EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

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The shifts and the shocks: bank risk, leverage, and the macroeconomy

ECB - Lamfalussy Fellowship Programme

No 2672/ June 2022

ECB Lamfalussy Fellowship Programme

This paper has been produced under the ECB Lamfalussy Fellowship programme. This programme was launched in 2003 in the context of the ECB-CFS Research Network on "Capital Markets and Financial Integration in Europe". It aims at stimulating high-quality research on the structure, integration and performance of the European financial system.

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Abstract

This paper studies the long-run evolution of bank risk and its links to the macroeconomy. Using data for 17 advanced economies, we show that the riskiness of bank assets declined materially between 1870 and 2016. But even though bank assets have become safer, the losses on these assets are associated with increasingly large output gaps. Before 1945, bank asset returns had no excess predictive power for future economic activity, while after 1945 they have outperformed non-financials as a predictor of GDP. We provide evidence linking this increasing connectedness between banks and the macroeconomy to secular increases in financial and macroeconomic leverage.

Keywords: bank risk, leverage, banking crises, macro-financial linkages, long-run trends

JEL classification codes: G01, G15, G21, E44, N20, O16

Non-technical summary

The interplay between banks and the macroeconomy has been of central interest to economists and policymakers at least since the Great Depression. This interplay is two-fold. On the one hand, banks hold risky loans and securities, which makes them exposed to macroeconomic risk. On the other hand, bank distress can hinder credit supply and money creation, meaning that banks can be a source of risk for the macroeconomy. But both banks' macroeconomic risk exposures, and the amount of risk they can generate, depend crucially on the structure of the banking sector. This structure has changed materially over the past 150 years, with banks becoming larger, more levered, and shifting their asset portfolios towards mortgages.

In this paper, we empirically study the interplay between bank and macroeconomic risks. To facilitate this analysis, we combine three recently developed datasets consisting of monthly and annual data on market returns on bank equity as well as accounting data on bank leverage and profitability. Using these data, we construct measures of bank risk, and study the links between bank risk and the macroeconomy, for 17 advanced economies between 1870 and 2016.

We start by documenting the long-run trends in bank asset risk. We construct three measures of asset risk, based on, respectively, the unconditional volatility, the market beta, and the level of bank asset returns (which we, in turn, estimate by unlevering the return on bank equity). All three measures point to material long-run declines in bank asset risk, with asset risks falling by a factor of about 5 between 1870 and 1950, and doubling between 1950 and 2016. But these declines in asset risks do not necessarily mean that the banking system has become safer. On the contrary, we show that combined measures of risk, such as the banking system z score and bank equity return volatility, did not decline and even increased over the long run. The reason for these increases is that the declines in asset risk were accompanied by sharp increases in leverage, which raised bank equity and default risks.

We then turn to study links between bank asset risk realisations and future economic outcomes. To do this, we regress future GDP growth on today's bank asset return, conditional on the returns on non-financial equity and other macro-financial variables which help reduce concerns about reverse causality. The main result of this analysis is that the macroeconomic consequences of bank asset losses have become much more severe over time. Before 1945, bank asset returns contained no information on future macroeconomic fundamentals beyond that contained in non-financial equities. After 1945, bank asset returns are strongly positively correlated with future GDP growth, outperforming non-financial equity as a predictor. We argue that these changing correlations are linked to the changing nature of the transmission of bank asset shocks to the broader macroeconomy. To support this hypothesis, we show that the predictive power of bank asset returns is much stronger in high-leverage and low-macroeconomic-risk regimes, particularly when it comes to negative returns, i.e., bank asset losses. This suggests that as bank assets became safer, banks have increasingly levered up against lower risk, increasing the amplification of bank asset losses to the real economy.

Taking a birds-eye view of our findings, we can highlight the following three broad historical phases in the evolution of macro-financial risks associated with banking. The early historical period was characterised by risky, well-capitalised banking, with banks exposed to high macroeconomic risk but little evidence of shock amplification. By the early to mid 20th century, bank assets had become safer and bank leverage had increased, but the connections between bank asset risks and future macroeconomic outcomes remained weak. In the late 20th century, a highly levered and rapidly growing banking sector faced some increases in asset risk, with bank asset losses followed by increasingly large reductions in economic activity.

Our findings carry the following two implications for policymakers. First, we show that macroeconomic risks arising from banking may be high even when measured bank asset risks are very low. This, in turn, means that low bank asset risks can, somewhat paradoxically, signal a high risk to overall macro-financial stability. Second and relatedly, looking ahead, future financial innovation and advances in risk management may well reduce bank asset risk further. But the historical experiences from past asset risk reductions tell us that this will not necessarily make the banking system, and the macroeconomy, safer.

1. Introduction

The interplay between banks and the macroeconomy has been of central interest to economists at least since the Great Depression (Fisher, 1933; Friedman and Schwartz, 1963; Bernanke, 1983). This interplay is two-fold. On the one hand, banks are exposed to macroeconomic risk through their loan and security portfolios (Begenau, Piazzesi, and Schneider, 2015; Nagel and Purnanandam, 2020). On the other, shocks to the banking sector can impair credit supply and money creation, with potentially adverse macroeconomic effects (Jordà, Schularick, and Taylor, 2013; Chodorow-Reich, 2014; Huber, 2018; Baron, Verner, and Xiong, 2021). Brunnermeier and Sannikov (2014) formalise this interplay in a theoretical framework featuring two different types of risk: exogenous risk arising from banks' exposures to macroeconomic shocks, and endogenous risk arising from amplification of these shocks within the banking system. But both banks' macroeconomic risk exposures, and their transmission through the financial system, depend crucially on the structure of the banking sector. Over the past 150 years, this structure has changed materially, with banks becoming larger, more levered, and shifting their loan portfolio towards mortgages (Schularick and Taylor, 2012; Philippon, 2015; Jordà, Schularick, and Taylor, 2016; Jordà, Richter, Schularick, and Taylor, 2021). As a result, the capacity of the banking sector to withstand and amplify macroeconomic shocks may also have changed over the long run.

This paper studies the long-run evolution of bank risk and its links to the macroeconomy. We start by studying trends in bank asset risk, its amplification through leverage, and the resulting changes in equity and default risk of the banking system. We then explore how the relationship between bank risk realisations and real activity has changed over time, and why. To do this, we estimate how the link between bank asset returns and future economic performance differs across time periods, macroeconomic risk environments, and banking system structures. To enable our analysis, we combine three long-run datasets on market returns on bank equity (Baron, Verner, and Xiong, 2021), bank balance sheets (Jordà, Richter, Schularick, and Taylor, 2021), and their profits and losses (Richter and Zimmermann, 2020). These data allow us to construct measures of bank risk, and study its realisations across 17 advanced economies for years 1870–2016.

We find that bank asset risk declined by a factor of five between 1870 and 1950 across several risk measures. After 1950, bank asset risk increased, but remained well below historical levels. The secular decline in asset risk was, however, accompanied by substantial increases in banking sector leverage and size, with bank equity and default risk remaining stable or even increasing. Turning to the macroeconomic consequences of these secular shifts, we show that even though bank assets have become safer, the losses on these assets are associated with increasingly large output gaps. Conditional on non-financial returns, changes in bank asset values had no excess predictive power for macroeconomic outcomes historically, but robustly predict GDP growth in the post World War II period. Guided by theory, we link this transition to secular changes in risk and leverage, showing that bank asset losses are followed by much lower GDP growth when past realised risks are low, and when bank assets are large relative to bank equity or GDP.

Our paper adds a risk perspective to the literature documenting long-run changes in the financial sector. Schularick and Taylor (2012) and Philippon (2015) have shown that the size of the financial sector increased materially during the 20th century. We show that this financialisation was accompanied by a decline in the riskiness of bank assets. Consistent with evidence on the growth in mortgage lending (Jordà et al., 2016), we also find that housing risk makes up an increasing fraction of bank asset risk. Importantly, facing lower asset risk, the banking sector increased its leverage relative to bank equity (as documented by Jordà et al., 2021), and to GDP. As a result, measures of overall bank risk, taking asset risk and leverage into account, have actually increased.

Taking a long-run perspective on bank asset risk also provides new insights on the drivers of macro-financial risk, and the nature of linkages between the real and financial sectors. Theoretical studies have shown that banks can transmit and amplify macroeconomic shocks through changes in net worth (Kiyotaki and Moore, 1997), credit frictions (Bernanke, Gertler, and Gilchrist, 1999), market liquidity, and asset prices (Brunnermeier and Pedersen, 2008; Adrian and Shin, 2010). We provide evidence linking bank asset returns to future macroeconomic outcomes, and show that these links are both state-dependent and time-varying in ways that are consistent with theory (Brunnermeier and Sannikov, 2014; Adrian and Boyarchenko, 2012). Our results provide support for the notion that the banking sector can be a source of risk for the macroeconomy, and that the macroeconomic risks arising from banking can be especially high in times of low macroeconomic volatility and high asset safety.

Empirically, previous studies have shown that materialisations of bank equity risk in the form of market returns (Baron et al., 2021) and systemic crisis events (Reinhart and Rogoff, 2009; Jordà et al., 2013) are followed by low GDP growth. By focussing on the effects of bank equity declines, however, these studies combine the impact of the fundamental bank asset risk realisations and their amplification through leverage. We separate equity risk realisations into these two components, and show that the macroeconomic consequences of large changes in bank asset values at low levels of leverage are much more benign than those of small changes in bank asset values at high levels of leverage. Consequently, the excess predictive power of bank risk realisations has changed over time in ways that can be linked to changes in size, leverage, and risk exposures of the banking system. These state-dependencies align well with recent findings of state-dependence in banking crisis probabilities and costs, with Danielsson, Valenzuela, and Zer (2018) documenting a "volatility paradox" of high crisis risk following periods of low stock market volatility, and Jordà et al. (2021) showing that crisis costs are higher when banks are less well capitalised. Our findings point to a volatility paradox at secular frequency, and link it to long-run shifts in financial and macroeconomic leverage (measured as, respectively, bank assets relative to bank equity, and to GDP).

We start our analysis by studying the long-run evolution of three measures of bank asset risk. All measures point to large historical asset risk declines before 1950, and moderate increases thereafter which did not fully compensate for these historical declines. We find that the volatility of the monthly market-implied return on bank assets (the unlevered excess equity return, constructed as in Doshi, Jacobs, Kumar, and Rabinovitch, 2019) fell from about 1ppt per month in the 1870s to about 0.2ppts per month in 1950, and gradually increased since then, to about 0.4ppts in 2010. The market beta of banking sector assets follows a similar trajectory, falling between 1870 and 1950, and increasing somewhat thereafter. Another measure of risk is the return on bank assets, with riskier assets, other things being equal, commanding a higher return.[1] Both accounting and market-implied returns on bank assets have declined by a similar amount to volatility over the long run, from about 2.5% per year in the 1870s to 0.5% per year in the 1950s and subsequent decades, consistent with banks receiving a lower compensation for their asset risk exposures.

We link these asset risk declines to, first, lower bank exposures to macro-financial risk, and, second, a less risky macroeconomic environment. We show that banks' exposures to interest rate risk and corporate credit risk – measured as market betas of asset returns on the relevant risk factors – experienced sharp declines in the period before 1930, and remained low thereafter. Unlike these risk exposures, the exposure to housing risk was close to zero historically and increased after 1970, consistent with the evidence of increasing importance of real estate backed loans on bank balance sheets (Jordà et al., 2013). We also document long-run declines in two macroeconomic risks relevant for banking: downside macroeconomic risk in the form of recessions (Nagel and Purnanandam, 2020), and the risk of high inflation or deflation, which can exacerbate the asset-liability interest rate mismatches and affect the real burden of debt (Fisher, 1933; Bernanke and James, 1991; Agarwal and Baron, 2021). Between 1870 and 1950, both the recession probability and the probability of high or negative inflation more than halved.

The falls in bank asset risk were accompanied by sharp increases in financial and macroeconomic leverage, with bank capital ratios falling by a factor of four, and bank assets relative to GDP increasing by a factor of six between 1870 and 2016.[2] These increases in financial and macroeconomic leverage have amplified the impact of bank asset returns on bank equity values, and increased their size relative to overall economic activity. In fact, none of the decrease in bank asset risk translated into lower risks of bank equity: on the contrary, measures of bank equity risk were stable before 1950, and increased in the subsequent decades. As a consequence of these increases in leverage and equity risk, the banking system's distance to default (z score) was actually lower after 1990, a time of low asset volatility, than before 1900, when asset risk was high.

In the second part of the paper, we explore how these long-run changes in asset risk and leverage affected the ability of banks to transmit and generate macroeconomic risk. To assess this, we first examine the predictive power of realised bank risk by regressing future GDP growth on today's realisation of the bank asset return, controlling for returns on non-financial equity and other macroeconomic covariates. In this, we follow the methodology of Baron et al. (2021) who show that bank equity returns predict macroeconomic outcomes, but we decompose the equity return into the underlying change in bank asset values and its amplification through leverage. This allows us to

[1] For example, Meiselman, Nagel, and Purnanandam (2020) show that in a cross-section of banks, accounting profitability offers a good proxy for systematic risk exposure.

[2] The increases in financial and macroeconomic leverage took place in different time periods, however. The fall in bank capital ratios took place between 1870 and 1950, and most of the increase in bank assets relative to GDP took place between 1960 and 2016.

first study the link between bank asset returns and macroeconomic outcomes, and, in a second step, to assess how this relationship depends on leverage.

We find that, on average, negative bank asset returns are followed by low GDP growth even after controlling for the returns of non-financials. But this impact varies substantially over time, and depends on banking sector leverage and past macro-financial volatility. Starting with the time dimension, we show that bank asset returns had no excess predictive power over non-financials before 1945 – a period of low leverage and high asset risk – but became a strong predictor of macro fundamentals after 1945, with a one standard deviation decline in bank asset values followed by 1% lower real GDP growth over the following 5 years. Non-financial equities, on the contrary, strongly predicted GDP growth before 1945, but lost their excess predictive power afterwards. We then link these changes in predictive power to the long-run shifts in bank risk and leverage documented in the first part of the paper. We show that when financial or macroeconomic leverage is high, or when past macro-financial volatility is low, bank asset returns have strong excess predictive power for future economic activity. When leverage is low or past volatility is high, this predictive power is absent. We further show that the leverage state dependencies are also present for bank equity (rather than asset) returns, which are strongly correlated with future GDP growth in high leverage regimes, but not in low leverage regimes. This shows that small falls in asset values in high leverage regimes are associated with much larger output gaps than large falls in asset values at low leverage, pointing to further amplification of bank asset risk realisations that goes above and beyond the effects on bank equity.

One economic interpretation of these results is that in the earlier historical period, banks were highly exposed to macroeconomic risks but did not amplify them, explaining the high asset volatility, low leverage, and low excess predictive power of bank asset returns for future GDP. Over recent decades, however, banks have begun to transmit and amplify economic shocks, with negative changes in bank asset values followed by lower GDP growth above and beyond what we would expect based on information contained in non-financial equities. These findings align with the theoretical predictions of Brunnermeier and Sannikov (2014), where the impact of bank shocks is amplified by banks levering up against low measured risks. To further study the potential mechanisms behind such amplification, we test whether the relationship between bank asset value changes and macroeconomic outcomes features asymmetries and non-linearities, both important mechanisms for shock transmission in the theoretical literature. We find support for both of these, showing that, (i) the predictive power of negative changes in bank asset values is larger than that of positive ones, and (ii) bank asset value changes have much stronger predictive power if the banking sector is in a crisis state. We also find that the asymmetries and non-linearities in (i) and (ii) are both increasing in leverage.

Other things being equal, the long-run decline in bank asset risk should have created a safer and more stable banking system. But in reality, this shift was accompanied by large increases in leverage, and much larger output gaps in the aftermath of bank asset losses. These findings apply not only to changes in bank asset values, but also to the behaviour of banks and the economy around systemic banking crisis events. In the final part of the paper, we document an increase in banking crisis costs over time, with post-crisis growth contractions much larger after 1945 (around 10% lower GDP after 5 years) than before (around 5% lower GDP after 5 years). We link these increases in crisis costs to rising financial and macroeconomic leverage by showing that crises that take place when banking sector assets are large relative to GDP or to bank equity are followed by larger economic contractions.

2. The shifts: changes in risk within banking

2.1. Measuring bank asset risk

Most bank assets are not traded, and hence their market prices and the corresponding volatilities are not directly observable. This makes it challenging to measure bank asset risk directly. To overcome this issue, we instead rely on a number of proxies for bank asset risk, which combine the market data on bank equity prices with data on bank capital structure to construct estimates of the market return on bank assets. Higher risk should make bank asset returns more volatile, higher (to compensate investors for this risk, see, e.g., Meiselman et al., 2020), and more exposed to variation in macro-financial risk factors such as interest rates (see, e.g., Begenau et al., 2015). To this end, we estimate proxies for bank asset return volatility, level, and risk exposures (betas). We complement these market-based estimates with accounting profit and loss data which have a broader coverage, but are somewhat less timely and may underestimate risk due to income smoothing. We describe how we construct each measure of asset risk below.

1. Volatility of bank asset returns: Our first proxy for asset risk is the volatility of banking sector asset returns. To calculate the realised excess market return on bank assets, we follow Doshi et al. (2019) and unlever the monthly excess market return on bank equity. To calculate this measure, we first compute the realised excess return on bank equity as the sum of the capital gain and dividends paid on listed bank stocks minus the government bill rate, and multiply it by the bank capital ratio to unlever it:

$$\begin{aligned} \mathrm{R}^{\text{asset}}_{i,t} &= \text{Capital Ratio}_{i,t} * \mathrm{R}^{\text{bank equity}}_{i,t}, \qquad (1)\\ \text{where } \mathrm{R}^{\text{bank equity}}_{i,t} &= \mathrm{P}_{i,t}/\mathrm{P}_{i,t-1} + \text{Dividends}_{i,t}/\mathrm{P}_{i,t-1} - \mathrm{R}^{\text{safe}}_{i,t},\\ \text{and Capital Ratio}_{i,t} &= \frac{\text{Equity Liabilities}_{i,t}}{\text{Total Liabilities}_{i,t}}. \end{aligned}$$

Above, $\mathrm{R}^{\text{asset}}$ is the realised excess return on bank assets, $\mathrm{R}^{\text{bank equity}}$ is the realised total return on bank equity, R^{safe} is the nominal short-term government bill rate, and the capital ratio is computed as the equity liabilities of the banking system divided by total (equity and debt) liabilities.

We then compute the standard deviation of this market return over 10-year rolling windows:

$$\text{Volatility}\left(\text{R}^{\text{asset}}\right)_{i,t} = \text{Std. dev.}\left(\text{R}^{\text{asset}}_{i,j,t}\right)_{t-5,t+5}, \tag{2}$$

where j and t are, respectively, the month and year indices, and i is the country index.

2. Bank asset return beta: In most standard asset pricing models, investors are compensated for exposures to systematic or undiversifiable risk, rather than total volatility. To construct a measure of the systematic risk exposure of bank assets, we compute the beta of the asset return with respect to the monthly excess return on non-financial equity:

$$\beta^{\text{market}}_{i,t} = \frac{\text{Cov}\left(\text{R}^{\text{asset}}_{i,j,t}, \text{R}^{\text{nonf equity}}_{i,j,t}\right)_{t-5,t+5}}{\text{Var}\left(\text{R}^{\text{nonf equity}}_{i,j,t}\right)_{t-5,t+5}}. \tag{3}$$

Above, Cov() is the covariance between the monthly realised excess return on bank assets and the excess return on non-financial equity, and Var() is the variance of non-financial stock returns, within a 10-year centered rolling window.

3. Level of bank asset returns: Alternatively, we can also study the level of returns to infer the bank risk profile with higher returns implying a compensation for a higher level of risk (Meiselman et al., 2020). We start with the standard accounting RoA measure calculated as net profits over assets:

$$\text{RoA}_{i,t} = \frac{\text{Net Profits}_{i,t}}{\text{Total Assets}_{i,t}}. \tag{4}$$

Above, net profits are the total profits of all domestic banks in country i and year t net of taxes and depreciation, and total assets are equal to the sum of bank equity and debt liabilities.[3]

Accounting standards differ across time and countries. Our data adjust for these differences when the required information is available, but some variation in accounting standards is likely to remain. Accounting data may also be slow to respond to new information and may therefore not reflect the full range of risks faced by banks in a timely manner. To this end, we complement the accounting RoA with a more timely and forward-looking measure based on market data. Realised market returns, however, only provide a noisy proxy for the investor compensation demanded for bearing risk. This is because they include unanticipated shocks in the form of new information – the unexpected return – as well as the expected return required as compensation for future anticipated risks (Elton, 1999). While averages of past realised returns may provide an accurate reflection of the average level of risk faced by banks, a direct expected return measure should be a better proxy for the time varying trend in the risk compensation. This is because the expected return measure is

[3]Note that unlike the excess market return measure, the accounting RoA measures total returns, gross of the safe interest rate. This is primarily because computing a comparable safe rate for accounting data is much more difficult than for market data. Nevertheless, we construct several alternative proxies for the accounting excess return measure, which all follow the same trend as our baseline measure in equation (4) (see Appendix Figure A.2).

much less noisy, and often moves in the opposite direction to realised returns over the medium run, as falls in the expected return reduce the rate at which future dividends are discounted and boost stock prices and realised returns.[4]

To compute the expected return on bank assets, we unlever the expected total return on bank equity by multiplying it by the bank capital ratio.[5] To compute the expected return on bank equity, we follow previous studies of the US stock market and use the simple dividend discount model (Gordon, 1962), which calculates the expected return as the sum of the dividend yield and long-run dividend growth. This gives us the following proxy for the expected return on bank assets, $\mathbb{E}(R^{\text{asset}})$:

$$\begin{aligned} \mathbb{E}\left(R_{i,t}^{\text{asset}}\right) &= \text{Capital Ratio}_{i,t} * \mathbb{E}(R_{i,t}^{\text{bank equity}}), \\ \text{where } \mathbb{E}(R_{i,t}^{\text{bank equity}}) &= \text{Dividends}_{i,t}/P_{i,t} + \overline{g_i}. \end{aligned} \tag{5}$$

Above, $\overline{g_i}$ is the long-run real dividend growth rate. Because historical dividend growth rates are very volatile, this biases up the estimates of $\overline{g_i}$ based on arithmetic averages of past dividend growth data. Within the framework of the Gordon model, $\overline{g_i}$ is equal to the average real capital gain, and we estimate it as the mean real capital gain on bank stocks in country i. Using historical averages of dividend growth rates instead of capital gains, however, leaves the trends in our data unchanged (see Appendix Figure A.2).[6]

4. Banks' exposures to credit, interest rate and housing risk Our final measure of bank asset risk relates to the exposures of asset returns to macro-financial risk factors, i.e., their betas. These allow us to capture the sensitivity of bank asset returns to changes in the relevant macro-financial risks, such as movements in interest rates and the performance of the corporate sector, over and above the responses to market risk [the market beta in equation (3)]. To calculate these risk exposures, we run the following rolling window regression:

$$R_{i,t}^{\text{asset}} = \alpha_i + \beta^{\text{mkt}} R_{i,t}^{\text{eq}} + \beta^{\text{irate}} R_{i,t}^{\text{gbond}} + \beta^{\text{credit}} R_{i,t}^{\text{corpbond}} + \beta^{\text{housing}} R_{i,t}^{\text{housing}} + u_{i,t}. \tag{6}$$

Above, R^{asset} is the realised market return on bank assets computed as in equation (1), R^{gbond} is the

[4]For example, Fama and French (2002) argue that while realised returns on US equities show no clear trend, the expected return declined between 1951 and 2000, with this decline pushing realised equity returns in the opposite direction (up) by boosting the discounted value of dividends and, hence, stock prices.

[5]To be consistent with the accounting RoA measure, and because of the difficulty in measuring the expected real safe rate, we again focus on total rather than excess returns.

[6]This market-based estimate of the asset return also ignores the risk premium on bank debt, which is difficult to measure and is likely to be small given that the majority of bank debt liabilities consist of insured deposits. As a further robustness check, we construct a market RoA estimate which accounts for the riskiness of bank debt, using the corporate bond spread as a proxy of the bank debt risk premium, as follows: $\widetilde{R}_{i,t}^{\text{asset, risky debt}} = R_{i,t}^{\text{ex. asset}} + (\text{Risky Debt}_{i,t}/\text{Total Liabilities}_{i,t}) * \text{Debt Risk Premium}_{i,t}$, where $R^{\text{ex. asset}}$ is the excess expected return on bank assets calculated by unlevering the expected equity return minus a proxy for the real safe rate estimated using the Del Negro et al. (2019) method, risky debt is equal to non-deposit bank debt liabilities, and the debt risk premium is the difference between yield to maturity on long-term corporate and government bonds. This measure follows the same trend as our baseline estimate in equation (5), see Appendix Figure A.2.

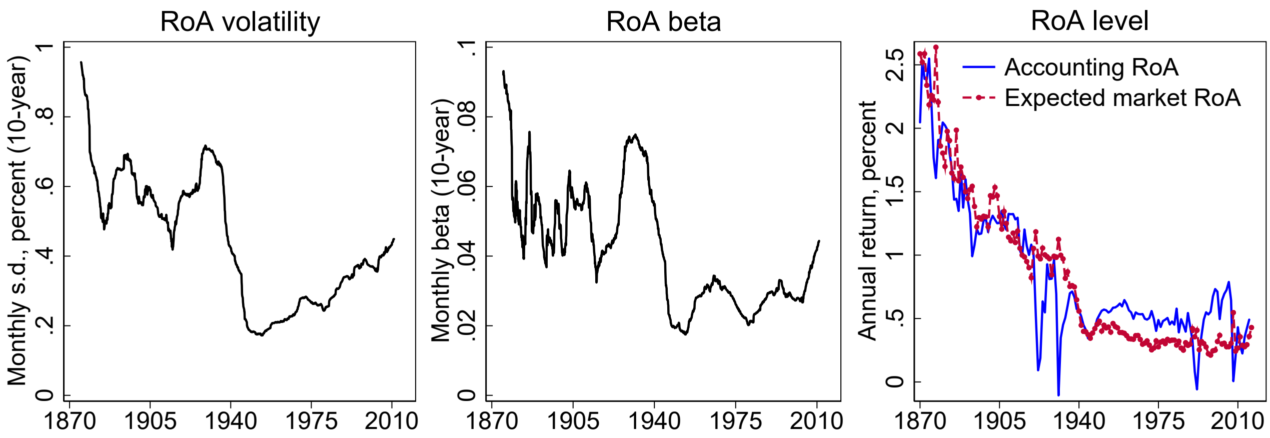
excess return on long-term government bonds (relative to the bill rate), $R^{corpbond}$ is the difference between the corporate bond return and the government bond return, and $R^{housing}$ is the excess return (capital gain plus rental yield) on residential real estate. In all regressions, we condition on the exposure to market risk by controlling for the realised aggregate stock market return R^{eq}. We run these regressions on centered, rolling 25-year windows between years 1882 and 2004, and require a minimum of 50 country-year observations in each rolling window sample.

This method for estimating risk exposures has a long tradition in finance (Flannery and James, 1984; Fama and French, 1993), with similar methods – albeit applied to more granular data – used in several recent studies to compute banks' exposures to credit and interest rate risk (Begenau, Piazzesi, and Schneider, 2015; Begenau and Stafford, 2021; Drechsler, Savov, and Schnabl, 2021). The three risk factors in our regression are chosen capture some of the most important types of risk exposures of the banking system. Since banks engage in maturity transformation and originate potentially risky loans, they are exposed to both interest rate risk and credit risk. Many bank loans also have real estate collateral, making banks potentially exposed to housing risk (Jordà et al., 2016). In our regression, the exposure to credit risk is captured by the beta on the excess corporate bond return, since variation in corporate bond premia is a proxy for the downside risk in the non-financial corporate sector (Nozawa, 2017). The government bond beta captures exposure to interest rate risk associated with maturity transformation, and the housing beta – to risk in the real estate sector.

Data: To construct these four asset risk measures, we combine three novel long-run datasets on market returns on bank equity, bank balance sheets, and bank profitability. The market returns data come from Baron et al. (2021) and cover the capital gains and dividends on listed bank and non-financial stocks. We slightly extend these data using our own estimates of bank and non-financial equity returns for Portugal and Switzerland. The bank balance sheet data come from Jordà et al. (2021) and consist of aggregate assets and liabilities of the banking sector, with liabilities broken down into capital (book equity), deposits and non-deposit debt. The bank profit and loss data come from Richter and Zimmermann (2020) and cover the aggregate accounting profits of the banking sector, both in nominal terms and as a ratio to bank equity or assets. The accounting (bank profit and balance sheet) data are annual, whereas the market data are available at both annual and monthly frequency. For measuring banks' credit and housing risk exposures, we additionally use the corporate bond return data from Kuvshinov (2020), and the housing return data from Jordà et al. (2019).

The broad scope of these datasets allows us to construct these measures of bank asset risk for years 1870 to 2016, for the following 17 advanced economies: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Figure 1: *Long-run trends in the risk of bank assets*



Notes: Left-hand panel: Standard deviation of the realised monthly market RoA, 10-year centered windows of pooled data for 17 countries. Realised RoA is the excess return on listed bank equity times the bank capital ratio (equity/assets). Middle panel: Monthly beta is the covariance of the realised monthly market return on bank assets and the return on non-financial equity, divided by the variance of the non-financial equity return, using 10-year centered windows of pooled data. Right-hand panel: Averages of 17 countries. Accounting RoA is net profits divided by total assets. Expected market RoA is the expected return on bank equity – equal to the dividend-price ratio plus country-average real capital gain – multiplied by the bank capital ratio.

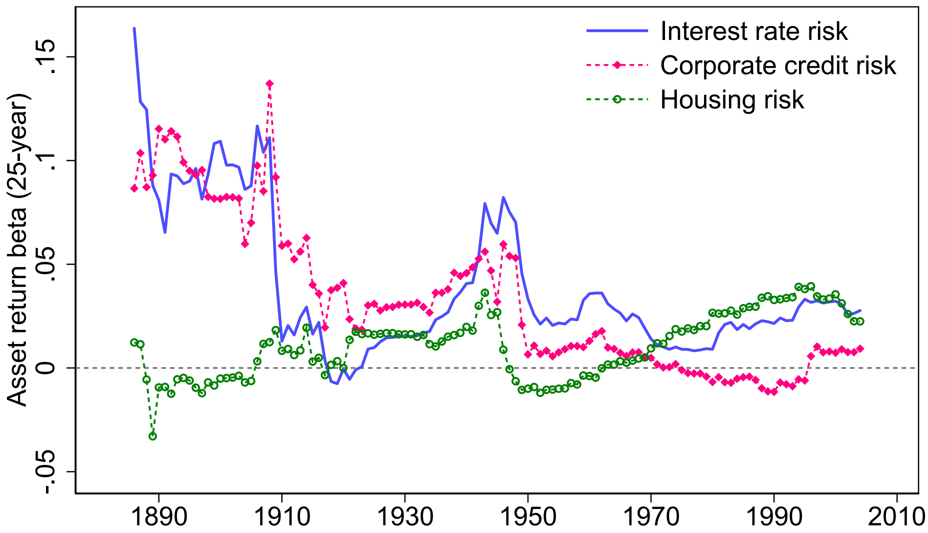
2.2. Trends in the risk of bank assets

Figure 1 plots the long-run evolution of our main measures of bank asset risk. The left-hand panel shows the overall volatility of our proxy for the realised excess market return on bank assets [equation (2)]. The middle panel shows the part of this volatility that corresponds to systematic risk and should therefore require compensation in the form of higher returns, the monthly asset return beta [equation (3)]. The right-hand panel shows the actual compensation in the form of the accounting, and the expected market return on bank assets [equations (4) and (5)].

All three of these risk measures suggest that over the long run, the riskiness of bank assets has declined considerably. Between 1870 and 1950, the volatility of the realised monthly market return on bank assets declined by a factor of five, from about 1% to 0.2%. Asset volatility increased after 1950, but remains considerably below its historical levels at the end of our sample. The asset return beta declined by a factor of about 4 between 1870 and 1950, and doubled between 1950 and 2010. Consistent with these declines in observed realised asset risk, the risk compensation in the form of bank asset returns also fell by a similar amount. Both the accounting and the market-based RoA declined from about 2.5% per year in 1870 to 0.5% per year in 1950, and remained low thereafter, with the accounting RoA registering a small increase after 1980.

Taken together, these various measures all point to sharp declines in bank asset risk between 1870 and 1950 followed by modest increases between 1950 and 2016, with the 2016 levels of asset risk well below the levels observed in late 19th and early 20th century. Even though each of these measures is an imperfect proxy for asset risk, Appendix Figure A.1 shows that in the underlying country-level

Figure 2: *Trends in bank asset risk exposures*



Notes: The risk exposures are time-varying betas obtained from regressing the realised excess market return on bank assets on excess government bond returns (interest rate risk), the difference between corporate and government bond returns (corporate credit risk), and the excess housing return (housing risk), controlling for the aggregate market return, estimated on centered rolling 25-year windows.

data, all three measures of RoA volatility, beta and level are strongly positively correlated, painting a consistent picture of the underlying movements in the riskiness of bank assets. Appendix Figure A.2 further shows that the time series patterns shown in Figure 1 hold for several alternative asset return measures, which calculate the excess RoA by unlevering the excess rather than total return on bank equity, use realised dividend growth rather than capital gains as a proxy for $\bar{g}$ in equation (1), or account for changes in the risk premium on bank debt.

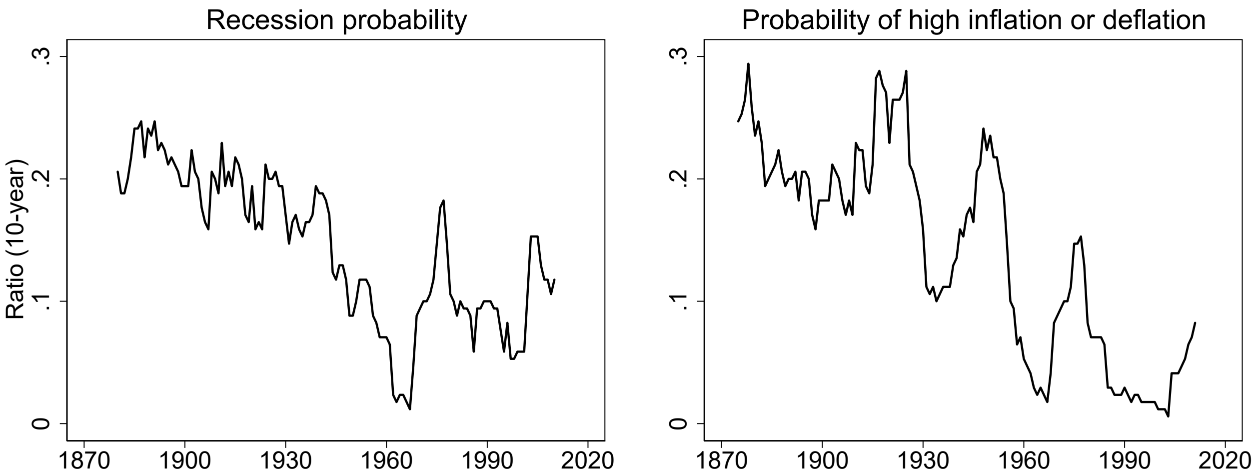
The decline in bank asset risk can be driven by lower exposures of bank assets to the underlying macroeconomic risks, for example, through changes in asset composition, diversification, and better risk management. Alternatively, it can be driven by reduction in the riskiness of the macroeconomic environment, for example, lower incidence of recessions and more stable inflation. There is evidence for both falls in risk exposures, and declining macroeconomic risk, in driving the long-run fall in the overall risk of bank assets. We start by looking at the long-run trends in banks' macro-financial risk exposures, measured as the market betas of realised bank asset returns on the returns of assets corresponding to the relevant macro-financial risk factors: credit risk of the banks' loan portfolio, proxied by the corporate bond return; interest rate risk associated with maturity transformation, proxied by the excess government bond return; and the risks associated with real estate collateral, proxied by the housing return (Section 2.1 and equation (6) provide more details on the estimation). The time-varying betas from these regressions are plotted in Figure 2, for 25-year centered rolling windows.

Figure 2 shows that exposures to interest rate risk and corporate credit risk were high historically, but declined markedly between 1890 and 1940. The immediate aftermath of World War II saw spikes in both of these risk exposures, while the post-1950 period saw stable and low interest rate risk exposures accompanied by further declines in the exposure to credit risk. Similarly to us, Drechsler et al. (2021) document a low interest rate risk exposure for US banks during the 1994–2017 time period, and attribute it to the stability of the banks' deposit franchise. Our evidence suggests that the post-1990 low levels of interest rate risk exposure extend to countries outside of the US, but not to the longer run historical period. In particular, interest rate risk exposures were high during the pre-1930 period before the introduction of deposit insurance. While banks were not exposed to housing risk historically, the post-1950s shift from business to mortgage lending was accompanied by increases in the exposure to housing risk.

One reason for the decline in bank asset risk, therefore, comes from the lower exposures to credit and interest rate risks, which could have come about from changes in asset composition, diversification, and risk management. Another reason why asset risk has declined is that the macroeconomic environment itself has become less risky throughout our sample period. While the late 19th and early 20th century period was characterised by frequent crises and recessions, the 1980s and 1990s were a period of the "great moderation" in macroeconomic risk (Barro, 2006; Stock and Watson, 2002; Sims and Zha, 2006). We next trace out the long-run evolution of two simple measures of macroeconomic risk that proxy for the risk environment in banking: the risk of recessions, and that of very high or negative inflation. Recession risk is a proxy for the downside risk of the macroeconomy, a likely driver of bank credit risk (Nagel and Purnanandam, 2020). Deflation can increase the real value of bank loans, making it more difficult for borrowers to repay them and increasing credit risk (Fisher, 1933; Bernanke and James, 1991; Eggertsson and Krugman, 2012), while high inflation can increase the mismatch between nominal interest rates paid on bank assets and liabilities, thereby raising the risks from maturity transformation (Agarwal and Baron, 2021).

Figure 3 plots the long-run trends in these two macroeconomic risk measures. We calculate the recession probability as the share of business cycle peaks within a centered 10-year window of pooled 17-country data. We define years with above 10% CPI growth (this threshold is in line with Agarwal and Baron, 2021) as inflationary and country-year observations with negative CPI growth as deflationary and calculate the probability of a start of an inflationary or deflationary period again using 10-year centered windows. Both of these risks have declined over the long run, with the bulk of the decline occurring during the pre-1950 period that also saw the strongest reductions in bank asset risk. Between 1870 and the second half of the 20th century, the probability of the economy being hit by a recession roughly halved, from more than 20% to about 10%, and the probability of high or negative inflation episodes fell from 20–25% in the late 19th century to below 10% in the post-1945 period. The decline in price level risk between 1870 and 1960 is due to a reduction in deflation episodes, while the post-1980s further decline is coming from a reduction in high inflation episodes. Both macro risk measures display a recent uptick due to the global financial crisis relative to the low levels in previous decades. Appendix Figure A.3 further shows that these reductions in macroeconomic risk were accompanied by falls in a number of financial risks, with the corporate bond default rate (a proxy for credit risk) and house price decline probability (a proxy for downside

Figure 3: *Trends in macroeconomic risks relevant for banking*



Notes: Rolling 10-year windows of cross-country data. Recession probability is the share of business cycle peaks within the window. Price level instability is the share of years where an inflationary or deflationary period started. Deflation is defined as years in which CPI growth was less than zero and inflationary periods are years with CPI growth greater than 10%.

housing risk) declining alongside the corresponding risk exposures. Interest rate risk, on the other hand, shows no signs of a long-run decline.[7]

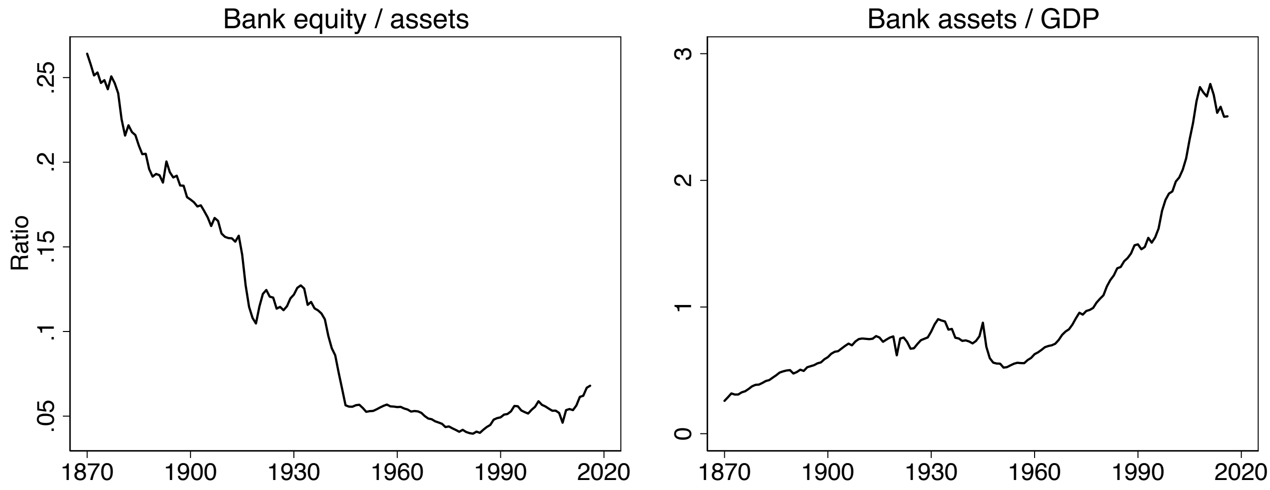
All measures of bank asset risk point to a considerable long-run decline, with large decreases between 1870 and 1950 followed by moderate increases which did not fully compensate for these historical declines. The asset risk declines were accompanied by falls in macro-financial risk exposures of bank assets, and broader declines in macroeconomic downside and inflation risk, helping rationalise why bank assets became safer.

2.3. Trends in bank leverage and equity risk

The riskiness of bank assets has declined over the long run. This does not, however, mean that banking system risk has decreased along all dimensions. Since asset risk is an important determinant of capital structure (see, e.g., Berg and Gider, 2017), decreases in risk may have increased the debt capacity and, hence, the leverage of the financial sector. At higher levels of leverage, any given change in asset values has a larger effect on equity values and, hence, default risk (Modigliani and Miller, 1958). The leverage amplification may even go above and beyond these direct effects, for example, increasing the likelihood of liquidity dry-ups and costly asset fire sales which further destabilise the financial system (Shleifer and Vishny, 1992; Brunnermeier and Pedersen, 2008). In the model of Brunnermeier and Sannikov (2014), the endogenous leverage responses to low exogenous

[7]For Figure A.3, we focus on downside risk in the credit and housing markets as these should be more directly linked to the riskiness of bank business and mortgage lending. For interest rate risk, we focus on total term premium volatility as bank assets and liabilities can be exposed to both increases and declines in interest rates.

Figure 4: *Trends in banking system leverage*



Notes: Annual data, unweighted averages of 17 countries.

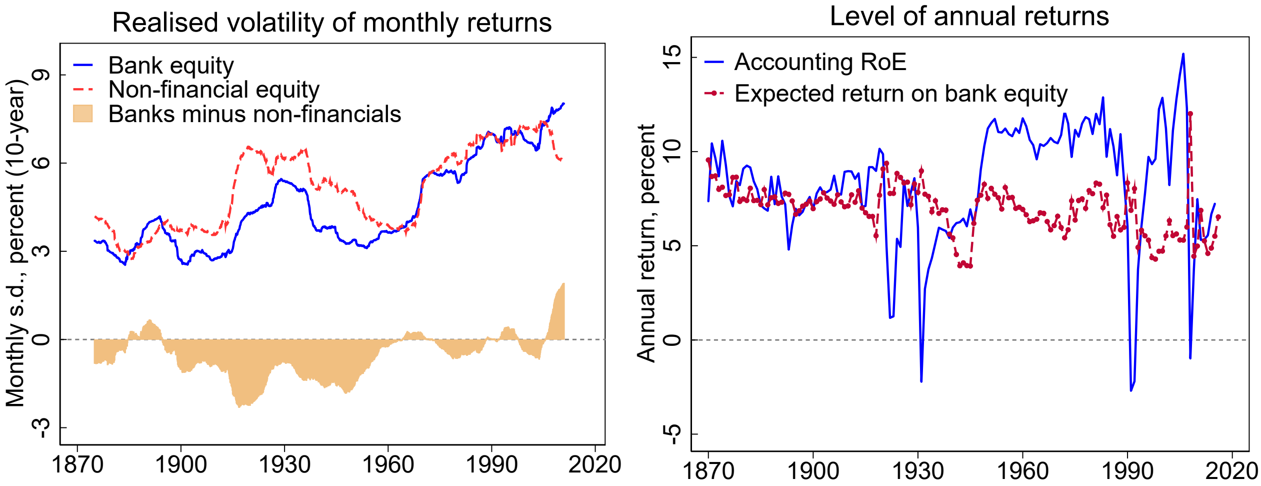
risk can potentially increase the systemic risk in banking. Danielsson et al. (2018) provide evidence for such a mechanism at cyclical frequency, showing that prolonged periods of low stock market volatility are reliable predictors of future banking crises. Here, we study whether this disconnect manifests itself in the long-run trends within banking.

In Figure 4, we plot the long-run trends in two measures of banking sector leverage: financial leverage (inverse of the bank equity/assets measure shown in the left-hand panel), and macroeconomic leverage (bank assets/GDP shown in the right-hand panel). The higher the financial leverage of the banking system, the larger is the effect of any given change in bank asset values on the value of bank equity and, therefore, the higher the banking system default risk. The higher the macroeconomic leverage, the larger the bank asset value changes are relative to total economic income. Both of these measures of leverage have increased materially over the long run as shown by Schularick and Taylor (2012) and Jordà et al. (2021). Bank equity fell from one-quarter to less than one-tenth of bank assets between 1870 and 1950, and remained close to these historically low levels afterwards. The ratio of bank assets to GDP increased from less than 0.5 in the 1870s to 2.5 in 2016.

What is the combined effect of these increases in leverage, and declines in bank asset risk? To gauge this, we start by mapping out the long-run trend in the risk of bank equity. The more volatile bank equity values are, the more likely the banking sector is to default. The left-hand panel of Figure 5 plots the equity return volatility [the rolling 10-year standard deviation of the monthly excess return on bank equity, $R^{\text{bank equity}}$ in equation (1)], alongside the volatility of non-financial stocks. Despite the declines in asset return volatility, equity return volatility has increased over the long run. The volatility of bank stock returns was flat between 1870 and 1950, and more than doubled between 1950 and 2010. While bank stocks were less volatile than non-financial stocks before 1950 (orange bars below zero), the volatilities of bank and non-financial equity are similar after 1950.[8]

[8]This convergence in bank and non-financial equity volatilities is even more remarkable in light of the

Figure 5: *Trends in bank equity risk*



Notes: Left-hand panel: Realised volatility is the standard deviation of monthly returns within a centered 10-year rolling window of pooled 17-country data. Right-hand panel: Averages of 17 countries. Accounting RoE is net profits divided by equity liabilities. Expected return on bank equity is the bank dividend yield plus country-average capital gain.

The right-hand panel of Figure 5 shows two measures of the level of bank equity returns, i.e. the implicit compensation for bank equity risk. Both the accounting-based measure, equal to net profits over equity liabilities, and the market-based measure, equal to the sum of the dividend yield and country-average real capital gain, have not declined over the long run, with the accounting RoE measure increasing after 1950. Appendix Figure A.4 shows the time trends in another measure of bank equity risk – the beta of bank stocks – and in bank equity exposures to the macro-financial risk factors specified in equation (6) (interest rate, credit, and housing risk). Bank equity beta was stable between 1870 and 1930, and increased by a factor of 3–4 between 1930 and 2015. The picture for exposures to macro-financial risk factors is more mixed, with bank equity exposures to credit risk declining over the long run, and those to housing risk increasing, consistent with the increasing importance of real estate backed loans on bank balance sheets (Jordà et al., 2016). Bank equity exposures to interest rate risk are volatile throughout history, but show no clear trend.

These trends are consistent with the banking system increasing its leverage in response to a calmer macroeconomic environment and increased ability of banks to manage risk. Appendix Table A.1 shows that the negative correlation between measures of leverage and bank asset risk persists beyond the broad time series patterns documented above. Even controlling for common cross-country variation via year fixed effects, and taking out country-specific trends via first differences, measures of bank asset risk remain strongly negatively correlated with financial leverage (bank assets/equity), while the correlation between equity risk and leverage is weak, consistent with the

large post-1950 increases in non-financial leverage reported for the US by Graham, Leary, and Roberts (2015) which, other things being equal and given the stability of bank capital ratios during this time period, should have increased the relative volatility of non-financial stocks.

Table 1: *Long-run changes in bank asset risk, leverage, and equity risk*

	(1)	(2)	(3)	(4)	(5)
	Level			Relative change	
	1880	1950	2010	1880–1950	1950–2010
Asset risk					
Market RoA volatility	0.65	0.24	0.40	-63%	+66%
Acounting RoA	1.88	0.52	0.49	-72%	-6%
Leverage					
Bank capital ratio	0.23	0.06	0.06	-73%	-7%
Bank assets / GDP	0.40	0.62	2.43	+55%	+293%
Equity risk					
Market RoE volatility	3.15	3.48	7.26	+11%	+108%
Accounting RoE	8.39	9.34	8.64	+11%	-7%

Notes: Columns 1–3: pooled averages of annual data for 17 countries in the 20-year centered window around the year (e.g. 1880 refers to the 1870–1890 average). The underlying annual return volatilities are constructed using 10-year centered rolling windows of monthly data. Columns 4 and 5 calculate the relative change between the corresponding benchmark years, with +100% a doubling and -50% a halving.

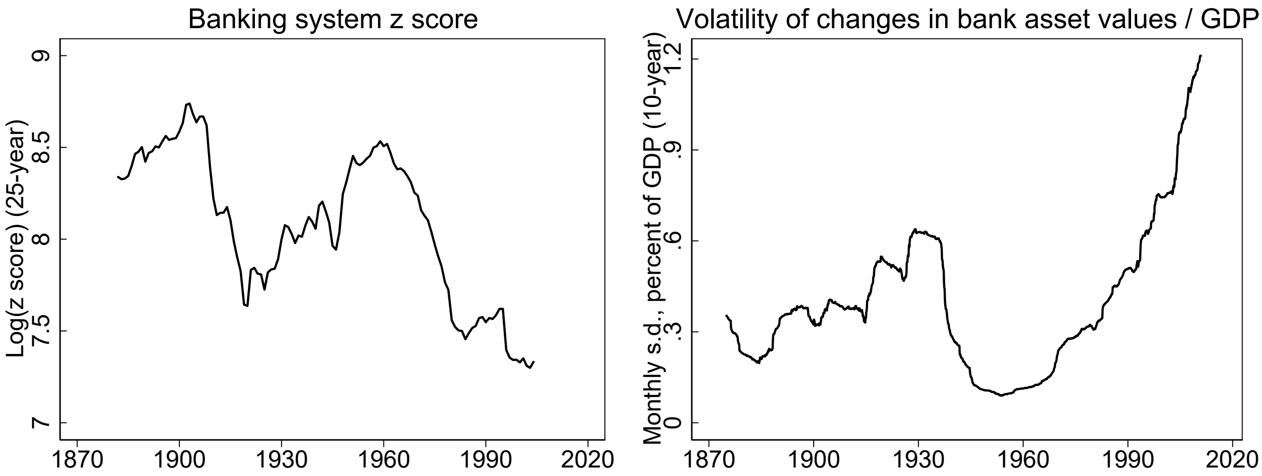
relative stability of bank equity risk measures over the long run.[9]

Table 1 summarises the long-run changes in bank asset risk, leverage, and equity risk. Bank asset risk shows a pronounced decline in the pre-1950 period, but this decline is almost matched by an increase in leverage, with all three of RoA volatility, RoA level, and bank capital ratios falling by between two-thirds and three-quarters between 1880 and 1950. As a result, bank equity risk remained virtually unchanged throughout this period, with the return on bank equity and its volatility showing modest relative increases of around one-tenth. After 1950, bank asset risk increased, but bank leverage did not respond to these increases, remaining at historically low levels. As a result, bank equity risk in the form of realised return volatility increased substantially. Furthermore, banks' macroeconomic leverage (the ratio of bank assets to GDP) quadrupled between 1950 and 2010, amplifying the volatility of changes in bank asset values relative to economic income.

The broad trends in Table 1 suggest that between 1870 and 1950, changes in leverage offset the reductions in bank asset risk, leaving the riskiness of the banking system largely unchanged. After 1950, increases in asset risk and macroeconomic leverage led to increases along some dimensions of bank risk. To explore these developments more formally, we construct two combined measures of banking system risk, based on asset risk and the two measures of leverage in our data. The first measure, the banking system z-score (Boyd and Graham, 1986), relates to financial leverage, and

[9]These findings are related to a large cross-sectional literature testing the relationship between equity risk, asset risk and capital structure of individual firms, grounded in the theoretical framework of Modigliani and Miller (1958). Similarly to our long-run evidence, these studies generally find that the positive correlation between leverage and equity risk is muted by countervailing changes in asset risk, which are negatively correlated with leverage (see, e.g., George and Hwang, 2010; Gomes and Schmid, 2010; Berg and Gider, 2017).

Figure 6: *Combined measures of banking system risk*



Notes: Left-hand panel: Averages of 17 countries. z score is the capital ratio plus RoA divided by the standard deviation of RoA, using centered rolling 25-year windows of annual accounting data. Right-hand panel: Standard deviation of nominal changes in bank asset valuations – calculated as market RoA times total bank assets – divided by nominal GDP, computed using 10-year rolling windows of pooled monthly market data.

tracks the probability of bank equity being wiped out by shocks to bank assets. The second measure relates to macroeconomic leverage, and tracks the volatility of changes in asset values of the banking system relative to GDP. We construct these two measures as follows:

$$z_{i,t} = \frac{\text{RoA}_{i,t} + \text{Capital Ratio}_{i,t}}{\text{Std.dev}(\text{RoA}_{i,t})_{t-12,t+12}} \tag{7}$$

$$\text{Volatility}^{\text{macro-fin}}_{i,t} = \text{Std.dev}\left(\text{R}^{\text{asset}}_{i,j,t} * \text{Bank Assets}_{i,t-1}/\text{GDP}_{i,t-1}\right)_{t-5,t+5} \tag{8}$$

Above, $\text{RoA}_{i,t}$ is the accounting return on bank assets in country i and year t, and $\text{Std.dev}()_{t-12,t+12}$ is its 25-year rolling standard deviation. $\text{R}^{\text{asset}}_{i,j,t}$ is the realised market return on bank assets in country i, year t and month j, and $\text{Std.dev}()_{t-5,t+5}$ is its 10-year rolling standard deviation in the pooled sample of 17 countries.

Figure 6 plots the long-run evolution of these two measures of banking system risk. Between 1870 and 1950, both variables show a relatively stable trend level punctuated by some medium-run cycles, with both risk measures peaking before the Great Depression – indicating a low z score and high macro-financial volatility – and normalising during the subsequent economic recovery. For the z score, during this early period, the decline in bank asset risk was offset by increases in financial leverage. For macro-financial volatility, the asset risk decline was offset by increases in banking sector size. After 1950 however, both of these measures point to increases in the overall risk of the banking system, as asset volatility increased alongside a highly levered and rapidly growing banking sector. Appendix Figure A.5 provides further indirect evidence that the banking system as a whole has become more risky over the past 50 years. It shows that two measures of banking system tail risk – the probabilities of bank equity crashes, and of systemic banking crisis events – more than tripled between 1960 and 2010.

These trends suggest that the combined impact of the observed trends in bank asset risk and leverage was far from neutral. Between 1870 and 1950, increases in bank leverage meant that despite declines in macroeconomic risk and macro-financial risk exposures, bank equity did not become safer. Between 1950 and 2016, the relatively small increases in the risk of bank assets and some types of risk exposures (e.g., housing risk) were amplified by the already high levels of bank leverage and rapid growth of bank balance sheets relative to GDP, such that combined measures of risk within banking actually increased, not only during the post-1950 period, but also over the whole sample period from 1870 to 2016.

3. The shocks: macro risks arising from banking

In the first part of the paper, we showed that the riskiness of bank assets has declined over the long run. At the same time, however, macroeconomic and financial leverage increased by a factor of 4–6 between 1870 and 2016. This means that even though shocks to bank asset values are, on average, smaller, their amplification through the banking system may be stronger. The banking system may have therefore moved from an equilibrium featuring high asset risk and low risk amplification through leverage, to one featuring low asset risk, but high amplification. Baron et al. (2021) have shown that on average, bank equity returns are positively correlated with future economic outcomes, even conditional on the returns on non-financial equity. These results point to a potential link between changes in bank asset values and future GDP. In this section, we investigate whether the relationship between bank asset returns and subsequent GDP growth has changed over time, and whether these changes are linked to the secular shifts in bank risk and leverage documented in the previous section.

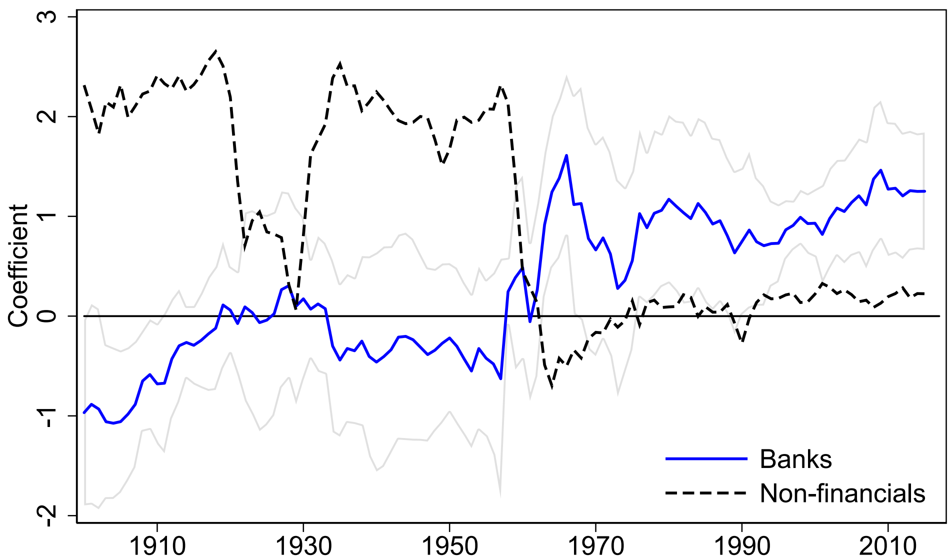
3.1. Bank asset returns and future macroeconomic outcomes

We first assess how the predictive power of changes in bank asset values for future economic activity has changed over time. We measure the medium-term performance of the real economy as the three-year growth in real GDP and denote it by $\Delta_3 y_{i,t+3}$. We then estimate the following predictive regression over rolling 30-year windows:

$$\Delta_3 y_{i,t+3} = \alpha_i + \beta^{\text{bank}} R_{i,t}^{\text{bank assets}} + \beta^{\text{nonf}}\, R_{i,t}^{\text{nonf equity}} + \epsilon_{i,t+3}. \qquad (9)$$

Above, $R_{i,t}^{\text{bank assets}}$ is the realised total return on bank assets calculated as the realised total bank equity return (capital gain plus dividend yield) times the lagged capital ratio, and α_i is a country fixed effect. To compare the predictive ability of bank returns to those of non-financials, we additionally include $R_{i,t}^{\text{nonf equity}}$, the total return on non-financial stocks, in the regression. This is

Figure 7: *Bank asset returns, non-financial returns, and future GDP growth: rolling regression coefficients*



Notes: Coefficients from a rolling (30-year backward-looking windows) predictive regression of cumulative future three-year real GDP growth (t to $t+3$) on the bank asset return and non-financial equity returns ($t-1$ to t). The coefficients correspond to the percentage point impact of a one standard deviation change in returns. The regressions include changes in bank asset values (solid line), changes in non-financial equity values (dashed line) and country fixed effects. The shaded area is a 90% confidence interval around the bank asset value coefficients calculated using standard errors dually clustered on country and year.

important because bank asset valuations depend on general current and future economic conditions as well as the current and future shocks to the banks' loan and security portfolios. Controlling for non-financial returns allows us to control not only for current but also for expected future conditions of non-financial listed firms, and leaves the coefficient β^{bank} to capture the bank-specific effects. Because market values of bank assets and equity are forward-looking, this coefficient captures both the impact of the contemporaneous shock to asset values on GDP growth, and the association between expected future bank losses and GDP.

The estimated coefficients for β^{bank} (solid line) and β^{nonf} (dashed line) are shown in Figure 7. The first estimates reported are from the year 1900 (based on a regression using data from 1870 to 1900). The figure also shows a 90% confidence band around the estimated coefficient for bank asset returns. In the late 19th century, non-financial returns predicted three-year-ahead output growth, but bank asset returns did not provide any additional information on future medium-term economic performance. The β^{bank} coefficient is either zero or negative at the beginning of the sample. β^{nonf}, on the other hand, is significantly positive. Fast-forwarding to today, the relationship has reversed: bank asset returns are a significant predictor of economic activity, with higher bank asset returns associated with higher three-year-ahead output growth. Non-financial returns, on the contrary, contain no additional information on future output.

Linking the start and end of our sample, Figure 7 shows that there has been a continuous improvement in the ability of bank asset returns to predict economic activity. Non-financial equity returns lost their additional predictive ability relative to bank asset returns shortly after World War II (WW2). A similar pattern emerges when we look at different prediction horizons, forecasting one- and two-year ahead growth, shown in the Appendix Figure A.6. These results suggest that the relationship between macroeconomic performance, bank returns and non-financial returns has changed materially over time.

We confirm and generalise this stylised fact by employing local projections (Jordà, 2005) to fully characterise output dynamics following bank asset return innovations. More specifically, we run a sequence of h regressions where the dependent variable is defined as the difference in log real GDP levels between years $t+h$ and t, that is $\Delta_h y_{i,t} = y_{i,t+h} - y_{i,t}$. Based on the finding above, we distinguish between a pre- and post-WW2 sample and compare bank asset returns to non-financials. In the specification, we therefore interact realised bank asset returns $R_{i,t}^{\text{bank assets}}$ and non-financial equity returns $R_{i,t}^{\text{nonf equity}}$ with indicators for the pre- and post-1945 period, as follows:

$$\begin{aligned}\Delta_h y_{i,t} = \alpha_{i,h} &+ \beta_h^{\text{bank, pre}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(\textit{year}{\leq}1945) + \beta_h^{\text{bank, post}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(\textit{year}{>}1945) \\ &+ \beta_h^{\text{nonf, pre}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(\textit{year}{\leq}1945) + \beta_h^{\text{nonf, post}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(\textit{year}{>}1945) \\ &+ \gamma_h \mathbb{1}(\textit{year}{>}1945) + \Phi X_{i,t} + \epsilon_{i,t+h}\,, \end{aligned} \tag{10}$$

for horizons $h = 1, ..., 5$. In addition to our return measures, we add an indicator for the post-1945 period to control for the increase in average GDP growth during this time, and a vector of control variables $X_{i,t}$ that includes contemporaneous GDP growth and changes in short-term interest rates, as well as four lags of all variables (bank and non-financial returns, GDP growth, and changes in short-term rates).

The results shown in Table 2 confirm the visual impression from Figure 7. Non-financial equity return innovations predict economic activity in the pre-WW2 period: high returns predict higher cumulative growth rates over all horizons h. This result seems intuitive: non-financial equities contain information about future cash flows of listed non-financial firms and thereby proxy for economic conditions (Stock and Watson, 2003). However, this predictive ability vanishes in the second half of our sample, and the coefficient is insignificant and close to zero in the post-WW2 period. Since non-financial returns and bank asset returns are included jointly in this regression, our results suggest that after 1945, non-financial returns contain little information on future growth beyond the information contained in bank asset returns. Turning to bank asset returns, we find no predictability in the pre-WW2 period. If anything, the coefficient is slightly negative at longer horizons. Again, this implies that bank asset returns contain no information beyond the information contained in non-financial equities in the first half of our sample. After 1945, bank asset returns emerge as a significant predictor of future growth.

One interpretation of these correlations is that shocks to bank asset values had little macroeconomic consequence before WW2, but had large macroeconomic effects in the post-WW2 period. An alternative interpretation is that bank equity prices were simply uninformative about fundamentals – reflected in future dividends or GDP growth – before WW2, but informative afterwards, with the

Table 2: *Bank asset returns and future GDP growth: before and after WW2*

	Year 1	Year 2	Year 3	Year 4	Year 5
Δ Bank asset values, pre-1945	0.23	-0.31	-0.34	-0.39	-0.48
	(0.21)	(0.26)	(0.38)	(0.44)	(0.43)
Δ Bank asset values, post-1945	0.61***	1.03***	1.05***	1.10***	0.92*
	(0.18)	(0.25)	(0.29)	(0.36)	(0.47)
Δ Non-financial equity, pre-1945	1.76***	2.43***	1.89***	1.51*	1.02
	(0.50)	(0.78)	(0.71)	(0.82)	(0.87)
Δ Non-financial equity, post-1945	0.31***	0.01	-0.32	-0.57	-0.51
	(0.09)	(0.15)	(0.24)	(0.35)	(0.38)
R^2	0.20	0.19	0.17	0.17	0.16
P-value, bank, Pre=Post	0.16	0.00	0.00	0.01	0.03
P-value, non-fin, Pre=Post	0.00	0.00	0.00	0.03	0.12
Country fixed effects	✓	✓	✓	✓	✓
Control variables	✓	✓	✓	✓	✓
Observations	1517	1517	1517	1517	1517

Notes: This table reports regressions of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{assets}}$ and $R_{i,t}^{\text{nonf equity}}$. Changes in bank asset values and non-financial equity returns are interacted with indicators for the pre- and post-1945 periods. All specifications include a post-1945 dummy, country fixed effects and control for contemporaneous GDP growth, changes in short-term interest rates and four lags of the interaction and control variables. Driscoll-Kraay standard errors in parentheses are adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

reverse true for non-financials. To evaluate this alternative hypothesis, we turn to the standard framework of dividend predictability regressions (Campbell and Shiller, 1988; Cochrane, 2008), and test the predictive power of bank and non-financial equity valuations (measured as the price-dividend ratio) for their own fundamentals (dividends), before and after WW2. Appendix Figure A.7 shows that both bank and non-financial equity valuations predict their own fundamentals across different horizons both before and after WW2, with the predictive power unchanged across the two time periods. This shows that the increased excess predictive power of changes in bank asset values for future GDP growth after WW2 is unlikely to be purely driven by changes in bank equity price informativeness.

3.2. Mechanisms

3.2.1 Leverage and volatility

Why did bank asset returns become a better predictor of economic growth after WW2? In the model of Brunnermeier and Sannikov (2014), shocks to the banking sector have more pronounced effects when banks are levering up against low measured risks. In the data, the post-1945 period was characterised by low macroeconomic risk, low bank asset risk, and high financial leverage and size of the banking sector. To more formally evaluate the link between bank risk, leverage, and the macroeconomy, we test whether the predictive power of changes in bank asset values for future economic activity varies across different leverage and volatility regimes.

We use a similar specification to equation (10), but we now split the sample by contemporaneous macroeconomic or financial leverage, and by previous realised macro-financial volatility. For the leverage specifications, we interact returns with an indicator for whether macroecononomic or financial leverage, $lev_{i,t}$, was above or below its full-sample mean $\overline{lev}$. For the volatility specifications, we interact returns with an indicator of whether past 10-year macroeconomic or bank asset return volatility, $vol_{i,t}$, was above or below its sample mean $\overline{vol}$.

$$\begin{aligned}\text{Leverage:}\quad \Delta_h y_{i,t} = {} & \alpha_{i,h} + \beta_h^{\text{bank, low}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(lev_{i,t} \leq \overline{lev}) + \beta_h^{\text{bank, high}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(lev_{i,t} > \overline{lev}) \\ & + \beta_h^{\text{nonf, low}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(lev_{i,t} \leq \overline{lev}) + \beta_h^{\text{nonf, high}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(lev_{i,t} > \overline{lev}) \\ & + \gamma_h \mathbb{1}(year > 1945) + \theta_h \mathbb{1}(lev_{i,t} > \overline{lev}) + \Phi X_{i,t} + \epsilon_{i,t+h}. \end{aligned} \tag{11}$$

$$\begin{aligned}\text{Volatility:}\quad \Delta_h y_{i,t} = {} & \alpha_{i,h} + \beta_h^{\text{bank, low}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(vol_{i,t} \leq \overline{vol}) + \beta_h^{\text{bank, high}} R_{i,t}^{\text{bank assets}} \times \mathbb{1}(vol_{i,t} > \overline{vol}) \\ & + \beta_h^{\text{nonf, low}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(vol_{i,t} \leq \overline{vol}) + \beta_h^{\text{nonf, high}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}(vol_{i,t} > \overline{vol}) \\ & + \gamma_h \mathbb{1}(year > 1945) + \theta_h \mathbb{1}(vol_{i,t} > \overline{vol}) + \Phi X_{i,t} + \epsilon_{i,t+h}. \end{aligned} \tag{12}$$

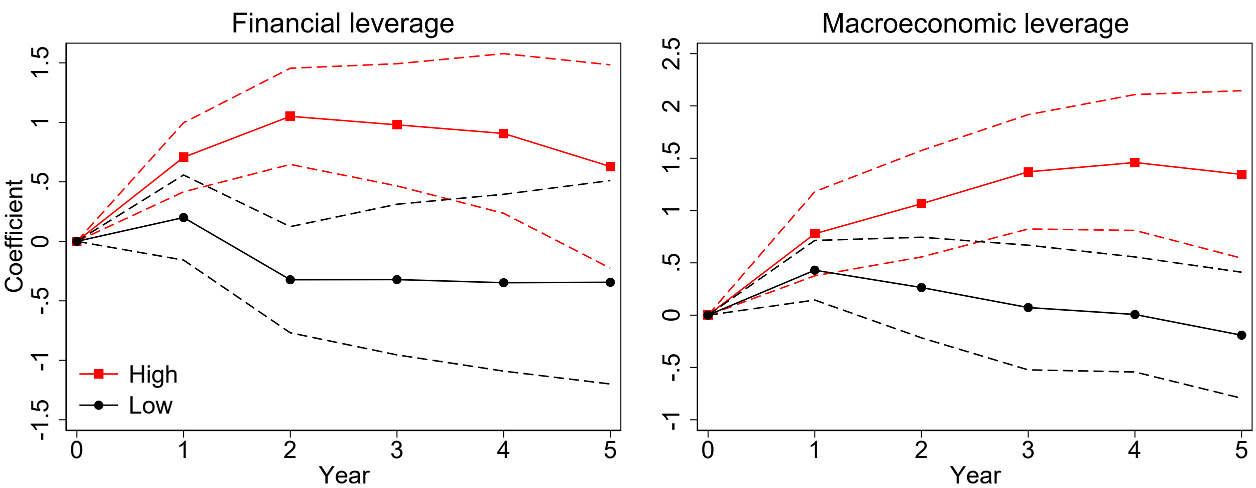
We run four different specifications, each using a different measure of leverage or volatility. In the first leverage specification, leverage is measured as the bank capital ratio, with below-sample-mean capital ratios corresponding to high leverage. In the second, leverage is measured as the ratio of bank assets to GDP. In the first volatility specification, volatility is measured as the share of recessions and high inflation or deflation episodes in the previous 10 years.[10] In the second, volatility is measured as the backward-looking 10-year standard deviation of annual bank asset returns $R^{\text{bank assets}}$. As in the time period split specification in equation (10), we control for a post-WW2 indicator, and contemporaneous values and four lags of GDP growth and short-term rates. We additionally control for the leverage (or volatility) indicator, and four lags of interactions between returns and leverage (or volatility).

Figure 8 shows the results of these four regressions, with the corresponding coefficients and significance tests shown in Table 3. The left-hand panel of Figure 8a shows that bank asset returns positively predict macroeconomic outcomes when bank leverage is high (red squares), while there is no such relation when bank leverage is low (black circles). Similarly, high macroeconomic leverage measured as the ratio of bank assets to GDP also means that changes in bank asset values have much higher predictive power for future GDP growth (right-hand panel). Turning to the volatility specifications, the left-hand panel of Figure 8b shows that after prolonged periods of macroeconomic stability – measured as a low incidence of recessions and high or negative inflation – bank asset

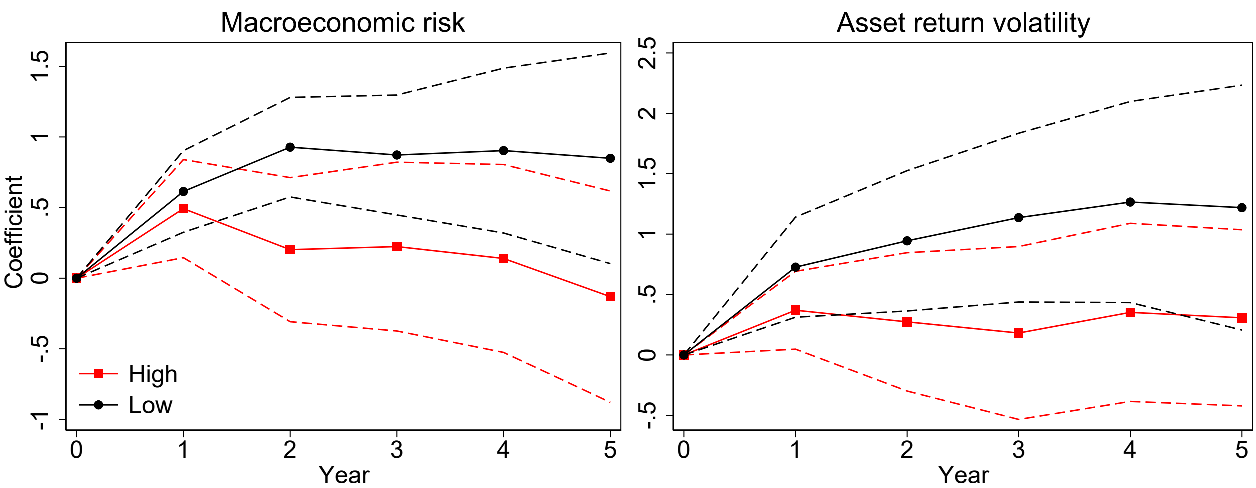
[10]To calculate this, we use the same approach as in Figure 3, and sum the number of business cycle peaks, or the first year of a deflationary or inflationary episode, within each country over the past 10 years, and divide these by the total number of observations with non-missing inflation and GDP growth data. We then split the sample according to whether this share is above or below the full-sample mean.

Figure 8: *Bank asset returns and future GDP growth: different leverage and volatility regimes*

(a) *Split by leverage regime:*



(b) *Split by volatility regime:*



Notes: This figure plots regression coefficients of real GDP growth from t to $t+h$ on $R^{\text{bank assets}}_{i,t}$ in different leverage and volatility regimes. We bin observations based on the mean financial leverage (high if equity/assets is below full-sample average), macroeconomic leverage (high if assets/GDP are above average), macroeconomic risk (high if probability of recession, high inflation or deflation between $t-10$ and $t-1$ is above average) and volatility (high if bank asset return standard deviation between $t-10$ and $t-1$ is above average), and include interactions of changes in bank asset values and non-financial equity values with high (above mean) and low (below mean) leverage and volatility dummies. All specifications include a post-WW2 dummy, country fixed effects, and control for contemporaneous GDP growth, changes in short-term interest rates and four lags of the interaction and control variables. Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer.

returns are strongly positively correlated with future economic activity at horizons of 1 to 5 years ahead (black circles). When past realised macroeconomic risks are high (red squares), bank asset returns show no excess predictive power for future GDP at horizons of 2 to 5 years. A similar result holds for the asset-risk-based volatility measure in the right-hand panel of Figure 8b, with asset

Table 3: *Bank asset returns and future GDP growth: different leverage and volatility regimes*

	Year 1	Year 2	Year 3	Year 4	Year 5
	Panel A: Returns binned by financial leverage				
Δ Bank asset values, low assets / equity	0.20	-0.32	-0.32	-0.35	-0.34
	(0.21)	(0.27)	(0.38)	(0.44)	(0.51)
Δ Bank asset values, high assets / equity	0.71***	1.05***	0.98***	0.91**	0.63
	(0.17)	(0.24)	(0.31)	(0.40)	(0.51)
R^2	0.19	0.18	0.16	0.17	0.16
P-value, High=Low	0.06	0.00	0.01	0.05	0.22
	Panel B: Returns binned by macroeconomic leverage				
Δ Bank asset values, low assets / GDP	0.43**	0.26	0.07	0.01	-0.19
	(0.17)	(0.29)	(0.35)	(0.33)	(0.36)
Δ Bank asset values, high assets / GDP	0.78***	1.07***	1.37***	1.46***	1.35***
	(0.24)	(0.30)	(0.33)	(0.39)	(0.48)
R^2	0.18	0.17	0.16	0.16	0.15
P-value, High=Low	0.22	0.05	0.01	0.00	0.00
	Panel C: Returns binned by macroeconomic risk				
Δ Bank asset values, low macro risk	0.61***	0.93***	0.87***	0.90**	0.85*
	(0.17)	(0.21)	(0.25)	(0.35)	(0.44)
Δ Bank asset values, high macro risk	0.49**	0.20	0.22	0.14	-0.13
	(0.21)	(0.30)	(0.36)	(0.40)	(0.45)
R^2	0.18	0.18	0.16	0.16	0.16
P-value, High=Low	0.65	0.03	0.10	0.13	0.10
	Panel D: Returns binned by asset return volatility				
Δ Bank asset values, low asset volatility	0.73***	0.94***	1.14***	1.27**	1.22**
	(0.25)	(0.35)	(0.42)	(0.50)	(0.60)
Δ Bank asset values, high asset volatility	0.37*	0.27	0.18	0.35	0.31
	(0.19)	(0.34)	(0.43)	(0.44)	(0.43)
R^2	0.15	0.15	0.13	0.13	0.13
P-value, High=Low	0.22	0.17	0.13	0.19	0.21
Country fixed effects	✓	✓	✓	✓	✓
Control variables	✓	✓	✓	✓	✓
Observations	1517	1517	1517	1517	1517

Notes: This table reports regressions of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{bank assets}}$ in different leverage and volatility regimes. We bin observations based on the mean financial leverage, macroeconomic leverage, macroeconomic risk and asset return volatility, and include interactions of changes in bank asset values and non-financial equity values with high and low leverage and volatility dummies. All specifications include a post-WW2 dummy, country fixed effects and control for contemporaneous GDP growth, changes in short-term interest rates and four lags of the interaction and control variables. Driscoll-Kraay standard errors in parentheses are adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

returns predicting future GDP in low return volatility, but not in high return volatility regimes.

Table 4: *Bank equity returns and future GDP growth: different leverage regimes*

	Year 1	Year 2	Year 3	Year 4	Year 5
Δ Bank equity, low assets / equity	0.59*	-0.37	-0.53	-0.93	-0.60
	(0.33)	(0.46)	(0.62)	(0.68)	(0.91)
Δ Bank equity, high assets / equity	0.46***	0.74***	0.77***	0.71***	0.52
	(0.11)	(0.18)	(0.22)	(0.27)	(0.32)
R^2	0.19	0.20	0.19	0.19	0.19
P-value, High=Low	0.71	0.03	0.05	0.03	0.28
Country fixed effects	✓	✓	✓	✓	✓
Control variables	✓	✓	✓	✓	✓
Observations	1628	1628	1628	1628	1628

Notes: This table reports regressions of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{bank equity}}$ in different leverage regimes. We bin observations based on the mean financial leverage (high if equity/assets is low), and include interactions of changes in bank and non-financial equity values with high (above full-sample mean) and low (below mean) leverage dummies. All specifications include a post-WW2 dummy, country fixed effects, and control for contemporaneous GDP growth, changes in short-term interest rates, and four lags of the interaction and control variables. Driscoll-Kraay standard errors in parentheses adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. *, **, and *** indicate significance at the 0.1, 0.05, 0.01 levels, respectively.

The results presented in Table 3 confirm the visual impression from Figure 8. Panel A shows that, with the exception of year five, realised bank asset risks are significantly associated with growth over the following years when bank capital ratios are low, and financial leverage is high. This result is in stark contrast with the relationship at low levels of financial leverage, which is, if anything, negative. The hypothesis that these coefficients are equal is rejected for horizons $h = 1, 2, 3, 4$. The results for macroeconomic leverage in panel B follow a similar pattern. Turning to the volatility specifications, the association between asset returns and future output growth is positive and significant at all horizons in low-volatility regimes, but is absent after year 1 in high-volatility regimes. Because macro-financial risk difficult to measure, the uncertainty around the response estimates is somewhat larger than for the leverage specifications, with the hypothesis that low- and high-volatility coefficients are equal being rejected at the 10% level for some, but not all horizons.

We have decomposed bank equity returns into the underlying bank asset return and leverage components, and found that realised bank asset risks are significantly associated with economic growth when leverage is high. This larger predictive power of bank asset return innovations in high-leverage regimes may be mechanical, and arise through high leverage amplifying a given asset return to generate a larger change in the return on bank equity. However, it could also be that leverage matters above and beyond the amplification from asset returns to equity returns, further strengthening the link between any given equity return realisation and future GDP.

As a test for the latter hypothesis, we now fix the size of the equity return innovation and run the same regression as in equation (11), replacing asset with equity returns. Table 4 shows the results of this exercise. When financial leverage is high, bank equity returns are strongly positively associated with future GDP growth, and this relationship is statistically significant for years 1 to 4. When financial leverage is low, the correlation between bank equity returns and future GDP growth is weak, often negative, and statistically insignificant for years 2–5. This shows that even for a given bank equity return, small changes in bank asset values at high levels of leverage have much larger predictive power for future GDP than large changes in asset values at low levels of leverage.

3.2.2 Non-linearity and asymmetry

The increasing connectedness between bank asset risk realisations and future macroeconomic performance can be linked to the secular increases in banking sector leverage and size, and declines in macro-financial risk documented in Section 2. In this section, we test whether these changes in predictive power across leverage and volatility regimes can be linked to the specific amplification mechanisms in the theoretical literature. The model in Brunnermeier and Sannikov (2014) predicts that the relationship between bank shocks and macroeconomic outcomes features asymmetries and non-linearities. While the amplification effects for positive return innovations are small in their model, losses are associated with strong amplification and low subsequent output growth. This effect is stronger when previous losses are large, and the banking sector is financially constrained. To evaluate the importance of these amplification mechanisms, we test the following model predictions in the data:

(i) Asymmetry: Negative bank asset risk realisations have stronger predictive power than positive realisations.

(ii) Nonlinearity: Bank asset risk realisations have stronger predictive power when the banking system is in a crisis state (i.e., severely constrained).

(iii) Leverage amplification: The predictive relationships in (i) and (ii) are stronger when leverage is high.

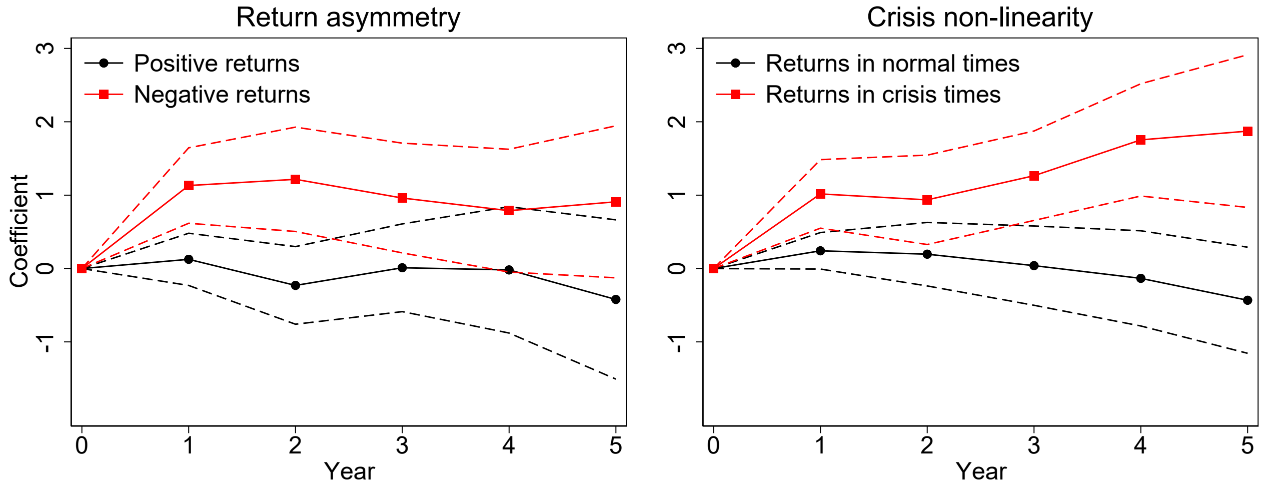
To test the first of these predictions, we distinguish between positive and negative returns, based on the following specification:

$$\begin{aligned}\Delta_h y_{i,t} = \alpha_{i,h} &+ \beta_h^{\text{bank, pos}} R_{i,t}^{\text{bank asset}} \times \mathbb{1}\left(R_{i,t}^{\text{bank asset}} \geq 0\right) + \beta_h^{\text{bank, neg}} R_{i,t}^{\text{bank asset}} \times \mathbb{1}\left(R_{i,t}^{\text{bank asset}} < 0\right) \\ &+ \beta_h^{\text{nonf, pos}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}\left(R_{i,t}^{\text{nonf equity}} \geq 0\right) + \beta_h^{\text{nonf, neg}} R_{i,t}^{\text{nonf equity}} \times \mathbb{1}\left(R_{i,t}^{\text{nonf equity}} < 0\right) \\ &+ \gamma_h \mathbb{1}\left(year > 1945\right) + \theta_h \mathbb{1}\left(R_{i,t}^{\text{bank asset}} \geq 0\right) + \Phi X_{i,t} + \epsilon_{i,t+h}. \end{aligned} \tag{13}$$

As in the volatility and leverage regressions in equation (11), we interact bank asset and non-financial equity returns with a dummy equalling 1 when these returns are either negative or positive, and control for a post-WW2 indicator, positive asset return indicator, and four lags of GDP growth, short-term rates and interactions between returns and the positive and negative return indicators.

The results shown in Figure 9 are in line with theoretical predictions. The left-hand panel shows that while positive returns (black circles) are unrelated to future macroeconomic performance,

Figure 9: *Bank asset returns and future GDP growth: asymmetry and non-linearity*



Notes: This figure plots regression coefficients of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{bank assets}}$, distinguishing between positive and negative returns (left-hand panel), and returns in the first three years after the start of a systemic banking crisis versus normal times (right-hand panel). All specifications include a post-WW2 dummy, country fixed effects, and control for contemporaneous GDP growth, changes in short-term interest rates, and four lags of the interaction and control variables. Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer.

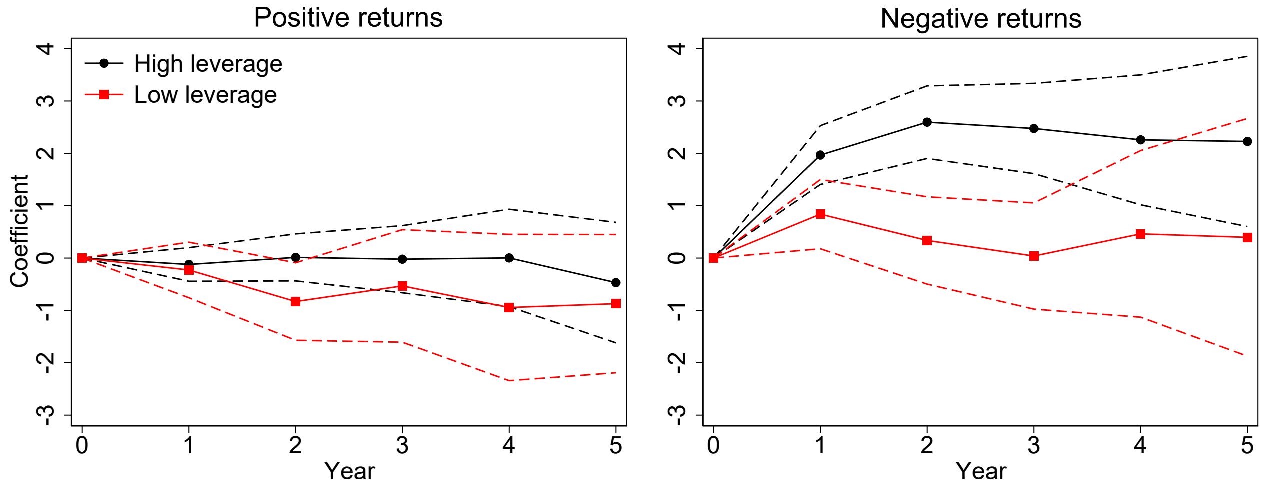
negative returns (red squares) are significantly associated with future output gaps. This strong asymmetry suggests that the baseline relationships studied in Section 3.1 are mainly driven by negative returns. These findings are in line with evidence in Baron et al. (2021), who show that more negative bank equity return innovations are more strongly correlated with future economic activity.

The right-hand panel shows results for an interaction between bank asset returns and a crisis indicator. The crisis indicator proxies for constraints due to previous losses, and takes unity in the first three years after the start of a systemic banking crisis.[11] In line with theoretical predictions, we find a strong relationship between asset returns and future GDP growth in crisis times, while there is no clear relationship visible during normal times. Taken together, the results suggest that the relationship between bank asset returns and macroeconomic outcomes is driven by negative returns in crisis states.

We have seen that the relationship between asset returns and future real economic outcomes is asymmetric, non-linear, and that it depends on leverage. A final test in this section looks at the interaction of the two. We first ask whether the response to positive and negative returns depends on leverage. To test for this, we include the interactions of leverage regimes and asset returns split by sign in the same regression. The results are presented in Figure 10. The left panel shows the response to positive bank asset returns at high and at low leverage levels. There is no strong relationship between positive returns and macroeconomic outcomes, neither at high nor at

[11]We follow the crisis definition of Baron et al. (2021), but results also hold for the narrative-based definition of Schularick and Taylor (2012).

Figure 10: *Bank asset returns and future GDP growth: asymmetry at different leverage levels*



Notes: This figure plots regression coefficients of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{bank assets}}$. Left and right panels show responses estimated from a regression that splits returns by leverage and sign. The left (right) panel shows real GDP responses to positive (negative) asset returns split by financial leverage (bank assets/equity). The specification includes a post-WW2 dummy, country fixed effects, and controls for contemporaneous GDP growth, changes in short-term interest rates, and four lags of the interaction and control variables. Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer.

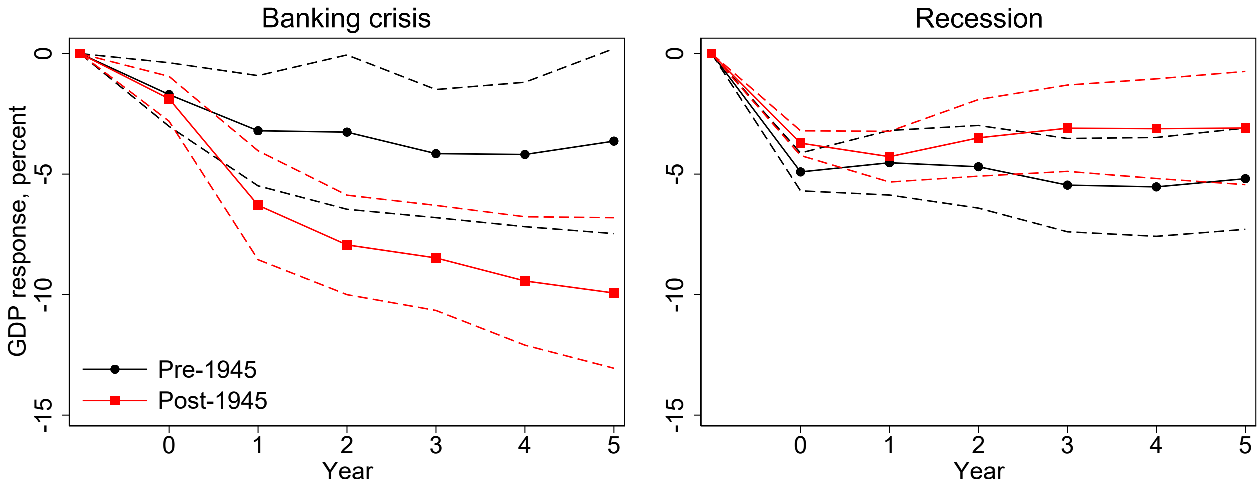
low leverage. The right panel shows that, similarly to positive returns, negative returns have little association with future GDP growth at low leverage levels. The relationship becomes different when a highly leveraged banking sector faces negative asset returns. In this case, the association between realisations of bank asset risk and real economic outcomes is particularly strong. The appendix contains additional results showing that the response to bank asset return innovations is similarly dependent on leverage when the banking sector is constrained due to a recent crisis (Figure A.8).

3.3. The time-varying cost of banking crises

In a final exercise, we study how the changes in the transmission of bank shocks to real activity are reflected in the costs of banking crises. By definition, banking crises reflect large, negative shocks to the banking sector. As a first step, we ask whether the costs associated with banking crisis events have changed over time. We estimate the output costs of a crisis as the difference between observed post-crisis output growth and a conditional forecast of pre-crisis growth, using the following local projection:

$$\Delta_h y_{i,t} = \alpha_{i,h} + \beta_h^{\text{pre}} C_{i,t} \times \mathbb{1}(year \leq 1945) + \beta_h^{\text{post}} C_{i,t} \times \mathbb{1}(year > 1945) \\ + \gamma_h \mathbb{1}(year > 1945) + \Phi X_{i,t-1} + \epsilon_{i,t+h}, \tag{14}$$

Figure 11: *GDP response to systemic banking crises and recessions: before and after WW2*



Notes: This figure plots regression coefficients of real GDP growth from $t-1$ to $t+h$ on systemic banking crisis and recession indicators before and after 1945 based on equation (14). Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. The corresponding coefficients and standard errors are shown in Table A.2.

for horizons $h = 0, ..., 5$. The dependent variable is defined as the difference in log real GDP level between years $t+h$ and $t-1$, that is $\Delta_h y_{i,t} = y_{i,t+h} - y_{i,t-1}$. Banking crisis events are defined using the narrative crisis chronology from Baron et al. (2021) and the variable $C_{i,t}$ takes value of one if a banking crisis started in country i and year t, and zero otherwise. Because we want to study time variation in crisis costs, we interact the banking crisis dummy with indicator variables for the pre- and post-1945 period. Our interest will be in the coefficients β_h^{pre} and β_h^{post} for the costs associated with banking crises in the pre- and post-1945 periods. In all regressions, controls $X_{i,t-1}$ include four lags of GDP growth and changes in short-term interest rates (for years $t-4$ to $t-1$), the post-1945 indicator, and four lags of the crisis indicator C interacted with the pre- and post-WW2 dummies. Note that the timing of this regression differs slightly from the previous section. To be consistent with the crisis cost literature (e.g., Jordà et al., 2013), we allow for a contemporaneous response of GDP to crises, whereas for asset returns [equation (10)] we only looked at the predictive ability for future GDP as in Baron et al. (2021).

The results for crises are shown in the left panel of Figure 11. In the right panel, we conduct the same exercise for garden-variety recessions. As previous literature has shown, crises are costly and are followed by low economic growth (Jordà et al., 2013; Baron et al., 2021). However, we document that there is a strong difference between pre-WW2 (black circles) and post-WW2 (red squares) crisis costs. Cumulative growth over a five-year window is close to an average recession in the pre-WW2 sample, while it is around 10 percentage points below trend in the post-1945 period.[12]

[12]Note that the pre-WW2 era was characterised by lower average growth rates, a higher incidence of banking crises, and shorter business cycles. While financial crises during the 1930s Great Depression were associated with large costs, pre-WW1 banking crises were often associated with no or very mild recessions.

The right-hand panel shows that this is a crisis-specific finding by contrasting the cost of crises to those of a typical recession (excluding those with a banking crisis in a ± 2 year window), identified using the Bry and Boschan (1971) algorithm. Recessions were costly both before and after WW2, with some of these costs notably persistent, in line with recent findings on the long-lasting costs of business cycles by Jordà, Schularick, and Taylor (2020). But the costs of a recession are more or less identical before and after WW2, whereas the costs of crises are not.

The analysis in Section 3.2.1 has shown that the relationship between bank asset returns and macroeconomic outcomes depends on the prevailing levels of macroeconomic and financial leverage. Jordà et al. (2021) showed that recessions associated with a banking crisis are milder when banking sector capital is high. We will now conduct a similar experiment, but first distinguish directly between all banking crises – rather than only crisis-related recessions – at high and low levels of financial leverage, and, second, compare banking crisis costs across different levels of macroeconomic leverage (or banking sector size).[13] More specifically, we compute the mean leverage at the start of all crises in our sample ($\overline{lev}$), and distinguish between crisis when leverage was above and below mean. As with returns, we run two different specifications, one using financial leverage (high when the banking system capital ratio is below mean), and another using macroeconomic leverage (high when bank assets to GDP are above mean):

$$\begin{aligned}\Delta_h y_{i,t} = \alpha_{i,h} + \beta_h^{\text{high}} C_{i,t} \times \mathbb{1}_{(lev_{i,t} \geq \overline{lev})} + \beta_h^{\text{low}} C_{i,t} \times \mathbb{1}_{(lev_{i,t} < \overline{lev})} \\ + \gamma_h \mathbb{1}_{(year>1945)} + \Phi X_{i,t-1} + \epsilon_{i,t+h}\,, \end{aligned} \tag{15}$$

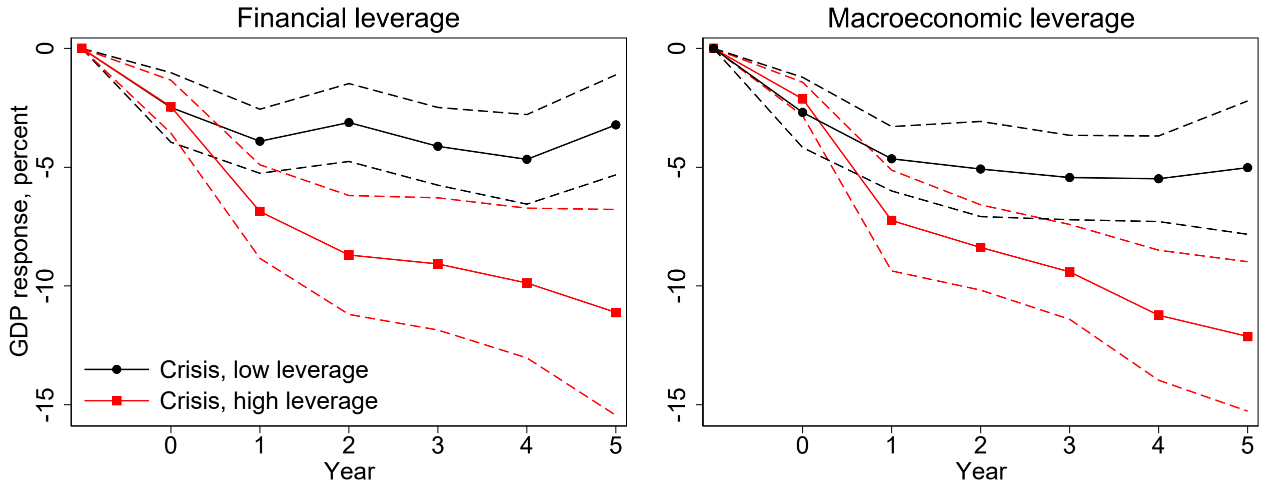
for $h = 0, ..., 5$. We include again a dummy for the post-1945 period, lagged changes in GDP growth and short-term interest rates, and lagged interactions of the crisis indicator with high and low leverage dummies as controls. We are interested in the coefficients β_h^{high} and β_h^{low}.

The left-hand panel of Figure 12 shows costs associated with a crisis at high financial leverage in red squares, and the cost of a crisis at low financial leverage in black circles. The difference between the two paths is clearly visible. While crises at low leverage are associated with small output costs after five years, a crisis at high leverage is associated with, on average, 11% lower GDP relative to the pre-crisis trend – an output cost that is 8% of GDP larger than that of low-leverage crises. Appendix Table A.3 shows the point estimates behind these results in panel A. It also presents a test for the equality of the β_h^{high} and β_h^{low} coefficients, which is rejected for all horizons larger than two years. In the right-hand panel of Figure 12, we show results for the split of crisis events by macroeconomic leverage. The corresponding point estimates and significance tests are shown in Panel B of the Appendix Table A.3. Crises in economies with high macroeconomic leverage are associated with significantly larger output costs over the following five years.

Taken together, these results show that higher levels of macro-financial leverage are associated

[13] Focusing on banking crisis related recessions implies implicitly that amplification from the banking sector to the real economy was already strong enough to generate a macroeconomic downturn, which is why we focus on all crisis events regardless of whether they were associated with a recession or not.

Figure 12: *GDP response to systemic banking crises: different leverage regimes*



Notes: This figure plots regression coefficients of real GDP growth from $t-1$ to $t+h$ on systemic banking crisis indicators interacted with financial and macroeconomic leverage indicators based on equation (15). Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. The corresponding coefficients and standard errors are shown in Table A.3.

with poorer macroeconomic performance in the aftermath of systemic banking crises. Given that much of the differences in crisis outcomes appear to be persistent, the present values of the high-leverage crisis costs are likely to be substantially larger than those of crises at low levels of leverage of the financial sector.

4. Conclusion

We have combined three recently developed datasets to trace out the evolution of bank risk across advanced economies between 1870 and 2016. In the late 19th century, bank asset returns were volatile, but the banking sector was small and well capitalised. In this environment, the excess predictive power of bank asset returns for future economic activity was negligible. The first 100 years of our sample saw a secular decline in both bank asset risk and capital ratios, with combined measures of bank risk reaching an all-time low in the 1950s. But post-1950s increases in banking sector size and asset return volatility, alongside already high levels of financial leverage, meant that by the end of our sample, combined measures of bank risk stand at an all-time high. The impact of these changes on macroeconomic fluctuations also appears to have been less than benign, with negative changes in bank asset values and systemic banking crises being associated with increasingly large output gaps.

Our findings suggest that over the long run, bank investments became safer, but the banking sector has become more risky for the real economy. Even though it may seem paradoxical at first, this conjecture resonates well with modelling approaches in which financial intermediaries play a key role in creating and amplifying macroeconomic risk. Our findings carry several further implications for researchers and policymakers. One is that narrow measures focused on bank asset risk may not offer a good proxy for the macroeconomic risks arising from banking, and vice versa. Going beyond the measurement of risk, a broader lesson looms in the background. The secular reductions in bank asset risk exposures suggest that, historically, advances in information technology and innovative financial contracts made it easier for banks to monitor and manage risk, thereby increasing the safety of bank assets. Through the endogenous response of the financial system, however, these innovations may have made the banking sector more risky for the economy, as anticipated prior to the global financial crisis by Rajan (2006). Going forward, new technology-driven innovations have the potential to reduce asset risks further. Systemic risks arising from banking may, however, increase even as asset risks decline – a lesson that policymakers should have in mind.

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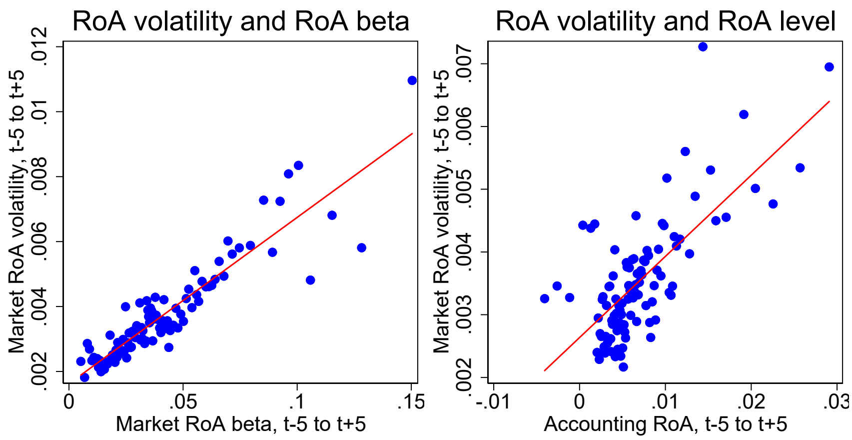
Appendix

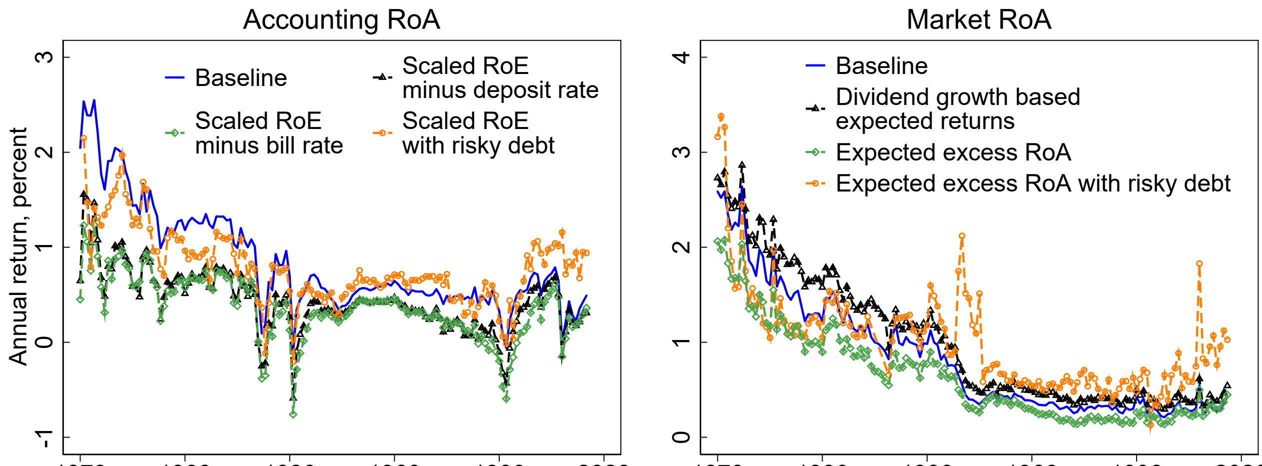
A. Risks within banking: additional material

Figure A.1: *Correlations between different measures of asset risk*



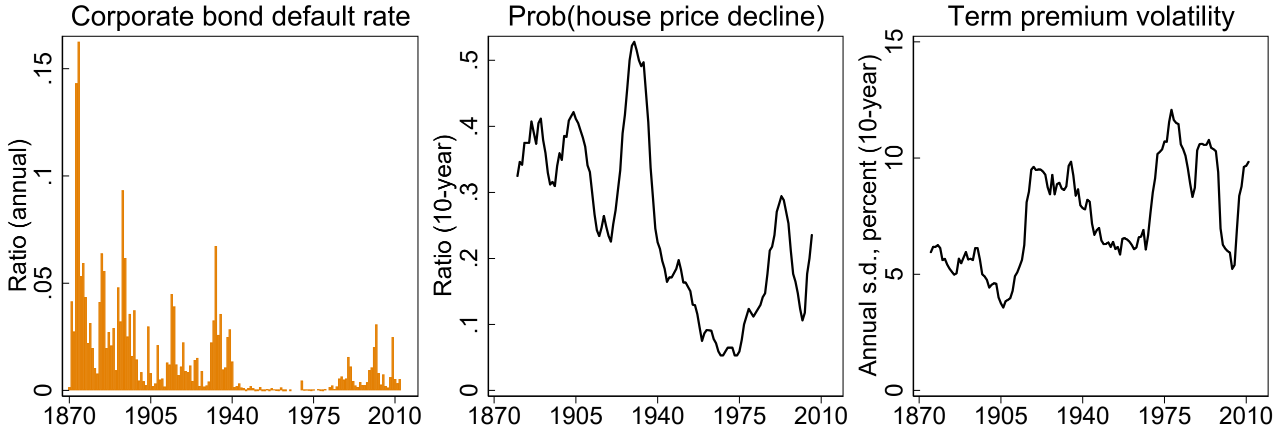
Notes: Binned scatter plots, 100 bins. Volatilities and betas are computed at country level, using 10-year windows of monthly returns. RoA level is the average accounting RoA over the same 10-year window. Underlying data are winsorised at 1% level and adjusted for country fixed effects.

Figure A.2: *Alternative bank asset return measures*



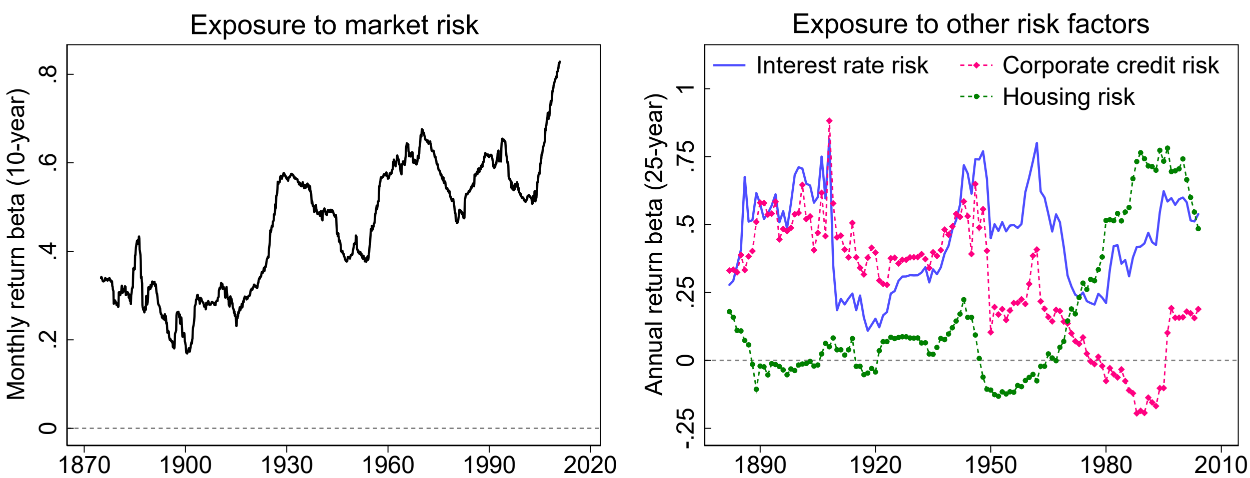
Notes: Left-hand panel: Baseline measure is equal to net profits divided by total bank assets. The scaled RoE minus deposit rate, and minus the bill rate, are calculated as the accounting RoE (net profits / equity liabilities) minus the safe rate, multiplied by the bank capital ratio, with the deposit rate and 10-year ($t-9$ to t) average government bill rate used as safe rate measures, respectively. Scaled RoE with risky debt is the scaled RoE minus the deposit rate plus the market debt risk premium (the corporate bond spread) multiplied by the share of risky debt to total equity liabilities, with risky debt set equal to all non-deposit debt liabilities of banks. Right-hand panel: Baseline measure is calculated as the bank dividend-price ratio plus country-average real capital gain, multiplied by the bank capital ratio. Dividend growth based expected returns sum the dividend yield and the country-average real dividend growth rate (winsorised at 1% level), instead of the average real capital gain. Expected excess RoA is the expected bank equity return minus the trend real safe rate calculated using the Del Negro et al. (2019) Bayesian model, multiplied by the bank capital ratio. Expected excess RoA with risky debt is the expected excess RoA plus the corporate bond spread multiplied by the ratio of non-deposit bank debt liabilities to total bank liabilities.

Figure A.3: *Long-run trends in financial risks*



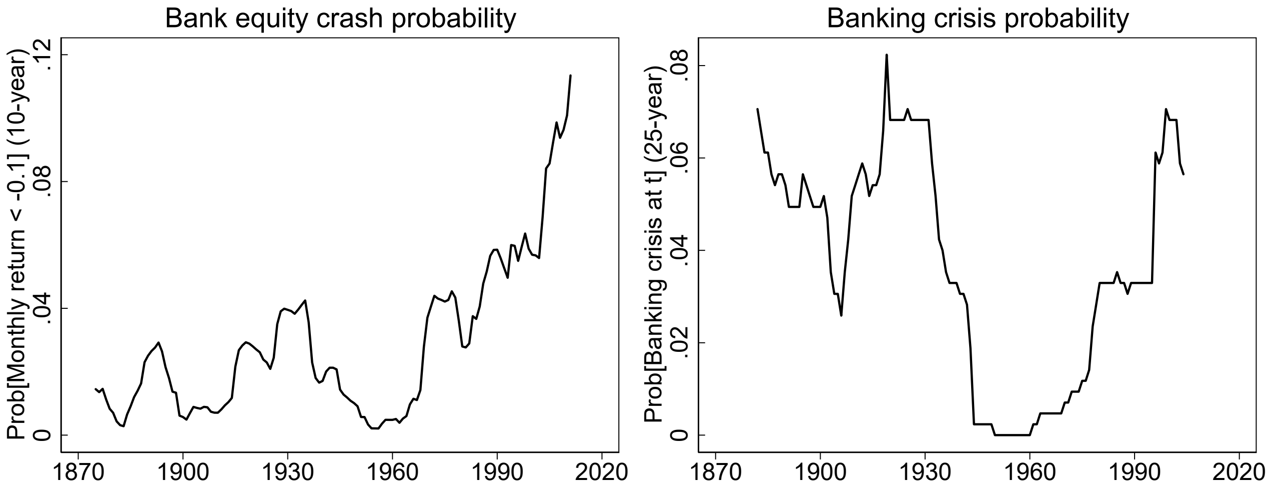
Notes: Left-hand panel: par value of bonds in default relative to all outstanding corporate bonds, US only, from Giesecke, Longstaff, Schaefer, and Strebulaev (2011). Middle panel: ratio of observations with negative housing capital gain to all observations with non-missing housing capital gain data within a centered 10-year window of pooled annual 17-country data. Right-hand panel: standard deviation of the annual excess government bond return (total return minus the short-term bill rate), centered 10-year windows of pooled cross-country data.

Figure A.4: *Bank equity risk factors*



Notes: The risk exposures are time-varying betas obtained from regressing bank stock returns on contemporaneous non-financial stock returns (market risk), excess government bond returns (interest rate risk), the difference between corporate and government bond returns (corporate credit risk), and the excess housing return (housing risk). Excess returns are the total return minus the short-term bill rate. Left-hand panel: Monthly betas estimated on centered 10-year windows. Right-hand panel: Annual betas controlling for the exposure to market risk, estimated on centered 25-year windows.

Figure A.5: *Frequency of bank equity crashes and banking crises*



Notes: Left-hand panel: A bank equity crash is a -10% or lower monthly bank stock return, probability is the number of crash observations within a 10-year centered rolling window divided by the total number of bank stock return observations. Right-hand panel: banking crisis events are defined using the narrative crisis chronology from Baron et al. (2021). The crisis probability shows the proportion of crisis observations relative to total observations within the 20-year rolling window (only the first year of the crisis is counted).

Table A.1: *Correlations between bank asset risk, equity risk and leverage*

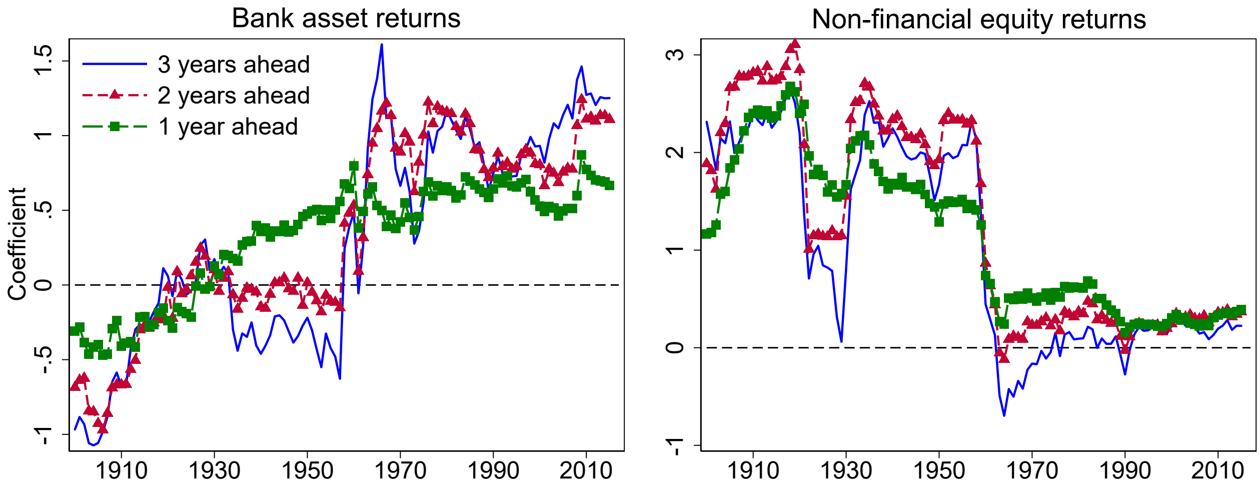
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Return volatility			Return beta			Return level		
	ln(Vol)	ln(Vol)	Δln(Vol)	ln(β)	ln(β)	Δln(β)	ln(R)	ln(R)	Δln(R)
	Panel A. Dependent variables: bank asset risk measures								
ln(Assets/Equity)	-0.59***	-0.97***	-0.64***	-0.15***	-0.27***	-0.17***	-0.04***	-0.03***	-0.03***
	(0.08)	(0.10)	(0.10)	(0.02)	(0.03)	(0.03)	(0.00)	(0.00)	(0.01)
R^2	0.32	0.63	0.45	0.27	0.47	0.29	0.42	0.60	0.20
Observations	1637	1637	1461	1421	1421	1224	2156	2156	2003
	Panel B. Dependent variables: bank equity risk measures								
ln(Assets/Equity)	0.39***	-0.04	0.05	0.28***	-0.19***	-0.12	0.01**	0.01	-0.07
	(0.08)	(0.09)	(0.10)	(0.06)	(0.07)	(0.10)	(0.01)	(0.01)	(0.05)
R^2	0.17	0.56	0.37	0.12	0.39	0.22	0.02	0.20	0.14
Observations	1639	1639	1463	1429	1429	1231	2156	2156	2003
Country fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year fixed effects		✓	✓		✓	✓		✓	✓

Notes: This table shows the results of regressing different measures of bank asset and equity risk on the log of financial leverage (bank assets/equity). In all regressions, the independent (x) variable is the log ratio of bank assets to equity in year t. The dependent (y) variable is the measure of risk computed for the centered five-year window around year t. Vol is the monthly asset (Panel A) or equity (Panel B) return volatility within a centered 5-year window around December of year t. β is the covariance of monthly asset (Panel A) or equity (Panel B) returns with the return on non-financial equity divided by the variance of the non-financial return, within the 5-year centered window. The return level is the accounting RoA (Panel A) or RoE (Panel B), averaged between years $t-2$ and $t+2$. The changes specifications in columns 3, 6, and 9 correlate the change in the log leverage (assets/equity) ratio between $t-5$ and t with the change in the risk measure between $t-5$ and t. Driscoll-Kraay standard errors in parentheses adjusted for autocorrelation of 5 lags. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

B. Macro risks arising from banking: additional material

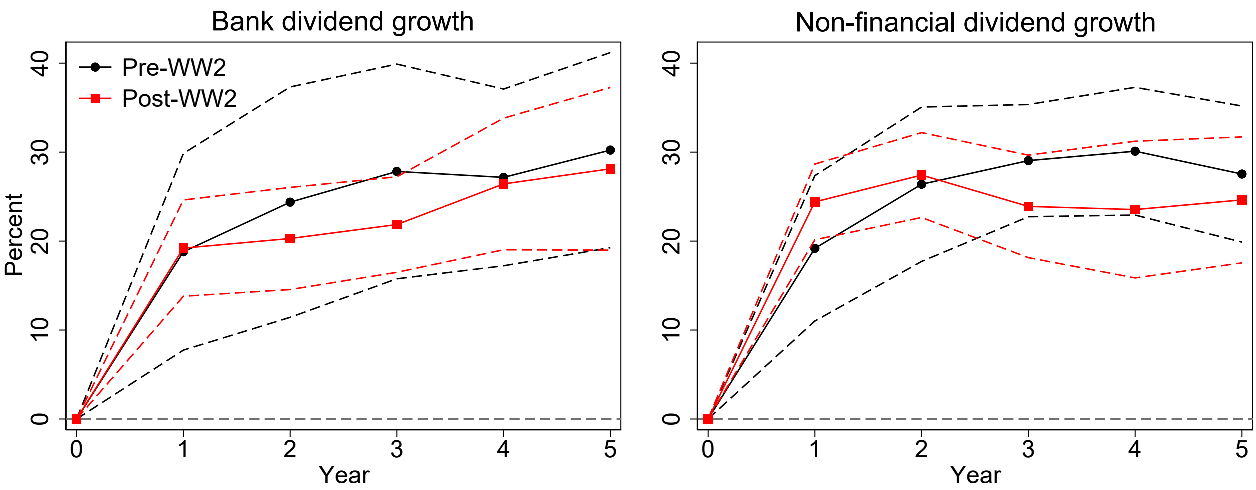
B.1 Bank asset returns and economic activity

Figure A.6: *Bank asset returns and future GDP growth, rolling regression coefficients at different horizons*



Notes: Coefficients from a rolling predictive regression of one-, two- and three-year ahead GDP growth. 30-year backward-looking windows. The regressions include changes in bank asset values (plotted in the left-hand panel), changes in non-financial equity values (ploted in the right-hand panel), and country fixed effects. Underlying return data are standardised by country with mean of zero and standard deviation of one.

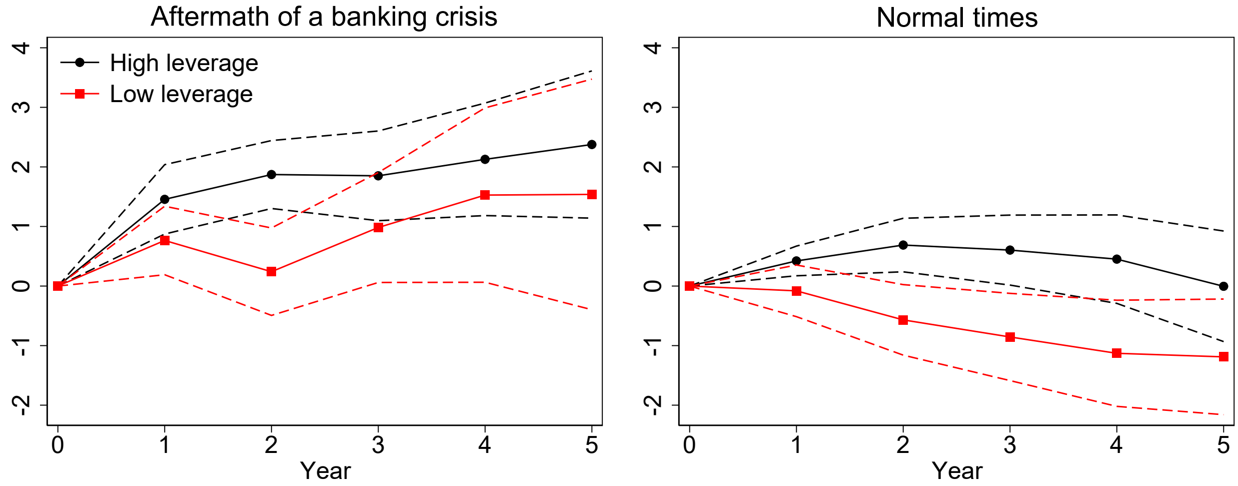
Figure A.7: *Bank and non-financial dividend predictability*



Notes: This figure plots regression coefficients of real dividend growth from t to $t+h$ on the price-dividend ratio $P_{i,t}/D_{i,t}$. The left-hand panel shows the coefficients for future log real bank dividend growth regressed on today's bank price-dividend ratio, conditional on the non-financial price-dividend ratio. The right-hand panel shows the coefficients for non-financial dividend growth regressed on the non-financial price-dividend ratio, conditional on the bank price-dividend ratio. Coefficients correspond to a one standard deviation change in the log price-dividend ratio. All data are winsorised at the 1% level. We differentiate between pre- and post-WW2 as described in equation (10). All specifications include a post-WW2 dummy, country fixed effects, and control for contemporaneous GDP growth, changes in short-term interest rates, and four lags of the interaction and control variables. Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer.

B.2 Mechanisms

Figure A.8: *Predictive power of changes in bank asset values for future GDP growth across crisis and leverage regimes*



Notes: This figure plots regression coefficients of real GDP growth from t to $t+h$ on $R_{i,t}^{\text{bank assets}}$. We bin observations based on mean financial leverage (high if equity/assets is low), and whether the returns are realised in the aftermath of a systemic banking crisis (3 years after the crisis start date, left-hand panel) or not (all other observations, right-hand panel). Banking crises are dated according to the chronology of Baron et al. (2021). All specifications include a post-WW2 dummy, country fixed effects, and control for contemporaneous GDP growth, changes in short-term interest rates, and four lags of the interaction and control variables. Dashed lines are 90% confidence intervals around the coefficient estimates based on Driscoll-Kraay standard errors adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer.

B.3 Time-varying cost of banking crises

Table A.2: *Response of GDP to systemic banking crises and recessions, before and after WW2*

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
	Panel A: Banking crises					
Crisis, pre-1945	-1.70**	-3.20**	-3.26*	-4.15***	-4.19**	-3.63
	(0.79)	(1.36)	(1.91)	(1.58)	(1.78)	(2.28)
Crisis, post-1945	-1.88***	-6.29***	-7.94***	-8.48***	-9.43***	-9.93***
	(0.55)	(1.34)	(1.23)	(1.30)	(1.58)	(1.86)
R^2	0.10	0.14	0.15	0.16	0.16	0.17
P-value, Pre=Post	0.86	0.11	0.04	0.03	0.02	0.03
	Panel B: Recessions					
Recession, pre-1945	-4.91***	-4.53***	-4.70***	-5.46***	-5.53***	-5.19***
	(0.47)	(0.80)	(1.02)	(1.15)	(1.22)	(1.25)
Recession, post-1945	-3.71***	-4.28***	-3.50***	-3.10***	-3.12**	-3.09**
	(0.31)	(0.63)	(0.95)	(1.07)	(1.23)	(1.40)
R^2	0.18	0.14	0.13	0.14	0.14	0.15
P-value, Pre=Post	0.04	0.81	0.36	0.11	0.13	0.23
Country fixed effects	✓	✓	✓	✓	✓	✓
Control variables	✓	✓	✓	✓	✓	✓
Observations	1952	1952	1952	1952	1952	1952

Notes: This table plots regression coefficients of real GDP growth from $t-1$ to $t+h$ on systemic banking crisis and recession dummies for the pre- and post-1945 period. All specifications include a post-WW2 dummy, country fixed effects, and control for four lags of GDP growth, changes in short-term interest rates, and the crisis and recession dummies. Driscoll-Kraay standard errors in parentheses adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. *, **, and *** indicate significance at the 0.1, 0.05, 0.01 levels, respectively.

Table A.3: *Output growth after banking crises: different leverage regimes*

	Panel A: Crises binned by financial leverage					
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Crisis, low assets / equity	-2.48***	-3.91***	-3.12***	-4.12***	-4.67***	-3.22**
	(0.87)	(0.80)	(0.98)	(0.97)	(1.12)	(1.25)
Crisis, high assets / equity	-2.45***	-6.87***	-8.69***	-9.07***	-9.88***	-11.11***
	(0.66)	(1.17)	(1.49)	(1.66)	(1.88)	(2.58)
R^2	0.14	0.20	0.18	0.17	0.16	0.16
P-value, High=Low	0.97	0.04	0.00	0.02	0.03	0.01
Observations	1456	1456	1456	1456	1456	1456
	Panel B: Crises binned by macroeconomic leverage					
Crisis, low assets / GDP	-2.69***	-4.64***	-5.08***	-5.43***	-5.49***	-5.02***
	(0.88)	(0.81)	(1.19)	(1.06)	(1.07)	(1.67)
Crisis, high assets / GDP	-2.13***	-7.24***	-8.38***	-9.41***	-11.23***	-12.12***
	(0.42)	(1.26)	(1.07)	(1.19)	(1.63)	(1.87)
R^2	0.13	0.19	0.18	0.17	0.17	0.16
P-value, High=Low	0.53	0.07	0.02	0.00	0.00	0.00
Observations	1453	1453	1453	1453	1453	1453
Country fixed effects	✓	✓	✓	✓	✓	✓
Control variables	✓	✓	✓	✓	✓	✓

Notes: This table plots regression coefficients of real GDP growth from $t-1$ to $t+h$ on systemic banking crises conditional on financial (assets/equity) and macroeconomic (assets/GDP) leverage based on equation (15). All specifications include a post-WW2 dummy, country fixed effects, and control for 4 lags of GDP growth, changes in short-term interest rates, and past crises. Driscoll-Kraay standard errors in parentheses adjusted for autocorrelation of $1.5 \times h$ lags rounded down to the nearest integer. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Acknowledgements

The contribution of Dmitry Kuvshinov has been prepared under the Lamfalussy Fellowship Programme sponsored by the ECB. Any views expressed are only those of the authors and do not necessarily represent the views of the ECB or the Eurosystem. We would like to thank Christian Eufinger, Xavier Freixas, Dmitry Khametshin, Moritz Schularick, and seminar participants at Bonn, UPF, and the Madrid-Barcelona workshop on banking and corporate finance for helpful comments and thank Matthew Baron for sharing data.

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PDF ISBN 978-92-899-5121-0 ISSN 1725-2806 10.2866/712618 QB-AR-22-037-EN-N