, low growth and low past profitability rather than low levels of capital seem to drive Japanese banks to hold a smaller proportion of their assets invested in the riskless asset. The same holds true for banks with a more diversified business model that is less reliant on interest income.

Results regarding non-performing loans are less clear cut but suggest banks facing loan performance problems reduce balance sheet risk by increasing the relative size of the sovereign bond portfolio, a result that matches the findings of Ogawa & Imai (2014).

The influence of the loan rate spread and margin (either in levels or first differences) are difficult to identify. The loan rate spread seldom is statistically significant or displays the expected negative sign. The cause may lie in the occasional runs to safety (Asian crisis first and GFC later) and the changes in monetary policy brought about by QQE that disrupted the relationship. The margin, an efficiency measure that can be regarded as a supply factor, although exhibiting the expecting negative sign in levels often fails to be significant, a result that mirrors that of Buch et al. (2016) using cost-to-income, but not that of Ogawa & Imai (2014).

On what regards other drivers of bank demand, we find that the need of collateral seems to be specific of regional banks, and we fail to find support for precautionary demand linked to risks in the markets for loans and for deposits.

Evidence suggests that unconventional monetary policy had a major disruptive effect over the drivers of bank demand of JGBs. From a policy point of view, the most worrisome sign is demand's loss of response to price-signals pointing to a market that is not working properly. This is possible a consequence of JGB yields having reached and stayed at the ZLB. BOJ's yield curve control policy keeps yields around 0% even if the pace of JGBs purchases decelerated after 2017. To restore the proper functioning of the JGB market it is important to normalize monetary policy and move away from the ZLB, which may require a large export of excessive savings and a weakening of the yen. The same holds true for the soundness of Japanese banks' balance-sheet. The prolonged low interest rate policy erodes profitability, fosters search for yield risky behaviour and/or pullback from financial intermediation. All these risks were acknowledged by the BOJ in its policy review of 2021 but for now the only movement seems to be a reduction in the volume of excess reserves earning a negative interest rate of -0.1%. In 2019, asset purchases were replaced by loans, which by increasing leverage, make the financial system more vulnerable to adverse shocks. Since loans fed banks' excess reserves, the marginal impact on GG bond holdings is negative even if lessened by resultant increase in debt-to-equity. This also indicates that it would require more than a simple passive asset holder stance from the BOJ to encourage banks to step up their holdings of government bonds. It requires an end (or a at least pause) in the expansion of the monetary base.

On another note, our results show that under an adverse economic shock demand and supply factors drive an initial increase in bank demand of sovereign bonds, while capital is eroded by losses. If sovereign concentration charges are levied based on the relation of a ratio of exposure to Tier 1 capital against a regulatory threshold, as has been put forward in the EU, that constraint is more probable to become binding under an adverse economic shock. The resulting increased charges would either press for a reduction of exposure, hindering banks possible countercyclical support of the sovereign, and/or a reduction of other exposures, namely lending to the real economy, admitting as less likely a costly capital increase. In the absence of any kind of external support, in both cases there is the risk that banks response ends up magnifying the initial adverse shock. Hence, if implemented, a very careful calibration of capital charges and thresholds is required to prevent or minimize undesirable effects.

The empirical analysis could be extended by modelling the allocation to excess reserves and estimating the VAR model underlying banks' asset allocation decision, thereby broadening the understanding of the drivers and interrelationships of the asset side of banks´ balance sheet.

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APPENDIX

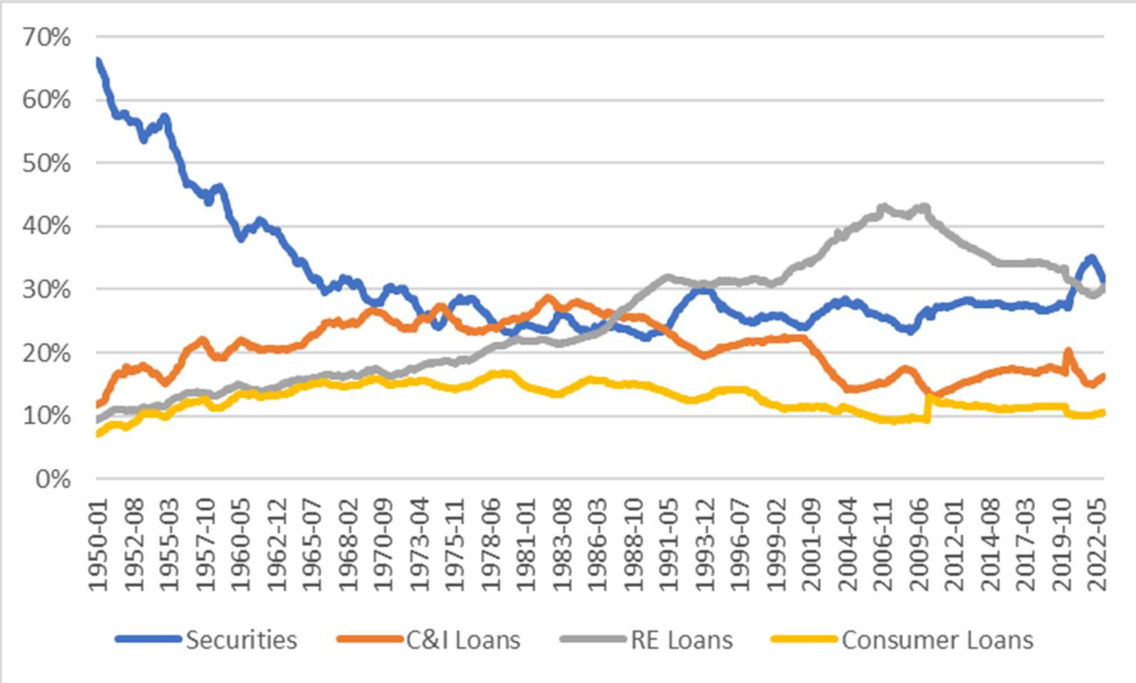

FIGURE A - 1 - PORTFOLIO SHARES IN BANK CREDIT OF US COMMERCIAL BANKS

Source: Flow of Funds Account, H.8 Assets and Liabilities of Commercial Banks in the United States. Board of Governors of the Federal Reserve System.

Notes: C&I Loans = Commercial and Industrial Loans; RE Loans = Real Estate Loans.

TABLE A - I – CORRELATION COEFFICIENTS OF MAIN EXPLANATORY VARIABLES OF JAPANESE BANKS PORTFOLIO SELECTION MODEL

	Loan rate spread	Margin	NPL ratio	Write Offs ratio	Leverage ratio	Due from banks to assets ratio	Output Gap	Std loan rates	Std loan to assets ratio
Loan rate spread	1.0000								
Margin	-0.0624	1.0000							
NPL ratio	-0.4559	0.4469	1.0000						
Write Offs ratio	-0.1551	0.1791	0.1742	1.0000					
Leverage ratio	-0.0635	0.1364	0.2557	0.0986	1.0000				
Due from banks to assets ratio	0.5661	-0.2067	-0.4168	-0.1179	-0.0043	1.0000			
Output Gap	0.2079	-0.0804	-0.1806	-0.0701	-0.0670	0.0572	1.0000		
Std loan rates	0.8193	-0.2177	-0.5560	-0.2326	-0.0642	0.5820	0.1914	1.0000	
Std loan to assets ratio	0.2370	-0.0085	-0.2505	-0.1204	-0.0167	0.1064	-0.0048	0.5501	1.0000

Notes: All variables are computed in logs but the standard deviations of both loan rates and loan to assets ratio. The calculation period is 2002 to 2021. The change in the log of margin not presented for the sake of conciseness has a maximum absolute value of 0.2597. The ratio of regional or prefectural to national output computed separately due to smaller sample size have a maximum absolute value correlation with other explanatory variables below 0.12. Computed separately for the same reason, correlations of (logs) ROE and ROA with other explanatory variables have a maximum absolute value of 0.2511 Source: Author’s calculations on data from JBA, BOJ, Bloomberg, and OECD.

TABLE A - II – JAPAN CROSS-SECTIONAL DEPENDENCE TESTS

	Pesaran (2004) CD Statistic		Pesaran (2015) CD Statistic	
Log GG bonds	131.62	***	102.375	***
Log Total Bank Assets	281.89	***	170.981	***
Log GG Bonds/Assets	177.49	***	100.955	***
Log Loan Rate/10-year JGB yield	319.87	***	265.323	***
Log Margin	157.35	***	144.473	***
Log NPL/Gross loans	267.08	***	231.972	***
Log Debt-to equity	50.25	***	30.474	***
Log of Regional(LT3)and National GDP real growth rate	9.75	***	8.701	***
Log of Regional(LT2)and National GDP real growth rate	11.43	***	10.967	***
Log (Gross) Charge-Offs/Gross Loans	n.a		34.634	***
Log Equity-to assets	49.07	***	29.863	***
Log ROA	109.35	***	101.297	***
Log Due from banks/Assets	213.54	***	175.224	***
Log Allowance for loan losses/Gross loans	217.45	***	212.291	***
Log Provisions for loan losses/Gross loans	n.a		47.771	***

Notes: The asterisks ***, **, * indicate significance at the 1, 5, 10% level. Pesaran(2004) has a null hypothesis of cross-sectional independence; Pesaran(2015) has a null hypothesis of weal cross-sectional independence. The tests are conducted over the period 2002-21. Pesaran (2004) test excludes a group of 19 banks for which there are less than 13 observations since the test requires a minimum number of observations, although it allows for unbalanced panels. Notwithstanding, it was not possible to compute ii in the cases marked as not available (n.a.). Source: Author's calculations on data from JBA, Bloomberg, and OECD.

TABLE A - III – HETEROSKEDASTICITY TESTS

H_0: constant variance of residuals					
Breusch-Pagan/Cook-Weisberg Test				White Test	
$\chi^2(1)$ Stat	p-value	F(1 , 1856)	p-value	$\chi^2(35)$ Stat	p-value
90.42	0.0006	4.36	0.0369	395.0700	0.0000

H_0: equality of variances across banks					
Brown and ForsytheTest				Levene Test	
W50		W10		W0	
F(129 , 1728)	p-value	F(129 , 1728)	p-value	F(129 , 1728)	p-value
3.2290	0.0000	5.2762	0.0000	8.0753	0.0000

H_0: equality of variances across time					
Brown and ForsytheTest				Levene Test	
W50		W10		W0	
F(15 , 1842)	p-value	F(15 , 1842)	p-value	F(15 , 1842)	p-value
3.4000	0.0000	3.5342	0.0000	3.9842	0.0000

Notes: Test on residuals from OLS regression of equation (1) over the period 2002-21 and all banks. The Levene test uses the mean (W0) as a measure of centre. Brown and Forsythe replace this measure with the median (W50) and with the 10% trimmed mean (W10). Conover, Johnson, and Johnson (1981) compare the properties of the mean and median tests and recommend using the median test for asymmetric data, as is the case of the Japanese data. Source: author's calculations.

TABLE A - IV – INITIAL MODEL: CUMBY-HUIZINGA SERIAL CORRELATION TEST

H_0: Serially Uncorrelated Ha: Serial correlation at range j					H_0: MA order lag-1 Ha: Serial correlation at lag j			
Lags Range From	To	χ^2 Stat.	df	p-value	Lag	χ^2 Stat.	df	p-value
1	1	36.153	1	0	1	36.153	1	0.0000
1	2	36.271	2	0	2	18.183	1	0.0000
1	3	36.537	3	0	3	33.507	1	0.0000
1	4	36.725	4	0	4	28.72	1	0.0000
1	5	53.253	5	0	5	27.491	1	0.0000
1	6	54.931	6	0	6	16.516	1	0.0000
1	7	64.646	7	0	7	15.239	1	0.0001
1	8	64.781	8	0	8	4.972	1	0.0258

Notes: Test robust to heteroskedasticity. MA = moving average; df = degrees of freedom; (*) indicates eigenvalues have been adjusted to make the matrix positive semidefinite. Source: Author's calculations.

TABLE A - V – ALTERNATIVE MEASURES OF JGB RETURNS

Variables		10-year JGB end of FY yield (1) Coef.	t Stat	(2) Coef.	t Stat	Annual Return of 10-year JGB Zero Coupon (3) Coef.	t Stat	(4) Coef.	t Stat
Constant	α	-2.016 ***	-10.44	-1.880 ***	-9.43	-0.888 ***	-3.55	-0.918 ***	-3.58
GG bonds to Total Assets (t-1)	β_0	0.741 ***	8.82	0.747 ***	8.94	0.763 ***	9.11	0.768 ***	9.29
Loan rate to 10y JGB yield/return	β_1	0.146 ***	3.86	0.073	1.28	0.230 ***	4.39	0.127 **	2.43
Margin	β_2	-0.109 *	-1.88			-0.146 **	-2.38		
ΔMargin	β_2			-0.307 ***	-4.73			-0.381 ***	-4.34
NPL ratio	β_3	0.061 ***	3.46	0.061 ***	3.95	0.085 ***	4.69	0.081 ***	5.56
Debt-to-equity	β_4	0.177 ***	5.04	0.177 ***	5.13	0.108 ***	3.23	0.103 ***	3.18
GDP to potential GDP x Assets	β_5	-0.018 ***	-5.55	-0.017 ***	-4.72	-0.006 ***	-5.73	-0.004 ***	-9.23
F Stat		954349 ***		687576 ***		3.31×10^6 ***		646081 ***	
df		(22,129)		(22,129)		(19,129)		(19,129)	
No bank effects F stat		2.2400 ***		2.2100 ***		1.9000 ***		1.7900 ***	
df		(129,1781)		(129,1779)		(129,1564)		(129,1564)	
No time effects F stat		0.51×10^6 ***		0.12×10^6 ***		0.20×10^6 ***		0.18×10^6 ***	
df		(16,129)		(16,129)		(13,129)		(13,129)	
Adj. R^2		0.8563		0.8568		0.8539		0.8544	
Root MSE		0.2376		0.2373		0.2541		0.2536	
AIC		-184.49		-189.51		49.039		42.8009	
$\chi^2(4)$ Stat.		1.721		1.782		4.900		6.638	
df		4		4		4		4	
Number of banks		130		130		130		130	
Number of observations		1933		1931		1713		1713	
Period		2002-21		2002-18		2002-21		2002-21	
Gaps in Period		2015,18,19		2015,18,19		2003,05,13,16,20		2003,05,13,16,20	

Notes: Dependent variable: GG bonds/Assets; Estimation: Fixed-effects with Driscoll-Kraay (1998) standard errors; F Stat. is the statistic of the F-test of overall significance; χ2(4) is the statistic of the Cumby-Huizinga test of serial correlation up to lag 4 with a null hypothesis of no serial correlation robust to within-cluster arbitrary correlation and between-cluster heteroskedasticity. The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Source: Author own calculations on data from JBA, BOJ and Bloomberg.

TABLE A - VI - ALTERNATIVE LEVERAGE MEASURES

Variables		Debt to Net Assets				Equity to Assets			
		(1)		(2)		(3)		(4)	
		Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat
Constant	α	-1.667 ***	-10.62	-1.526 ***	-9.83	-1.908 ***	-9.28	-1.776 ***	-8.69
GG bonds to Total Assets (t-1)	β_0	0.756 ***	9.26	0.762 ***	9.37	0.754 ***	9.21	0.760 ***	9.31
Loan rate to 10y JGB yield/return	β_1	0.179 ***	4.30	0.092	1.60	0.172 ***	3.95	0.091	1.51
Margin	β_2	-0.130 *	-1.78			-0.121 *	-1.68		
ΔMargin	β_2			-0.330 ***	-5.85			-0.319 ***	-5.64
NPL ratio	β_3	0.069 ***	3.96	0.067 ***	4.43	0.070 ***	3.87	0.068 ***	4.38
Debt-to-net assets/Equity to Assets	β_4	0.087 **	2.36	0.085 **	2.33	-0.156 ***	-4.30	-0.155 ***	-4.35
GDP to potential GDP x Assets	β_5	-0.017 ***	-6.95	-0.016 ***	-6.28	-0.018 ***	-7.40	-0.017 ***	-6.89
F Stat		$4.38*10^6$ ***		381595 ***		$7.38*10^6$ ***		717779 ***	
df		(23,129)		(23,129)		(23,129)		(23,129)	
No bank effects F stat		2.2500 ***		2.1500 ***		2.2900 ***		2.2100 ***	
df		(129,1896)		(129,1894)		(129,1896)		(129,1894)	
No time effects F stat		$0.17*10^6$ ***		$0.13*10^6$ ***		$0.11*10^6$ ***		$4.0*10^6$ ***	
df		(17,129)		(16,129)		(16,129)		(17,129)	
Adj. R^2		0.8595		0.8600		0.8604		0.8609	
Root MSE		0.2397		0.2393		0.2389		0.2385	
AIC		-152.36		-158.90		-165.34		-171.80	
$\chi^2(4)$ Stat.		4.482		5.238		4.247		4.864	
df		4		4		4		4	
Number of banks		130		130		130		130	
Number of observations		2049		2047		2049		2047	
Period		2002-21		2002-21		2002-21		2002-21	
Gaps in Period		2016,19		2016,19		2016,19		2016,19	

Notes: Dependent variable: GG bonds/Assets; Estimation: Fixed-effects with Driscoll-Kraay (1998) standard errors; F Stat. is the statistic of the F-test of overall significance; χ2(4) is the statistic of the Cumby-Huizinga test of serial correlation up to lag 4 with a null hypothesis of no serial correlation robust to within-cluster arbitrary correlation and between-cluster heteroskedasticity. The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Source: Author own calculations on data from JBA, BOJ and Bloomberg.

TABLE A - VII - ALTERNATIVE LOAN BOOK QUALITY MEASURES

Variables		Write-offs Ratio				Allowance loan losses				Provisions loan loasses			
		(1)		(2)		(3)		(4)		(5)		(6)	
		Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat	Coef.	t Stat
Constant	α	-1.875 ***	-3.76	-1.831 ***	-3.77	-2.032 ***	-6.36	-1.926 ***	-5.87	-1.845 ***	-4.51	-2.273 ***	-4.78
GG bonds to Total Assets (t-1)	β_0	0.921 ***	22.22	0.924 ***	23.04	0.757 ***	9.64	0.761 ***	9.72	0.823 ***	10.45	0.831 ***	10.49
Loan rate to 10y JGB yield/return	β_1	0.328 ***	5.10	0.319 ***	3.65	0.217 ***	3.78	0.145	1.42	0.313 ***	7.46	0.208 ***	2.73
Margin	β_2	-0.029	-0.28			-0.117	-1.20			-0.147	-1.28		
ΔMargin	β_2			-0.014	-0.10			-0.198 **	-2.35			-0.002	-0.01
Loan book quality	β_3	0.011 **	2.55	0.011 **	2.44	0.018	0.51	0.013	0.33	-0.007	-1.38	-0.004	-0.76
Debt-to-equity	β_4	0.315 ***	4.31	0.311 ***	4.60	0.200 ***	3.53	0.201 ***	3.57	0.204 ***	4.40	0.209 ***	4.21
GDP to potential GDP x Assets	β_5	-0.015 **	-2.56	-0.015 **	-2.52	-0.020 ***	-4.77	-0.019 ***	-4.58	-0.016 ***	-3.10	-0.448 ***	-4.24
F Stat		456953 ***		65462 ***		514729 ***		$1.09*10^6$ ***		336583 ***		475659 ***	
df		(23,123)		(23,123)		(23,129)		(23,129)		(23,129)		(23,129)	
No bank effects F stat		1.1000		1.1300		1.3800 ***		1.3400 ***		1.8500 ***		1.8000 ***	
df		(123,1364)		(123,1362)		(129,1904)		(129,1902)		(129,1450)		(129,1449)	
No time effects F stat		45300 ***		78410 ***		$10*10^6$ ***		$0.65*10^6$ ***		40465 ***		11457 ***	
df		(17,123)		(17,123)		(17,129)		(16,123)		(17,129)		(17,129)	
Adj. R^2		0.8311		0.8315		0.8184		0.8184		0.8579		0.8576	
Root MSE		0.2680		0.2679		0.2912		0.2913		0.2549		0.2552	
AIC		200.49		198.07		648.27		648.88		51.55		55.88	
$\chi^2(4)$ Stat.		6.393		6.823		4.488 *		3.950		9.453 *		8.766 *	
df		4		4		4		4		4		4	
Number of banks		124		124		130		130		130		130	
Number of observations		1511		1509		2,057		2055		1603		1602	
Period		2002-21		2002-21		2002-21		2002-21		2002-21		2002-21	
Gaps in Period		2016,19		2016,19		2016,19		2016,19		2016,19		2016,19	

Notes: Dependent variable: GG bonds/Assets; Estimation: Fixed-effects with Driscoll-Kraay (1998) standard errors; F Stat. is the statistic of the F-test of overall significance; χ2(4) is the statistic of the Cumby-Huizinga test of serial correlation up to lag 4 with a null hypothesis of no serial correlation robust to within-cluster arbitrary correlation and between-cluster heteroskedasticity. The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Source: Author own calculations on data from JBA, BOJ and Bloomberg.

TABLE A - VIII – ENDOGENEITY OF LOAN RATE SPREAD AND MARGIN: IV ESTIMATION RESULTS

Variables	Model 1				Model 2			
	(1)		(2)		(3)		(4)	
	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat
GG bonds to Total Assets (t-1)	0.743 ***	17.19	0.744 ***	16.88	0.753 ***	18.60	0.753 ***	18.89
Loan rate to 10y JGB yield/return	0.259	1.18	0.262	1.45	-0.094	-0.38	-0.040	-0.21
Margin	0.236 *	1.72	0.248 *	1.93				
ΔMargin					-1.101 **	-2.47	-0.980 **	-2.27
NPL ratio	0.070 ***	2.73	0.082 ***	3.11	0.086 ***	3.43	0.093 ***	3.71
Debt-to-equity	0.180 ***	3.21	0.180 ***	3.30	0.151 ***	2.58	0.152 ***	2.76
GDP to potential GDP x Assets	-0.013 ***	-2.84	-0.011 ***	-2.58	-0.010 **	-2.40	-0.011 ***	-2.81
ROA (t-2)	0.021 ***	2.91	0.023 ***	2.95	0.012	1.41	0.016 *	1.85
Due from banks / Assets	-0.052 ***	-5.36	-0.053 ***	-5.66	-0.047 ***	-4.21	-0.048 ***	-4.51
Loan Rate Spread x Repo x Mkt Major Players	-0.039	-0.83	-0.019	-0.71	-0.030	-0.55	-0.018	-0.79
Loan Rate Spread x Top Banks by Assets	0.080 **	2.06	0.030	1.04	0.068	1.26	0.014	0.42
Qtle 1 Banks by Asset Growth	-0.052 ***	-3.14	-0.043 ***	-2.82	-0.060 ***	-3.44	-0.050 ***	-3.21
Qtle 2 Banks by Asset Growth	-0.018 *	-1.80	-0.016	-1.56	-0.014	-1.36	-0.011	-1.03
Loan Rate Spread x Qtle 3 Banks by Leverage	0.026 **	2.46	0.028 ***	3.31	0.021 *	1.85	0.028 ***	3.30
Qtle 3 Banks by Leverage	-0.036 **	-2.03	-0.031 **	-2.03	-0.022	-1.25	-0.023	-1.50
Std GDP to potential GDP x Assets	0.018 **	2.17	0.021 ***	2.96	0.043 ***	3.81	0.036 ***	3.73
Std (log) deposit-to-assets x Deposit-to-assets	-0.051	-1.02	-0.050	-1.00	-0.039	-0.83	-0.034	-0.77
Std (log) loan-to-assets ex trust banks x Mean loan-to-assets	-0.536 *	-1.78	-0.415	-1.55	-0.331	-1.07	-0.192	-0.78
F Stat	227.050 ***		220.760 ***		220.19 ***		211.71 ***	
df	(33,129)		(35,129)		(32,128)		(34,128)	
Root MSE	0.2362		0.2391		0.2371		0.2381	
AIC	-161.79		-115.63		-143.88		-130.18	
Number of banks	130		130		129		129	
Number of observations	1916		2143		1809		2036	
Period	2002-21		2002-21		2002-21		2002-21	
Gaps in Period	2016,19				2016,19			
Hansen J (p-value)	0.4239		0.5198		0.4040		0.3423	

Notes: Notes: Dependent variable (log) GG bonds-to-assets; Estimation method - IV estimation by fixed-effects with bank-clustered standard errors to allow for intra-institution correlation with no degrees-of-freedom adjustment for the number of fixed effects as proposed by Arellano (1987); MSE - Mean squared error; AIC – Akaike information criteria; all variables in logs but the standard deviations; no constant is estimated; the coefficients estimates associated with time and bank fixed effects are omitted; F Stat. is the statistic of the F-test of overall significance; Hansen J reports p-values of the null hypothesis that the instruments used are not correlated with the residuals The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Source: Author own calculations on data from JBA, BOJ and Bloomberg.

TABLE A - IX – IV ESTIMATION EXOGENEITY TESTS

	Model 1		Model 2	
	C Stat.	(p-value)	C Stat.	(p-value)
NPL ratio	0.253	0.6150	1.255	0.2626
Debt-to-Equity	0.656	0.4180	1.221	0.2692
Due from Banks to Assets	1.317	0.2512	3.450	0.0632
GDP to potential GDP x Assets	1.716	0.1902	3.321	0.0684
ROA (t-2)	0.081	0.7758	0.086	0.7691
Loan Rate Spread Interactions			3.659	0.3007
Loan Rate Spread x Repo x Mkt Major Players	1.338	0.2474		
Loan Rate Spread x Top Banks by Assets	0.610	0.4347		
Loan Rate Spread x Qtle 3 Banks by Leverage	0.856	0.3548		
Asset Growth Dummies			1.501	0.4722
Qtle 1 Banks by Asset Growth	1.326	0.2495		
Qtle 2 Banks by Asset Growth	0.000	0.9875		
Qtle 3 Banks by Leverage	0.539	0.4628	1.447	0.2290
Volatility variables			3.974	0.2643
Std GDP to potential GDPx Assets	0.873	0.3502		
Std (log) deposit-to-assets x deposit-to-assets	1.558	0.2120		
Std (log) loan-to-assets ex trust banks x mean loan-to-assets	0.089	0.7660		

Notes: The C statistic is defined as the difference of the Hansen statistics of the equation with the smaller set of instruments and the equation with the full set of instruments, including the ones being tested. Under the null hypothesis both the smaller set of instruments and the ones being tested are valid. The instruments being tested are all included instruments. The equation that does not use these orthogonality conditions treats the tested instruments as included endogenous variables. Source: Author own calculations on data from JBA, BOJ and Bloomberg.

TABLE A - X - DPD SYSTEM GMM ESTIMATES OF REGIONAL AND 2^{ND} ASSOCIATION BANKS

Variables	Model 1				Model 2			
	Regional		2nd Association		Regional		2nd Association	
	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat	Coef.	z Stat
Constant	-1.301 ***	-4.13	-1.554 ***	-4.23	-0.761 ***	-3.00	-0.571	-1.21
GG bonds to Total Assets (t-1)	0.911 ***	19.07	0.851 ***	19.74	0.942 ***	22.76	0.852 ***	14.06
Loan rate to 10y JGB yield/return	0.392 **	2.18	0.305	1.24	0.079	0.43	-0.414	-1.04
Margin	-0.212	-1.50	-0.140	-0.82				
ΔMargin					-0.673	-1.50	-1.219 *	-1.65
NPL ratio	0.030	1.25	0.050	1.30	0.053	1.47	0.104 *	1.79
Debt-to-equity	0.058 **	2.15	0.100 ***	3.51	0.035	1.44	0.064 **	2.45
GDP to potential GDP x Assets	-0.017 ***	-3.14	-0.011 **	-2.03	-0.012 **	-2.35	-0.007	-1.13
ROA (t-2)	0.024 ***	3.57	0.013 *	1.88	0.021 ***	2.61	0.019 *	1.81
Due from banks / Assets	-0.027 ***	-4.01	-0.020 **	-2.14	-0.027 ***	-4.65	-0.019 **	-1.96
Loan Rate Spread x Repo x Mkt Major Players	0.016 **	2.31			0.017 **	2.18		
Loan Rate Spread x Top Banks by Assets								
Qtle 1 Banks by Asset Growth	-0.014	-1.47	-0.087 ***	-4.23	-0.018 *	-1.77	-0.089 ***	-3.30
Qtle 2 Banks by Asset Growth	-0.010	-1.02	-0.035 **	-2.14	-0.010	-1.06	-0.039 **	-2.21
Loan Rate Spread x Qtle 3 Banks by Leverage	0.002	0.24	0.027 **	2.16	0.007	0.77	0.039 ***	2.65
Qtle 3 Banks by Leverage	0.004	0.29	-0.029	-1.22	0.000	0.02	-0.046 **	-2.34
Std GDP to potential GDPx Assets	0.010	1.03	0.035 *	1.80	0.008	0.84	0.013	0.63
Std (log) loan-to-assets ex trust banksxmean loan-to-assets	-0.220	-0.92	-0.252	-0.70	0.094	0.59	0.602	1.16
Std (log) deposit-to-assets x deposit-to-assets	-0.684 **	-2.18	-1.432 ***	-2.77	-0.537 *	-1.66	0.131	0.11
Wald χ2	544127 ***		921856 ***		857946 ***		571578 ***	
df	33		32		33		32	
Arellano-Bond test for AR(2) in first differences (p-value)	0.431		0.106		0.345		0.303	
Hansen J test of over-identifying restrictions (p-value)	0.939		0.716		0.919		0.817	
Number instruments	39		38		42		41	
Number of banks	65		47		65		47	
Number of observations	1089		728		1089		728	
Period	2002-21		2002-21		2002-21		2002-21	
Gaps in Period	2016,19		2016,19		2016,19		2016,19	

Notes: Dependent variable (log) GG bonds-to-assets; Estimation method – Two-steps 'System' GMM of Arellano & Bover (1995) and Blundell & Bond (1998) with forward orthogonal deviations and bank-clustered standard errors with Windmeijer's correction to allow for intra-institution correlation; endogenous variables: lagged dependent variable; loan rate spread and the (change in) margin; regression 1 uses as additional instrument the ratio of general and administrative expenses to ordinary income; regression 2 uses the same variable but lagged and as additional instruments in the level equation the deposit rate, the lagged ratio of allowances to loans losses to loans and the lagged ratio of general and administrative expenses to loans; regression 4 uses as additional instruments in the level equation the deposit rate, the lagged ratio of allowances to loans losses to loans and the lagged ratio of general and administrative expenses to loans; all variables in logs but the standard deviations; the coefficients estimates associated with time fixed effects are omitted; Wald Stat. is the statistic of the χ2-test of overall significance. Arellano-Bond test for AR(2) reports the p-value, failure to reject the null indicates that lags of the dependent variable (and any other variables used as instruments that are not strictly exogenous), are in fact endogenous, thus inappropriate instruments; Hansen J reports p-values of the null hypothesis that the instruments used are not correlated with the residuals The asterisks ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.