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Sovereign Risk and Bank Lending: Theory and Evidence from a Natural Disaster

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Abstract: We quantify the sovereign-bank doom loop by using the 1999 Marmara earthquake as an exogenous shock leading to an increase in Turkey's default risk. Our theoretical model illustrates that for banks with higher exposure to government securities, a higher sovereign default risk implies lower net worth and tightening financial constraint. Our empirical estimates confirm the model's predictions, showing that the exogenous change in sovereign default risk tightens banks' financial constraints significantly for banks that hold a higher amount of government securities. The resulting tighter bank financial constraints translate into lower credit provision, suggesting that there is a significant balance-sheet channel in transmitting a higher sovereign default risk toward real economic activity.

JEL classification: E32, F15, F36, O16

Key words: banking crisis, bank balance sheets, lending channel, public debt, credit supply

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I Introduction

Financial institutions play a pivotal role in supplying credit both to private sectors and sovereign governments. Lending to their own sovereigns increase the exposure of the domestic financial institutions to sovereign risk.[1] An increase in sovereign risk constitutes a direct balance sheet shock to the banks that hold sovereign debt (Gennaioli, Martin, and Rossi (2014), Holmstrom and Tirole (1993), Sosa-Padilla (2018), Morelli, Ottonello, and Perez (2022)). Higher sovereign risk can also affect banks' financial performance by reducing the collateral value of the sovereign bonds and thereby banks' ability to secure funding. Finally, the sovereign risk may be transmitted to banks' lending to non-financial sector via its effect on bank balance sheet (Arellano, Bai, and Bocola (2020)). These concerns played out most notably in the 2012 Eurozone crisis. However, the surge in government borrowing across both advanced and emerging markets, spurred by the Covid-19 crisis, has brought them back to the fore.

Nevertheless, quantifying the effect of sovereign risk on bank balance sheet and credit provision is a challenging task. In particular, it is difficult to identify a causal relationship between sovereign risk and banking sector distress due to the bank-sovereign doom loop episodes, which underline the well-known facts about the coincidence of sovereign crises and banking crises (Reinhart and Rogoff (2009)). First, sovereign risk can increase endogenously due to weak banks. In the presence of a financial crises, banks under financial stress face a risk of becoming insolvent, which can result in the need for a government bailout. As governments recapitalize banks to backstop the financial system as a lender of last resort, such bailouts can increase sovereign risk (Acharya, Drechsler, and Schnabl (2014)). Second, the bank balance sheet shocks are mostly anticipated and unfold simultaneously with the sovereign debt crisis. For example, banks can actively manage their balance sheet by buying/selling government bonds in response to changes in sovereign risk. Furthermore, the value of the existing government bonds may not change on the bank balance sheet even when sovereign

[1] Sovereign governments mostly borrow from domestic residents (Aguiar and Amador (2014), Tomz and Wright (2013), Reinhart and Rogoff (2009), Wei and Yue (2019), and Fang, Hardy, and Lewis (2022)).

ratings go down, if banks are recording all assets at book value. In this case, the shock to the bank balance sheet may not be observed in the data. A bank will change its behavior in terms of private sector lending given the lower market value of bonds, but the change in the value of the bonds may not be observed on the balance sheet. In this case, one can can erroneously attribute the change in bank lending to other factors and/or conclude that there is no effect of increased sovereign risk on lending through bank balance sheets. Third, if the troubles in the banking sector and/or increased sovereign risk lead to a recession and increased uncertainty, the demand for credit by private sector will go down. Therefore, in the absence of an exogenous shift in credit supply conditions while keeping the demand constant, the variations in the credit provision can simply reflect the recessionary environment potentially affecting loan demand rather than the deterioration in bank balance sheets which potentially affect the supply. Last but not least, lack of appropriate micro data and therefore reliance on macro data can complicate disentangling factors affecting loan demand from loan supply.

This paper investigates the link between government bonds, banks' financial constraints and credit market disruptions using a unique natural experiment and detailed micro level data that solves the aforementioned identification issues. We first provide an analytical framework to identify the banks' balance sheet channel. In particular, based on Bocola (2016), we derive an empirical measure for the changes in the financial constraints of banks, who are heterogeneous in their net worth and portfolio, and hence face different changes in their funding constraint as the economy experiences an unexpected increase in sovereign risk. Second, we utilize the 1999 Marmara Earthquake as an unanticipated exogenous fiscal shock that elevated Turkey's sovereign risk. The unanticipated nature of the shock makes it impossible for the banks to accumulate or run down government debt in expectation of sovereign risk. Hence, this helps us to rule out moral hazard and/or risk shifting scenarios due to sovereign default expectations. Third, we use an administrative portfolio data for the universe of banks in Turkey between 1997–2002 to analyse how banks' exposure to sovereign debt at the time of the unanticipated exogenous shock affects their financial constraints and credit provision in the aftermath of the earthquake.[2]

Our empirical strategy relies on the size and the unanticipated nature of the fiscal shock. In terms of the size of the fiscal shock, the Marmara earthquake is significant. It hit on August 17, 1999 at a Richter Scale of 7.6 in the industrial heartland of Turkey.[3] The region's population share in the country total is 25 percent and GDP share is 50 percent. Total cost of the disaster in August 1999 is estimated to be 20 billion USD, which is 11 percent of GDP as of 2000.[4] The Marmara Earthquake is listed in top ten in the U.S. NGDS Significant Earthquakes database on all earthquakes recorded in history.[5] To put this event in context, the ratio of damaged buildings (including key industrial/chemical factories) is 4 times higher than 1995 Kobe earthquake and 12 times higher than 1994 Northridge earthquake. Following the earthquake, the spreads on government bonds went up as well as the maturity of the government debt got shorter, indicating an increase in default risk. The value of the government bonds declined, constituting a negative shock to banks' balance sheets; more so for the banks with high ex-ante exposure to sovereign debt.

In the empirical analysis, we study how the unexpected exogenous earthquake shock tightens the banks' financial constraint. In particular, we construct bank-specific Lagrange multipliers to proxy the degree of the financial constraint following Bocola (2016). We show that this measure correlates negatively with bank lending. We then analyse how this model-based financial constraint proxy differs across banks with low and high exposure to government debt following the earthquake. These results show that banks' financial constraints tightened by more following the shock when they had greater exposure to government debt.

[2]While we focus on the time period around the Earthquake for identification, these concerns and mechanisms continue to be broadly relevant. See for example this news report, where Turkish banks in late 2022 are reportedly concerned about regulation pushing them to hold more government debt.

[3]Throughout the paper, we use the Marmara Earthquakes as two Earthquakes which took place in August 1999 and November 1999. The major one hit cities in the Marmara Region such as Istanbul, Kocaeli, Sakarya, Duzce, Bolu, Yalova, Eskisehir and Bursa in August 17th, 1999 and was associated with substantial economic and social costs. The second one happened on November 12th, 1999 in Duzce Region.

[4]See Akgiray, Barbarosoglu, and Erdik (2004) and National Geophysical Data Center, NOAA. doi:10.7289/V5TD9V7K.

[5]National Geophysical Data Center / World Data Service (NGDC/WDS): Significant Earthquake Database. National Geophysical Data Center, NOAA. doi:10.7289/V5TD9V7K provided in National Oceanic and Athmospheric Administration available at http://www.ngdc.noaa.gov.

Furthermore, we show that this tightening of constraint reflects the balance sheet channel, as banks saw valuation effects on their balance sheet and their net worth and profits were also negatively affected. Therefore, the empirical analyses validate the model's predictions and point to the bank's balance sheet channel in transmitting the unexpected sovereign risk onto the credit supply.

We next go more in depth to show a causal link from sovereign risk to bank lending using a differences-in-differences methodology. We find that banks with higher exposures to government debt before the earthquake decreased lending more than the banks with lower exposures. We show that this is not driven by pre-existing trends, changes in credit demand, changes in firm risk (NPLs), by ex-ante adjustments in sovereign bond holdings and other alternative explanations. We use the earthquake as an instrument to show how the impact of this fiscal shock operates through an increase in government bond yields.

Finally, we quantify the impact of the fiscal shock on bank lending, showing that the impact is economically significant. Our estimates imply that a bank that holds 18 percent of its assets in government bonds (the average in our sample) decreases credit to assets ratio by 3.5 percentage points during regular times (a normal time crowding out effect) and by an additional 1.5 percentage points during the earthquake. These are sizeable effects. The actual decline in credit to assets rate is 3 percentage points during the earthquake period. Hence, our estimates can explain half of the actual decline in credit provision from August to November 1999, on average.

Our paper contributes in novel ways to the literature that relates the sovereign debt crises to private sector's access to credit. The existing literature focuses on the rise in sovereign spreads and/or actual defaults as the sovereign shock. For example, Arteta and Hale (2008) find evidence of a decline in foreign credit over the period between 1984 and 2004 for 30 emerging markets in the aftermath of a sovereign debt crisis that these countries experienced. Arellano et al. (2020) document a negative direct effect of sovereign risk on Italian firms, especially for firms in regions where banks were highly exposed to government debt.

Our paper is also related to those papers that focus on the balance sheet channel, such as Bofondi and Sette (2018) and Gennaioli, Martin, and Rossi (2018). Both papers look at the effect of sovereign debt crises/defaults on lending to real sector. Bofondi and Sette (2018) interpret their finding on reduced credit supply as a "lender-of-last-resort" shock, since they do not find any differential results based on bank characteristics but rather they find a country effect. Gennaioli et al. (2018), on the other hand, find that banks who hold more government bonds during normal times for liquidity reasons cut lending more during defaults. Using data from a wide array of past emerging market sovereign defaults, Gennaioli et al. (2014) shows a negative relation between bank lending and holdings of sovereign bonds during default episodes.

In the European context, Becker and Ivashina (2014) use firm-level data on bank borrowing and bond issuance to document that European companies were more likely to substitute loans with bonds when banks in their country owned more domestic sovereign debt and when that debt was risky. Popov and Van Horen (2015) and De Marco (2019) show that after the start of the Euro Area sovereign debt crisis, banks from non-stressed countries with sizeable exposures to stressed sovereign debt reduced their syndicated lending and increased their loan rates more than non-exposed banks. Acharya, Eisert, Eufinger, and Hirsch (2019) combine syndicated loan data with company-level data, to investigate the real effects of the loan supply contraction triggered by the sovereign crisis. These studies in general uses limited European Banking Authority (EBA) stress test data for banks' sovereign exposures. Altavilla, Pagano, and Simonelli (2015), uses confidential ECB monthly exposure data for a longer time span and also finds a sizeable balance sheet effect for banks who were exposed more to sovereign risk.

Lastly, our paper is related to the studies that emphasize the the role of banks' balance sheet in transmitting shocks. Morelli et al. (2022) show that around Lehman Brothers' bankruptcy, emerging-market bonds held by more distressed global banks experienced larger price contractions. Bai, Kehoe, and Perri (2019), and Gilchrist, Wei, Yue, and Zakrajšek (2022) study global risk and the financial capacity of international financial intermediaries as determinants of sovereign spread dynamics.

Our paper is different from all the above papers in a number of ways. First, our analysis relies on the data from the regulatory filings of banks' on their exposure to the government debt. More importantly, we make use of the unique natural experiment which was a tipping point for the sustainability of public debt. In this sense, we have an exogenous increase in sovereign risk, whereas all of the empirical papers in the literature undertakes their analysis in the middle of the sovereign debt crisis. Hence our paper provides causal evidence on the balance sheet channel. Finally, by utilizing both various measures on banks' financial health and the conceptual framework on how government securities affected banks' financial constraints and further lending behaviour, we shed light on potential mechanisms whereby exogenous increase in sovereign default risk affect the credit provision, and potentially the real economy, through its effect on banks' financial performance.

The rest of the paper is structured as follows. The next section presents the theoretical framework on how sovereign risk affects the banks' balance sheets. Section 3 presents the country background for Turkey. Section 4 presents our data. Section 5 presents empirical results. Section 6 presents some further robustness analysis. Section 7 concludes.

II Theory

We first present the theoretical framework to study how sovereign risk negatively impacts the credit supply through banks' balance sheet. Based on the model, we then conduct an empirical analysis for Turkey during the earthquake using the bank-level data for Turkey.

The model is based on Bocola (2016). It is a standard growth model enriched with a financial sector as in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). The economy is populated by households, final good producers, capital good producers, and a government. The household is a combination of workers and bankers. Workers supply labor to final good firms. Bankers intermediate savings and invest in government bonds and the firms. Financed by the bankers, firms produce using labor and capital from capital good producers. The government issues long-term bonds and taxes households in order to finance government spending. The actions of the government are determined via fiscal rules. The government bonds are non-state contingent, but the government can default on its payment.

The households' problem is standard. Denote the state variables by S. The households take wage $W(S)$, government taxes $\tau(S)$, firm profit $\Pi(S)$, and the risk free return $R(S)$ as given. From the households' standard consumption-saving problem of maximizing the life-time utility with the flow utility function $u(c, l)$, one can obtain the households' pricing kernel $\Lambda(S, S') = \beta\,[u_c(c', l')/u_c(c, l)]$.

The banker uses his accumulated net worth, n, and households' savings, b', to buy government bonds and claims on firms. The banker also lives to the next period with a survival probability ψ. a_B and Q_B denote the quantity and price of government bonds acquired by the bankers. $R_B(S', S)$ is the realized bond returns next period. The claims on the firms bought by bankers is a_K with price Q_K. The realized return on these claims next period is denoted by $R_K(S', S)$. Taking prices as given, a banker chooses $\{a_B, a_K, b'\}$ to maximize the present discounted value of dividends paid to the household.

As in Gertler and Karadi (2011) and Bocola (2016), there is an agency problem between bankers and their creditors. After making the portfolio choice, the banker can divert a fraction λ of the total assets and transfer these resources to his household. Doing so causes the banker to go bankruptcy and the creditors can recover the remaining $(1 - \lambda)$ of the assets.

The banker's problem is

$$
\begin{aligned}
v^b(n;S) &= \max_{b',a_B,a_K} \mathbf{E}_S \left\{ \Lambda(S',S) \left[(1-\psi)n' + \psi v^b(n';S') \right] \right\}, \\
&\text{s. t.} \\
\sum_{j=\{B,K\}} Q_j(S)a_j &\leq n + \frac{b'}{R(S)}, \\
\lambda \left[\sum_{j=\{B,K\}} Q_j(S)a_j \right] &\leq v^b(n;S), \\
n' &= \sum_{j=\{B,K\}} R_j(S',S)Q_j(S)a_j - b', \\
S' &= \Gamma(S),
\end{aligned}
$$

As in Bocola (2016), the solution to the banker's dynamic program is

$$
v^b(n;S) = \alpha(S)n.
$$

where the marginal value of wealth, $\alpha(S)$, solves

$$
\alpha(S) = \frac{E_S\left\{\Lambda(S',S)\left[(1-\psi)+\psi\alpha(S')\right]R(S)\right\}}{1-\mu(S)}.
$$

$\mu(S)$ is the Lagrange multiplier on the incentive constraint which satisfies

$$
\mu(S) = max\left\{1 - \left[\frac{E_S\left\{\Lambda(S',S)\left[(1-\psi)+\psi\alpha(S')\right]R(S)\right\}n}{\lambda\left[Q_K(S)a_K + Q_B(S)a_B\right]}\right], 0\right\}.
$$

One can write the incentive constraint as

$$
\frac{\sum_{j=\{B,K\}} Q_j(S)a_j}{n} \leq \frac{\alpha(S)}{\lambda},
$$

implying that the leverage of a banker cannot exceed the threshold $\frac{\alpha(S)}{\lambda}$. When the bank net worth is low, the constraint on bank leverage is more likely to bind. When this happens, the banker obtains fewer resources from households and reduces his demand for government and firms' claims.

As shown in Bocola (2016), the Lagrange multiplier on the incentive constraints of bankers, as a measure of financial constraints faced by the banks, is a function of their leverage, and of the spread between the interbank rate and the risk-free rate

$$\mu_t = \frac{\left[\frac{R_{interbank,t} - R_t}{R_t}\right] \text{lev}_t}{1 + \left[\frac{R_{interbank,t} - R_t}{R_t}\right] \text{lev}_t} \tag{1}$$

In this model, banks can be heterogeneous in terms of their net worth and in their asset holdings. The aggregate dynamics are unaffected. Yet at the bank level, depending on the decomposition of their assets, the financial constraints and the net worth of the banks may be affected differently by the exogenous sovereign risk. This, in turn, has heterogenous effect on the banks' ability to supply credit. Our empirical analysis sheds light to this channel by showing how banks with different holdings of government bonds transmit an unexpected Earthquake shock onto the credit supply in Turkey.

Based on this theoretical model, when the government is subject to an unexpected shock that raises the sovereign default risk, the banks' net worth is reduced, tightening the financial constraint. Therefore, the demand for firms' claim reduces. Using Turkey's micro-level data, we will later provide a formal empirical analysis based on difference in differences estimation in order to analyze how financial constraints of the banks with different levels of exposure to government securities responded to exogenous shock to sovereign risk induced by the earthquake. We will further analyze how tighter financial constraints for the banks were translated into their credit provision.

III Country Background

Towards the end of 1980s, the Turkish economy was characterized by a sizable savings gap arising from both private and public sector, as a result of which Turkey liberalized the capital account in 1989. After the capital account liberalization, the banks started borrowing mainly from international markets and purchased government securities which offered high real returns in domestic currency.

While the capital account liberalization made the government debt finance easier, the political developments in early 1990s resulted in a further deterioration in public finances, resulting in a larger public sector borrowing requirement by 1993-1994 and ultimately a major financial crisis in 1994, after which the government's dependence on the domestic borrowing increased further. In the period between 1994 and 1998, the government incentivized the banks further to finance the public debt by borrowing from abroad in foreign currency and lending to government in domestic currency. This led to higher maturity and FX risk in the banking sector.[6] While the government tried to limit the growth rate of debt stock by cutting net non-interest expenditures, the government debt continued to increase due to high interest expenditures on domestic debt.[7] However, a series of events, such as Asian Crises and Russian Crises increased government's debt burden due to interest rate expenditures in 1997-1998 period (see Figure 1). In both crises, the government debt has increased due to higher interest rate burden.

However, the tipping point for the sustainability of the Turkish government's debt were the series of earthquakes in Marmara Region, notably the one on August 17th 1999 followed

[6] In order to facilitate this process, the monetary policy in the period between 1994 and the end of 1999 was geared towards providing considerable foresight in exchange rate for the banks. As part of the managed floating exchange rate regime implemented by the Central Bank, the monthly depreciation rate of Turkish lira vis-a-vis against hard currencies, more precisely against a basket of 1 US Dollar and 1.5 German Marks, was kept in line with monthly inflation rate. However, the government policies to support the banks' ability to finance government deficit also included explicit guarantees for banks deposits given by the Savings Deposit Insurance Fund, so that the banks could collect deposits and invest in TL denominated government securities.

[7] See Dervis, Gros, Oztrak, Bayar, and Isik (2004) for a brief account of public sector debt dynamics and its finance in 1990s.

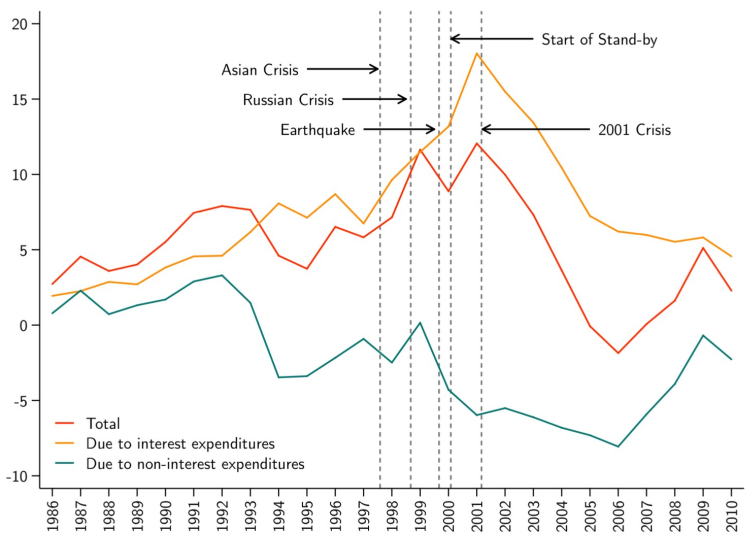

Figure 1: Public Sector Borrowing Requirement/GDP (%)

by another important one on November 12th 1999. These disturbed the relative stability debt to GDP ratio and led to a rise in the ratio of net debt due to easing in the fiscal stance and increase in the contingent fiscal liabilities due to the natural disaster due to high economics and social costs. For example, August 1999 earthquake brought about a total cost estimated to be around 20 billion USD, i.e. roughly 11 percent of the GDP at year 2000 current prices unanticipatedly.[8]

As shown in Table I, the borrowing cost for government and the default risk has increased sharply as a result of the earthquake. Table I shows approximately a 10 percentage point increase in 3 month coupon yields of floating T-bills after the earthquake, TableI also shows the EMBI+ spread increased 100 basis points after the earthquake.

The risks to public debt sustainability due to the 1998 Russian Crises and the 1999

[8]These costs consist of government expenditures including those for damaged infrastructure, tax revenue losses due to production losses and tax deferrals and rise in the contingent government liabilities due to the earthquake. See Akgiray et al. (2004) for more.

Table I: Sovereign risk

	(1)	(2)	(3)
	Compounded Interest Rates on Government Bond Auctions (Percent)		Turkish Bond-Spreads
	For Bills with Approximately 550 Days to Maturity	For Bills with Approximately 1,050 Days to Maturity	EMBI+
July 1999	117.71	119.91	564
August 1999	123.80	127.62	665

Notes: (1) Source: CBRT for Columns 1 and 2. (2) The numbers in Columns 1 and 2 show the annual compounded interest rates on auctions for 3-month coupons for floating rate government bonds of approximately 550 and 1050 days to maturity. (3) Numbers in Column 3 are the end-of month basis-point value of EMBI+ spread for Turkey.

Earthquake is also visible from the ex-ante real interest rates in government auctions, shown in Figure 2, and the difference between real interest rate and the annual GDP growth rate, shown in Figure 3. The former shows that the ex-ante real interest rates on government debt marked an increase from 20 percent to 36 percent in the aftermath of the August Earthquake.[9] As a key debt sustainability measure, the difference between real interest rates and GDP growth further widened in 1999 due to poor growth performance in the first half of 1999 due to Russian crises. Both Figure 2, and Figure 3 also highlight the fact that the earthquake happened as a big unanticipated shock just at the peak of concerns about government debt sustainability.

It is important to compare the Earthquake with the Russian Crises and the 2001 Crises in

[9]For calculating the ex-ante real interest rates, we use annualized compounded nominal interest rates on government domestic debt auctions. For calculating inflation expectations, we assume that the inflation expectations are adaptive, in line with the research and policy communications of the CBRT, and calculate as the weighted average of realized inflation rates and CBRT's target inflation rates. For 1997-2000, we make use of the implicit inflation targets communicated through the CBRT's official monetary policy documents and Governor's speeches. For the period before August 2001, where the expected inflation rates were not published by the CBRT, we generate the expected inflation rates as a 0.5 times the inflation target plus 0.5 times the realized inflation rate. For 2001 and onwards, we use explicitly announced inflation targets.

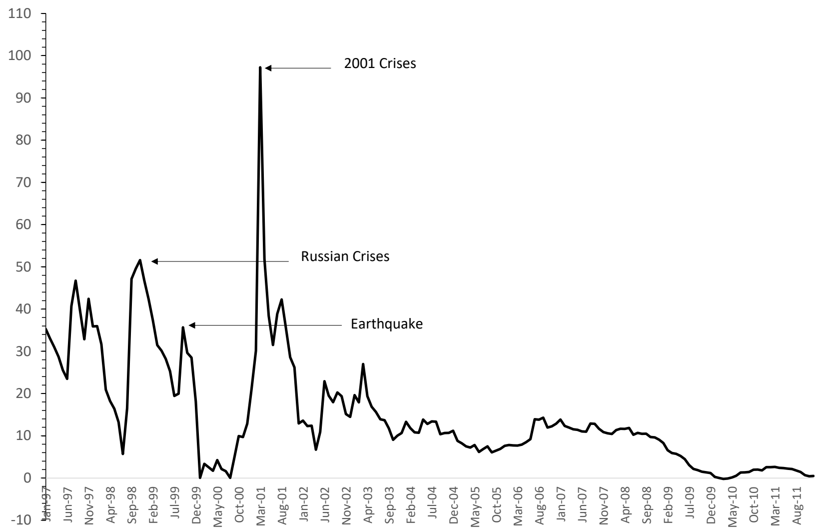

Figure 2: Average Ex-Ante Real Interest Rate on the Primary Auctions on the Government Debt Securities (Percent)

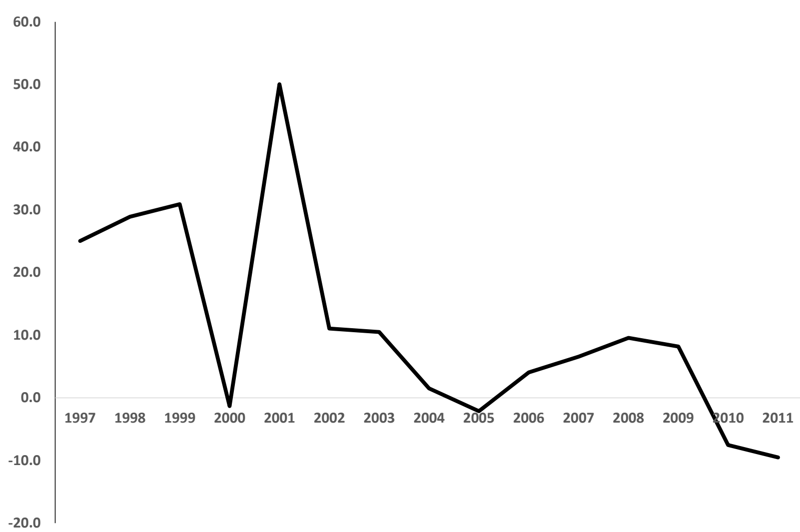

Figure 3: Ex-Ante Average Real Interest Rate on Government Borrowing minus Annual GDP Growth (Percentage Points)

terms of how well the latter shocks can serve for the purpose of assessing the causal effect of an exogenous increase in the sovereign risk on bank balance sheets and lending behavior. In comparison, the rise in the government debt stock and the real interest rate during 2001 crises were higher. The Russian crises differs from the 1999 Earthquake, as it is associated with a sizable recession which also suppressed the demand for loans as the Turkish economy was hit due to its exposure on exports to Russia. On the other hand, during the Earthquake, there was no evidence of decline in loan demand, wide spread defaults as well as a region-wide or country-wide recession.[10] Finally. unlike the Earthquake, 2001 Crises does not provide us a clean experiment for assessing the causal effect of an exogenous increase in the sovereign risk on bank balance sheets and lending behavior, due to the fact that it was quite anticipated starting from late 2000.

Another observation underlying the deterioration in the perceptions of the public debt sustainability was the change in the maturity structure. Figure 4 shows that the share of short term borrowing by government increased from 20 to 50 percent during the earthquake period, which later fell again following the Stand-By Program in December 1999.

It is worth emphasizing that the increase in the debt sustainability concerns following the Marmara earthquakes has been influential on the timing and content of the Stand-By agreement between Turkey and IMF. The Stand-By program, announced by the Government and the CBRT announced aimed at reducing inflation and restoring the fiscal balance, which involved a 36-month Stand-By agreement with the IMF.[11] The program led to a temporary improvement in the government borrowing cost, which has mitigated some of the adverse effects on bank balance sheets observed in 1998-1999 period. In addition, the sudden drop in interest rates following the announcement of the exchange rate peg has also revitalized the economic activity and demand for credit. In that sense, the timing and nature of the

[10] As a support for this argument, while the estimated credit risk of the total banking sector due to the earthquake was 1.5 billion USD in 1999 according to CBRT's estimates (roughly 900 million USD for private bank credits and 600 million USD for public bank credits), the total amount of loan rescheduling as of August 2000 was only 26 million USD.

[11] See Özatay and Sak (2002) for an account of the 2000 Stand-By program and 2000–2001 Financial Crises in Turkey.

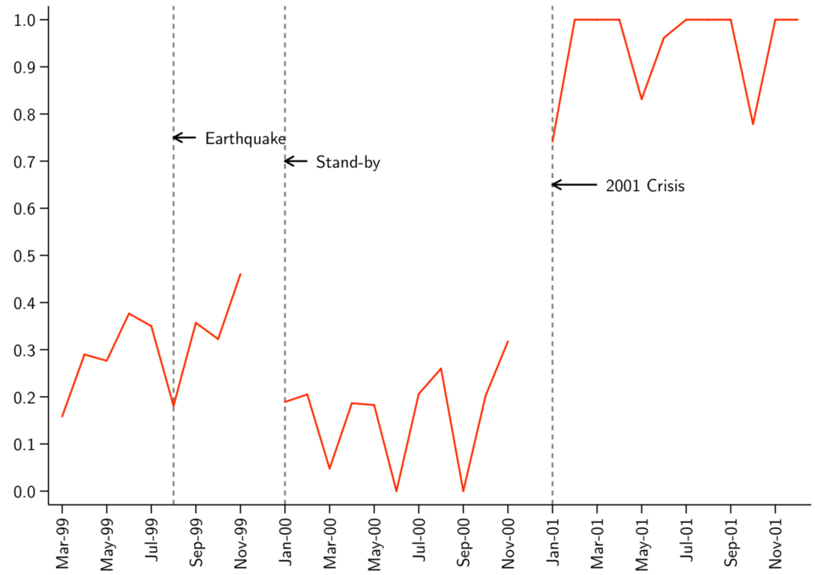

Figure 4: Ratio of Short Term Borrowing in Total Government Borrowing

Stand-By program, as an endogenous policy response to the deterioration in debt sustainability after the earthquake, work as a factor which can bias the negative effects of adverse fiscal shock on bank balance sheets and lending towards zero. Therefore, we think that our key results, i.e. banks with higher government securities holdings being more financially constraint and cutting the lending more following the earthquake, is more conservative than what unobserved counterfactual of "No Stand-By Response" would have suggested.

Finally the Stand-By program was abandoned in February 2001. While the tipping point of the crises was a dispute between President and the Prime Minister, the key factors were the deterioration of the overall program due to sluggish structural reform agenda, the weaknesses in the banking sector and the surge in current account deficit real appreciation of the Turkish lira due to high inflation. This was followed up with a new Stand-By Program in 2001 which resulted in a substantial improvement in the economic fundamentals and the end of financial repression due to lower public sector borrowing requirement.

IV Data and Descriptive Statistics

This section presents the main dataset in our empirical analysis. We use administrative monthly bank balance sheet data from Turkey for 1997–2011 period. This data is collected regularly as part of the *Monitoring Package*, which is the data collection and processing system for monitoring and regulation purposes. All the banks operating within Turkey are obliged with reporting their balance sheets as well as extra items by the end of month to the regulatory and supervisory authorities, such as the CBRT and the Banking Regulation and Supervision Agency (BRSA). We also use the extra reporting of the banks, such as the decomposition of the banks' securities portfolio including the information on which particular securities are held by banks by the end of each month, net positions against domestic and foreign creditors and the currency denomination of assets and liabilities through interbank operations. The banks in our sample are all banks operating within Turkey, regardless of the ownership status or the classification with respect to the main activity such as deposits banks or investment banks.

Table A1 presents the key descriptive statistics of our banks. We observe a significant cross-sectional heterogeneity with respect to holdings of government securities in banks' balance sheets, where mean is around 18-20 percent depending on the period and it can be as high as 46 percent.[12] Table A2 presents key macro indicators.

An interesting feature of the Turkish banking sector is that the banks in Turkey have experienced a remarkable portfolio relocation between 1997 and 1999, as the government securities holdings as a ratio of total credit extended to non-financial sector doubled within two years, as shown in Figure 5. Even during this period, the banks have shown some hetereogeneities. Figure 6 plots the share of government securities in bank's total assets for the average bank and for the aggregate, where the aggregate behavior is driven by the large banks. It is clear that there is no significant difference between large banks and small banks

[12]For a world-wide sample of banks, the average for government debt holdings to assets is 12 percent and for German banks it is 15 percent. See Gennaioli et al. (2018) and Buch, Koetter, and Ohls (2016), respectively.

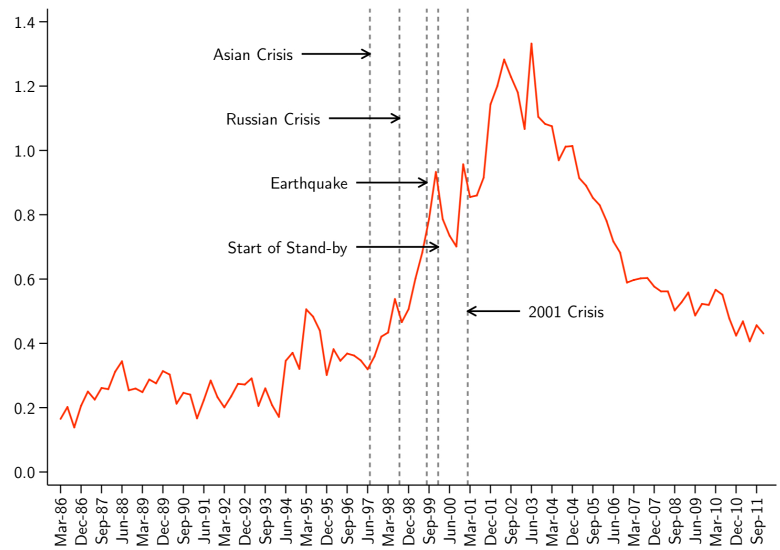

Figure 5: Government Bond Holdings/Credit to Non-Financial Sector

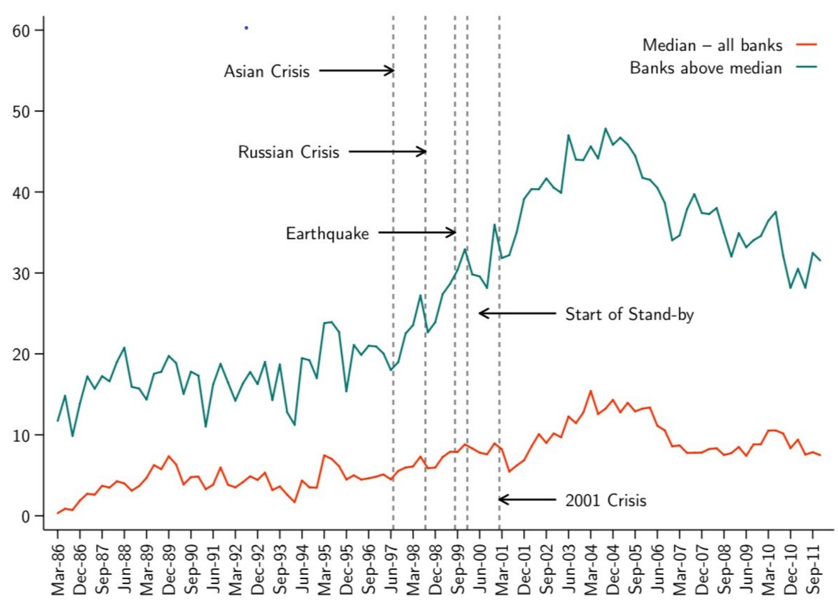

Figure 6: Government Bond Holdings as a Ratio of Banks' Total Assets

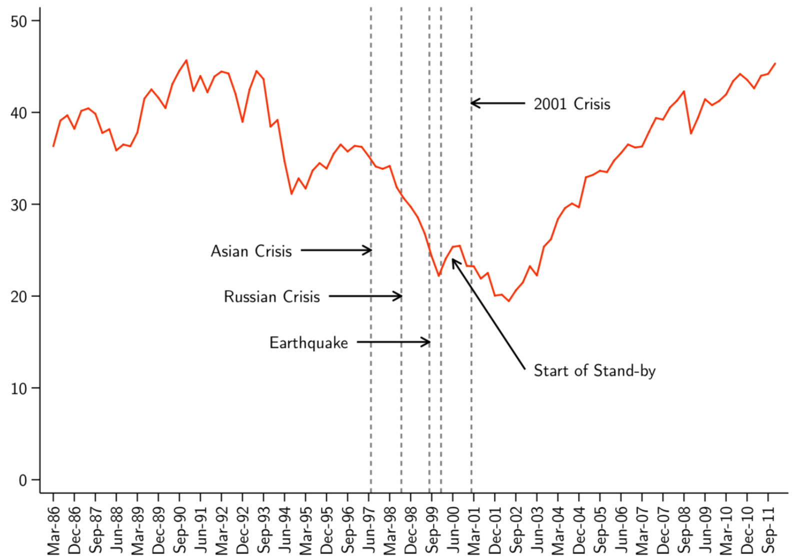

Figure 7: Lending to Private Sector as a Ratio of Banks' Total Assets

until the 2001 crisis, where in the eve of this crisis, both increased their exposure—large banks much more so—to government debt. As shown in Figure **??** , there is an increase in holdings of government debt exposure right up until the 2001 crisis.

Figure 7 presents aggregate data, plotting credits to non-financial sector as a ratio to total assets of the financial sector, where this ratio falls to 22 percent from approximately 36 percent during the events starting with Asian crisis. This figure mimics our previous Figure 5 where we show typical bank also decreases credit to non-financial sector during this period, increasing loans to government sector by similar amounts.

V Empirical Results

In the subsequent empirical analysis, we will examine, how an unanticipated sovereign risk shock (driven by the Earthquake) affects banks' lending via the balance-sheet channel. We will thus examine in turn, (i) the model implied relationship between the bank's constraint (e.g. the Lagrange multiplier) and lending, and how the earthquake shock impacted that constraint (i.e. the balance sheet channel); (ii) the natural experiment of the earthquake to identify and quantify the causal impact of an increase in sovereign risk on bank lending; and (iii) the effect of increasing government bond yields on lending given sovereign exposure.

A Inspecting the Model Mechanism: the Balance Sheet Channel

We begin by examining the model mechanism in the data. Using the framework derived above based on Bocola (2016), we compute the bank-specific Lagrange multipliers and estimate the impact of the earthquake on the financial constraints for banks with different government bond holdings.

In the model, the lagrange multiplier for the banks' incentive constraint, presented in equation (1), is effectively the same across banks. This is because all banks have the same λ in their constraint, so despite their different net worth and portfolio, they end up with the same leverage in equilibrium. There is no closed form solution to the model with heterogeneous λ. However, we can use the functional form of the multiplier from equation (1) as a starting point to explore bank heterogeneity, as banks with different exposure to government bonds will - on impact - have different leverage when the sovereign risk shock hits. We take this to the data to examine how leverage and this functional form of the lagrange change after the shock, and how these changes are related to lending.

We measure the lagrange multiplier for the banks incentive constraint, presented in Equation(1), in two ways. Our primary measure, denoted by Lagrange-1 in our empirical results, is calculated by using the ex-ante real annual interest rate (i.e. annualized nominal interest rate minus the realized annual inflation rate) in Turkish Lira interbank money markets and the ex-ante real US FED Funds rate as the measure of risk free interest rate. This reflects the fact that US Fed Funds rate is the benchmark interest rate for an economy which is fully integrated to the international banking flows. However, in terms of measurement, Lagrange-1 results in negative spreads in periods of high inflation realizations in Turkey than ongoing nominal interbank money market interest rates. As the lagrange multiplier can not be negative, we replace these values with 0s. [13].

As an alternative in our all empirical analysis, we also calculate Lagrange-2, which differs from Lagrange-1 in two ways: when calculating ex-ante real interest rates, we use the measure forward looking inflation expectations instead of realized inflation rates and the T-Bill interest rates instead of Interbank interest rates. In particular, we use the inflation expectations which are weighted average of CBRT's inflation target and the realized inflation rates. In particular, the Turkish economy was on a disinflation path in the period between 1997 and mid 2000s, where the interest rates on Turkish Lira denominated assets and liabilities also reflected the expectations for lower inflation. Therefore, the real interest rate calculations based on realized inflation rates can result in negative real interest rates. Hence, for Lagrange-2, we use ex-ante real interest rates based on a expected inflation measure which is adaptive in nature, such that it reflects both realized inflation rates and the lower inflation targets.[14] Second difference is the use of annual compound government bond interest rates, as they reflected the market interest rates in Turkey better than the annual compounded Interbank money market interest rates.

Figure 8 plots how the distribution of banks' financial constraints, measured by Lagrange1, changes over time. It can be seen from the figure that banks' financial constraints intensified during the major events, such as the 1998 Russian Crises, 1999 Earthquake and 2001 crises. We can further see that the financial constraints tightened during these events for banks that are at different points in financial constraints distribution.[15]

[13]Whenever we use Lagrange-1 in our analysis, we further examine robustness of our analysis to dropping the observations where the measure lagrange multiplier is equal to zero

[14]In the calculation of Lagrange 2, we use expected inflation rates using 0.5 for both the weights of realized and target inflation rates. However, our analysis is robust to utilization of different weights when calculating the inflation expectations.

[15]Finally, while it is not the main focus of this paper, the figure also suggests that the banks faced a decline in their financial constraints in post 2001 period due to various potential factors, such as abundant global liquidity and a better macroeconomic and financial outlook in Turkey due to structural and regulatory reforms.

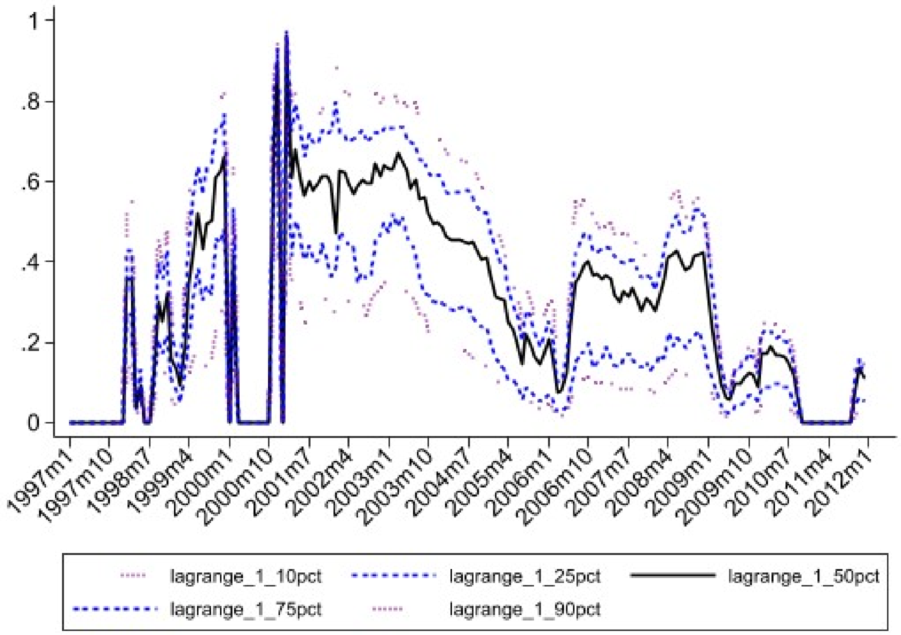

Figure 8: Banks' Financial Constraints (Lagrange1)

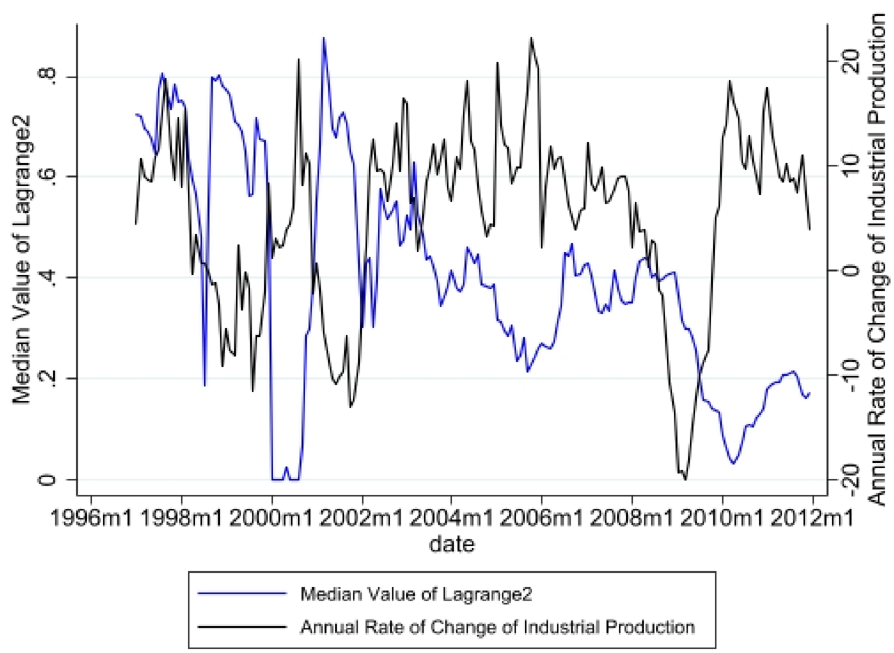

Figure 9: Countercyclicality of Lagrange-1 and Lagrange-2

Table II: Countercyclicality of Financial Constraints

	(1) Lagrange1	(2) Lagrange2
Annual Growth Rate of Industrial Production	-0.0067**	-0.0047***
	(0.0019)	(0.0019)
Observations	180	180
r2	0.79	0.63

Dependent variable in column 1 are the the median values of the Lagrange1 and Lagrange2 variable calculated using equation X and Y, respectively. Independent variable is the annual growth rate of the industrial production rate in Turkey. Sample spans January 1997-December 2011. Errors are robust. * p < 0.10, ** p < 0.05, *** p < 0.01

Table II and Figure 9 shows that the banks' financial constraint measures have a negative correlation with the changes in industrial production index. These observations are consistent with Bocola (2016), who shows for Italy that banks financial constraints feature a significant countercyclicality.

We first test the basic relationship implied by the model that tighter financial constraints are associated with lower lending. For this, we estimate:

$$\Delta L_{it} = \alpha \Delta \mu_{it-1} + \gamma \Delta X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \tag{2}$$

where L_{it}, is banks' lending. We measure the loan supply with credit provision normalized by assets, that is, share of credit to non-financial firms in total assets. ΔL_{it} is the change in the bank lending. $\Delta \mu_{it-1}$ is the change in the incentive constraint for the bank i at month $t-1$. X_{it-1} is a vector of controls (government bond holdings, interbank assets, cash holdings and loans). λ_i and λ_t stand for bank-fixed effects and month-fixed effects, respectively. Table III shows that when the lagrange multiplier rises (i.e. when the constraints have tightened), private lending typically falls. This is also directly connected to a key piece of the lagrange multiplier, leverage (columns 4-6). The results hold with controls (columns 2 and 5) and controlling specifically for government bond holdings (columns 3 and 6).

Table C4 in the appendix presents an alternative specification. Here, we examine the relationship in levels, for consistency with our empirical approach in the following section.

Also, we drop observations where Lagrange=0 (i.e. when real interest rate is negative), adjust the window for the Earthquake to end in November (before the Stand-By Program is announced) and also include bank-quarter fixed effects to account for slower moving bank-specific factors such as the demand for loans by a specific bank. The results again confirm that tighter bank constraints based on the model are associated with lower private lending. Finally, we find these results also holds for our alternative Lagrange2 measure.

Table III: Financial constraints and lending

	(1)	(2)	(3)	(4)	(5)	(6)
Δ Lagrange1$_{it}$	-0.0321**	-0.0279**	-0.0248*			
	(0.0127)	(0.0129)	(0.0126)			
Δ Leverage$_{it}$				-0.000498**	-0.000505**	-0.000465*
				(0.000244)	(0.000248)	(0.000243)
Δ Gov Bond Holdings$_{it}$			-0.0637***			-0.0880***
			(0.0162)			(0.0176)
Observations	4746	4736	4736	5062	5052	5052
R^2	0.00427	0.00600	0.0164	0.00271	0.00363	0.0249
Banks	82	82	82	82	82	82
BankFE	Yes	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes

Dependent variable is the change in the private lending to assets ratio. Lagrange1 as defined in the text. Controls include the changes in interbank asset ratio, cash to assets ratio, and capital to assets ratio. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Next, we test whether banks with a higher exposure to the government securities market before the earthquake faced tighter constraints after the earthquake by estimating estimate the following equation:

$$\Delta\mu_{it} = \gamma\Delta\mu_{it-1}+\beta_1 Gov\ Debt\ Exp_{it-1}+\beta_2 Earthquake_t \times GovDebtExp_{it-1}+\beta_3 X_{it-1}+\lambda_i+\lambda_t+\epsilon_{it} \quad (3)$$

where $\Delta\mu_{it}$ is the change in the incentive constraint for the bank i at month t. The parameter of interest here is β_2, which gives the banks with different exposures to governments securities faced heterogeneity in changes in the incentive constraints after the earthquake. A positive and significant value of β_2 suggest that the banks holding a higher share of assets in government securities had their constraint tighten by more after the earthquake than other similar banks with less government exposure. X_{it-1} stands for all the controls, including the interactions between the lagged values of the key assets in banks balance sheets (such as credit, net interbank balances, cash) with the major events in our sample with potential effect on Turkish economy (such as the Asian Crises, Russian Crises, 1999 Earthquake and the 2001 Crises), discussed earlier.[16] λ_i and λ_t stand for bank-fixed effects and month-fixed effects, which control for the time-invariant unobserved heterogeneity across banks and all common shocks to the banks (including aggregate demand effects due to the earthquake), respectively. Finally, this specification allows for the lagged dependent variable to control for the possible time-varying unobserved heterogeneity in the change in the dynamics of the incentive constraints.

Column 1 of Table IV shows that banks with greater holdings of government bonds saw their constraint tighten by more after the earthquake. While we observe tightening of the constraints after the other events as well, the effects are smaller and not statistically significant. Column 2 confirms the impact on leverage as the key component of the constraint.

Table C5 in the appendix shows the robustness of this relationship to dropping periods where Lagrange1=0 (in columns 1-2), and adding bank-quarter fixed effects.[17] Table C6 shows this same setup examining the impact on the level of the constraint (rather than the change). Again, we find that higher bond holdings at the point of the earthquake was associated to tighter constraints. Lastly, Columns 1 and 2 of Table C7 shows the earthquake negatively impacted our Lagrange2 constraint measure.

We provide further evidence on how the rise in sovereign risk driven by the earthquake led to the deterioration of the financial structure of the banks. The banks whose balance sheets were exposed to government debt in large quantities before the earthquake, suffer from a balance sheet shock after the earthquake, due to a lower value of this asset on their

[16]We define the crises and other dummies as follows. The Asian crisis is a binary variable equal to 1 between July 1997–December 1997. The Russian crisis is a binary variable equal to 1 between August 1998–January 1999. The earthquake is a binary variable equal to 1 between August 1999–November 1999. The Turkish crisis is a binary variable equal to 1 between February 2001–December 2001.

[17]The specification also drops the lagged dependent variable as a control.

balance sheet, that cause their net worth to go down. Column 3 of Table IV examines banks' financial asset valuation changes between current and previous period as a ratio to their total assets. In practice, the banks have to reevaluate the value of their portfolio as the prices change since they do not mark their portfolio to market (during our period of study).[18] This item in the balance sheet directly affects the equity structure of the banks. For the banks which hold the same government security portfolio both at time t-1 and t, an increase (a decrease) in the price of the government security induces a revaluation which increases (decreases) in portfolio's monetary value. Therefore, a decline in the price of bonds results in the decline in the equity via negative effect on the valuation account. We find that the banks with higher share of government securities in their balance sheets had a higher decline in the value of their portfolio, given the decline in the value of this asset with the fiscal shock.

Banks with high sovereign exposure also experience declines in their profits and net worth. This can be shown clearly in Figures 10 and 11, which plots the average net worth and profits (relative to assets) for banks with above and below the median exposure to government bonds. Banks were similar along these measures until the earthquake shock. Columns 3-6 of Table C7 provide regression evidence to further support of the balance sheet deterioration impacting profits and net worth.

In terms of magnitudes from the estimates in Tables IV and C7, we find that a bank in 90th percentile of the government bond exposure distribution, which holds roughly 40% of its portfolio in government securities, suffers a 0.6 percentage point loss to the value of its portfolio as a ratio to its assets, a 2 percentage point decline in its' net worth as a share to its assets, and a 1.5 percentage point loss in its profits as a share of assets.

[18]Notice that the rule of keeping the sovereign bonds in the trading book and marking them to the market value, was introduced to Turkish banks after December 2002 regulation for the banks' accounting standards.

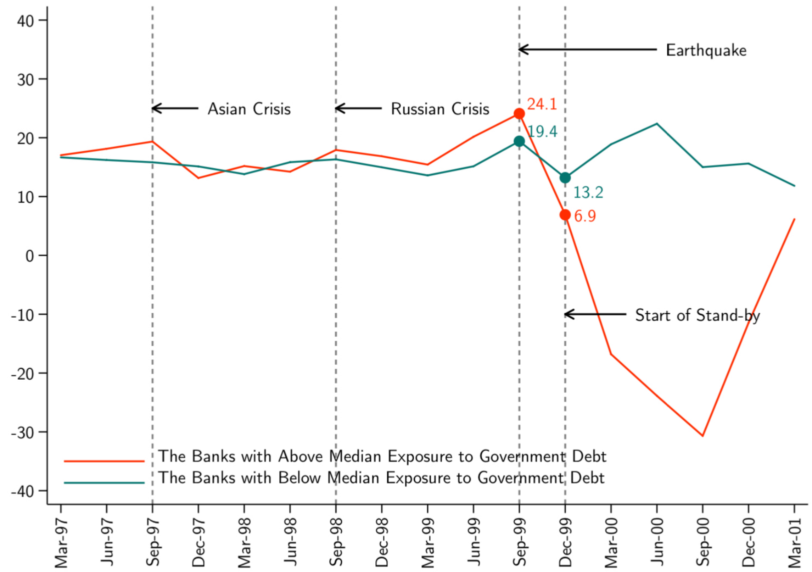

Figure 10: Net Worth of Banks with High-Low Exposure to Government Bond Market

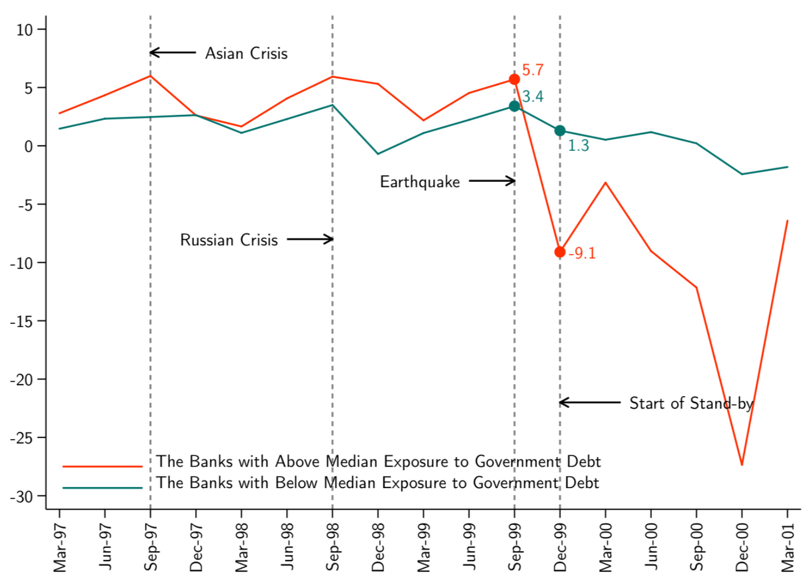

Figure 11: Profits of Banks with High-Low Exposure to Government Bond Market

Table IV: Earthquake and bank financial constraints

	(1) ΔLagrange1	(2) ΔLeverage	(3) ΔValuation
Gov Bond Holdings$_{it-1}$ $\times$ Earthquake$_t$	0.0711**	2.862*	-0.0154*
	(0.0291)	(1.455)	(0.00864)
Gov Bond Holdings$_{it-1}$	-0.0160	-0.158	0.00471
	(0.0452)	(0.967)	(0.0101)
Gov Bond Holdings$_{it-1}$ $\times$ Russia$_t$	0.0527	3.129**	-0.0672
	(0.0552)	(1.336)	(0.102)
Gov Bond Holdings$_{it-1}$ $\times$ Asia$_t$	0.00375	0.849	0.0300
	(0.0312)	(3.535)	(0.0778)
Gov Bond Holdings$_{it-1}$ $\times$ 2001 Crisis$_t$	0.0304	1.590	-0.0108
	(0.0339)	(1.299)	(0.0183)
Observations	4629	4967	4807
R^2	0.139	0.0726	0.0804
Banks	82	82	82
BankFE	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Dependent variables shown in column titles. Controls include interbank assets, cash holdings, and lending, all in ratio to assets and also including their interactions with the main crisis events. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Government Exposure during the Earthquake and Private Lending

We next move to examining directly the impact of exposure to government bonds during the earthquake on private lending. For this analysis, we pursue a difference-in-difference identification strategy.

Government bond holdings are not random. We first try to understand their determinants and correlated factors with holdings across banks. Also important for our identification is whether these determinants of government bond holdings vary systematically at the time of earthquake. This helps us identify which variables may capture similar variation across banks as does their government bond holdings, and if they may shift during the earthquake. These variables would be important to control for in our regressions in order to rule out other channels that may be affected by the earthquake shock and thus spuriously drive our results with government bond holdings.

Table V examines the variables correlated with the government bond holdings. The main correlates of government bond holdings are interbank balances, cash holdings, and capital. Banks with a higher capital ratio hold less government bonds in their portfolio, but increase their holdings during the earthquake, as these are the stronger banks. Bank with larger interbank balances also hold fewer government bonds, especially so during the earthquake, since greater surpluses on their interbank balances means they need less government bond holdings as collateral. Banks with higher cash holdings than average hold less government debt, but increase their holdings at the time of earthquake. This can be associated with risk taking behavior but also with supplying government with the needed funds since these are the more liquid banks.

In addition to controlling for these factors in our regressions, we make some other observations that justify this empirical approach. First, for our difference-in-difference approach to be valid, we need to ensure that there are no parallel trends in our outcome variables (e.g. lending) based on the treatment variable (government bond holdings). As can be seen in Figures 10 and 11, banks with greater exposure to sovereign bonds did not appear to perform worse before the earthquake than other banks in terms of profits and net worth. Figure 12 shows this is also the case for the loan provision. Thus, a negative and significant coefficient on the interaction between the government debt exposure and the earthquake variable does not reflect the already existing deterioration for banks with higher exposure, but rather the impact of the earthquake on the banks' balance sheet performance and the loan provision. We further address this concern with a placebo test in the appendix.

Another important observation for our identification is the fact that there was no visible change in government bond holdings in the aftermath of the earthquake. Table A3 presents the average ratios for government securities to assets and loans to assets before and after the earthquake. It is clear that average exposure to public debt stayed around the same but average credit provision declined. This highlights that the shock was not anticipated and banks were not otherwise adjusting their portfolio in a way that would affect our estimation.

Now, we go into more depth to causally identify the effect of an increase in government

Table V: Correlates of government bond holdings

	(1)	(2)	(3)	(4)
Interbank Balances$_{it}$	-0.445***	-0.402***	-0.440***	-0.396***
	(0.0346)	(0.0238)	(0.0435)	(0.0308)
Cash Holdings$_{it}$	-0.847	-2.104**	-0.953	-2.202**
	(0.824)	(1.028)	(0.820)	(1.025)
NPLs$_{it}$	-0.537	-0.218	-0.490	-0.162
	(0.551)	(0.602)	(0.552)	(0.605)
Capital$_{it}$	-0.0577***	-0.0645***	-0.0610***	-0.0657***
	(0.0197)	(0.0174)	(0.0219)	(0.0178)
Size$_{it}$	0.00860	0.0106	0.00957*	0.0121
	(0.00546)	(0.0126)	(0.00545)	(0.0125)
Domestic Bank$_i$	-0.00215		-0.00451	
	(0.0253)		(0.0285)	
State Bank$_i$	0.0107		0.0164	
	(0.0272)		(0.0284)	
Interbank Balances$_{it}$ $\times$ Earthquake$_t$			-178.4*	-202.4***
			(100.8)	(67.17)
Cash Holdings$_{it}$ $\times$ Earthquake$_t$			3.009***	2.987***
			(0.646)	(0.649)
NPLs$_{it}$ $\times$ Earthquake$_t$			0.0893	0.0594
			(0.577)	(0.485)
Capital$_{it}$ $\times$ Earthquake$_t$			0.163**	0.165**
			(0.0796)	(0.0810)
Size$_{it}$ $\times$ Earthquake$_t$			-0.00622	-0.00766
			(0.00442)	(0.00493)
Domestic Bank$_i$ $\times$ Earthquake$_t$			0.0108	0.0166
			(0.0236)	(0.0289)
State Bank$_i$ $\times$ Earthquake$_t$			-0.106**	-0.0964**
			(0.0401)	(0.0384)
Observations	5145	5145	5145	5145
R^2	0.0503	0.0383	0.0586	0.0516
Banks	82	82	82	82
BankFE	No	Yes	No	Yes
TimeFE	Yes	Yes	Yes	Yes

Dependent variable is government bond holdings. Earthquake is a dummy that takes a value of 1 for August 1999-November 1999. Variables are normalized by assets. Size is log of total assets in Turkish Lira (deflated to 2000 prices). Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

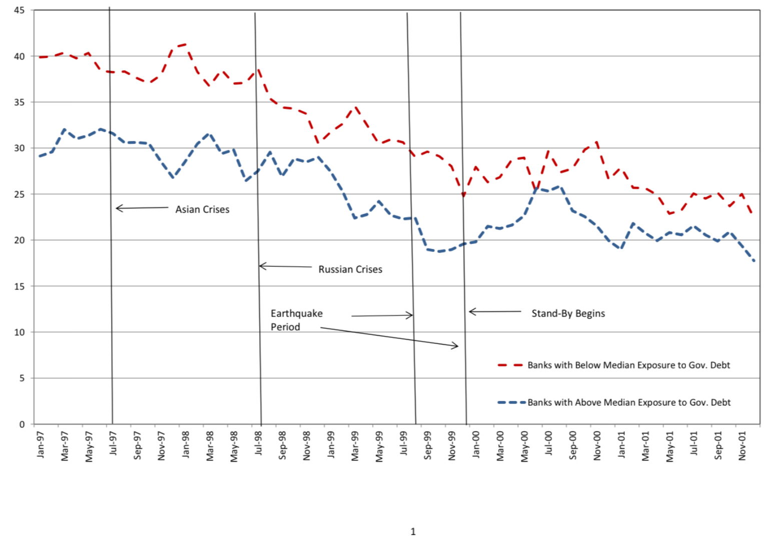

Figure 12: Loan Provision of Banks with High-Low Exposure to Government Bond Market

debt holdings on bank credit provision. We utilize the unique natural experiment of the earthquake to isolate one direction of the bank-sovereign nexus, as it generates an unanticipated fiscal burden (and thus increases sovereign risk), but does not directly impact the banking sector. In particular, we directly examine the causal effect of exposure to government debt at the time of the exogenous increase in sovereign risk by estimating the following specification:

$$L_{it} = \beta_1 Gov\ Debt\ Exp_{it-1} + \beta_2 Earthquake_t \times GovDebtExp_{it-1} + \beta_3 X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \quad (4)$$

where i is bank, t is month and λ_i and λ_t stand for bank-fixed effects and month-fixed effects, which control for the time-invariant unobserved heterogeneity across banks and all common shocks to the banks (including direct effect of the earthquake), respectively. X is a vector of controls for the main potential determinants of government bond holdings (interbank assets, cash, and capital) that may be correlated with loan provision at regular times and at crisis times, as explored above.[19]

The outcome of interest, L_{it}, is banks' lending. We measure the loan supply with the credit provision normalized by assets, that is, the share of credit to non-financial firms in total assets. We measure the government debt exposure, $Gov\ Debt\ Exp_{it-1}$, by the ratio of banks' government security holdings to total banks' assets. β_2 shows how the outcomes of banks with low and high exposure to government debt differ before and after the exogenous shock. In order to assure that we do not capture the effects of other events that might have affected the sustainability of the government debt differently, we also control for the interactions of government debt with the other major events that happened before and after the 1999 Marmara Earthquake, such as Asia Crises, Russia Crisis, Stand-by agreement, and 2001 crisis. The direct effects of these events are absorbed by the month fixed effects. We use lag government debt holdings by 1 month, but in the appendix examine robustness to lagging by 2 or 3 months, using a time invariant measure, and adjusting the earthquake window, among other checks. Other bank-time varying factors (interbank assets, cash holdings, and bank capital) are included in X, as explored in Table V.

First, to highlight the intuition, Table VI estimates a simple cross sectional regression by collapsing the sample in two periods as pre- and post-earthquake. Loans to the private sector as a ratio to total assets for each bank are averaged over the period from August 1999 to November 1999. Similarly government bond holdings as a ratio to total assets for each bank are also averaged over the period from January 1999 to July 1999, along with the controls in X. This simple cross-sectional regression shows that the banks with higher pre-earthquake exposure to government bonds had lower lending than other banks after the earthquake. This effect is robust to including controls correlated with bond holdings and to excluding state owned banks and banks that were ever taken over by Savings Deposit Insurance Fund (SDIF).

Table VII presents the results of the full panel regression. Column 1 shows the basic

[19] The Appendix provides a summary of a conceptual framework based on Khwaja and Mian (2008) that can support such regression equation, including an extension to incorporate bank-quarter fixed effects, discussed more below.

Table VI: Pre-Earthquake Exposure and Post-Earthquake Lending

	(1) All	(2) All	(3) No State	(4) No SDIF
Avg Gov Bond Holdings before EQ	-0.305**	-0.410***	-0.428***	-0.356**
	(0.127)	(0.124)	(0.128)	(0.165)
Observations	78	78	73	58
R^2	0.0612	0.238	0.248	0.242
Controls	No	Yes	Yes	Yes

Dependent variable is the average private lending over August 1999-November 1999. Independent variables are the pre-earthquake (Jan 1999 - Jul 1999) average of government bond holdings, cash holdings, capital, and interbank assets. All variables are in ratio to total assets. Sample spans 1997-2002. Errors are robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

relationship, column 2 adds interactions of bond holdings with the other major events, column 3 adds interactions of the controls with the earthquake dummy, and column 4 drops banks that were ever state-owned, and column 5 drops banks that were ever taken over by the SDIF (see discussion below). These results show that banks with larger exposure to government bonds had lower lending following the earthquake. The range of estimate suggest that the decline in lending is 1-2% of assets for the median exposure bank (holding 16% of assets as government bonds) and 2.2-4.4% of assets for the 90th percentile bank (with 37% exposure). The overall decline in lending was 2.9 percentage points, so the average holdings (18%) explains roughly half of the decline if we take the high estimate from column 4 (0.8*0.18) and three-quarters of the decline if we take the estimate from column 5. Note that the direct effect of holding government bonds is consistently negative. The bank with average holdings has 3.5 percentage point of asset lower private lending relative to a bank without exposure. This captures the natural crowding out effect, as putting more resources towards government lending means less available for private lending. The balance sheet shock due to the earthquake adds an additional kick to this relationship.

The effect of bond holdings during other events is intuitive. We do not find significant differential impact across banks by their holdings of government debt following the Asian and Russian crises. These events are external shocks. Although they had an effect on Turkish economy, and even on the spreads to a certain extent via contagion fears, they should not have a differential effect on the balance sheet of banks holding high or low levels of Turkish bonds since these events do not constitute a direct fiscal shock to Turkish government's ability to pay its debt. By the same token, we should expect to see a large negative effect for Turkey's own banking, currency, and sovereign debt crisis of 2001. These columns show a similar negative effect of government bond holdings during the 2001 crisis, though not significant. While the 2001 crisis was larger, it was an endogenous crisis that was also anticipated in advance, contributing to the lower and less precisely measured effect than expected.[20] Although both the Earthquake period and the 2001 Crisis period are associated with heightened sovereign risk and decline in the value of government bonds, the earthquake allows us to directly estimate the causal impact given the exogenous and unanticipated nature of this event.

One threat to our identification is that banks with large exposure to the government sovereign risk might also lend to riskier borrowers whose businesses may suffer due to the earthquake. If this were the case, these banks' credit contraction would be driven by a deterioration in borrower quality rather than through exposure to government bonds. However, neither at the aggregate nor at the average level were non-performing loans increasing during the earthquake period; on the contrary, they were on a decline as shown below in Figures 13 and 14 respectively.

For the period prior to 2003, there is no loan level data in Turkey, therefore we cannot fully control for the loan demand. However, since our bank level data is monthly, we can use bank-quarter fixed effects, which capture slower moving changes in loan demand.[21] This argument is supported by the loan officer survey data provided by CBRT, as presented in Figure B1 in the Appendix. It shows that the loan officers rarely report a sudden change in the credit demand within a quarter, especially for the non-financial corporate sector which

[20] These patterns can be seen throughout our other tables in the text and appendix. The coefficient on the interaction with the 2001 crisis is negative and sometimes significant, though not always, with magnitudes similar to that of the earthquake. The coefficients on the Russian and Asian crises are only sporadically significant.

[21] This argument is based on the framework presented in the appendix, where we show that the bank-quarter fixed effects can help in capturing the first order effect of customer j on loan by bank i at time t η_{ijt}, even when we do not observe borrower level variation.

Table VII: Earthquake and lending: time-varying panel

	(1)	(2)	(3)	(4) No State	(5) No SDIF
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	-0.0607*	-0.0754**	-0.0763**	-0.0811**	-0.123***
	(0.0351)	(0.0376)	(0.0342)	(0.0357)	(0.0365)
Gov Bond Holdings$_{it-1}$	-0.214***	-0.195***	-0.193***	-0.190***	-0.138***
	(0.0361)	(0.0384)	(0.0387)	(0.0410)	(0.0350)
Gov Bond Holdings$_{it-1}$ × Russia$_t$		0.00206	0.00251	-0.00376	-0.0558
		(0.0532)	(0.0532)	(0.0536)	(0.0666)
Gov Bond Holdings$_{it-1}$ × Asia$_t$		0.000722	-0.000287	-0.0149	-0.00931
		(0.0978)	(0.0975)	(0.0938)	(0.115)
Gov Bond Holdings$_{it-1}$ × 2001 Crisis$_t$		-0.0548	-0.0546	-0.0642	0.0256
		(0.0355)	(0.0356)	(0.0395)	(0.0453)
Observations	5061	5061	5061	4743	3878
R^2	0.121	0.123	0.124	0.131	0.0815
Banks	82	82	82	77	62
BankFE	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
ControlsXEarthquake	No	No	Yes	Yes	Yes

Dependent variable is private lending. Earthquake is a dummy equal to 1 for August 1999 - November 1999. Asia is a dummy equal to 1 for Jul 1997- Oct 1997. Russia is a dummy equal to 1 for Sep 1998 - Nov 1998. 2001 Crisis is a dummy equal to 1 for Dec 2000 - Dec 2001. Controls include lagged values of interbank assets, cash holdings, and capital. All variables are normalized by assets. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

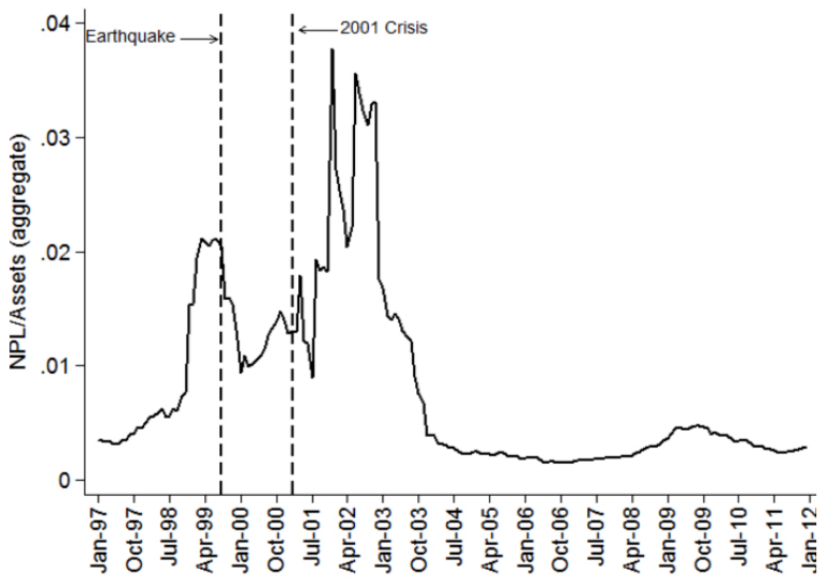

Figure 13: Non-performing Loans to Assets: Aggregate

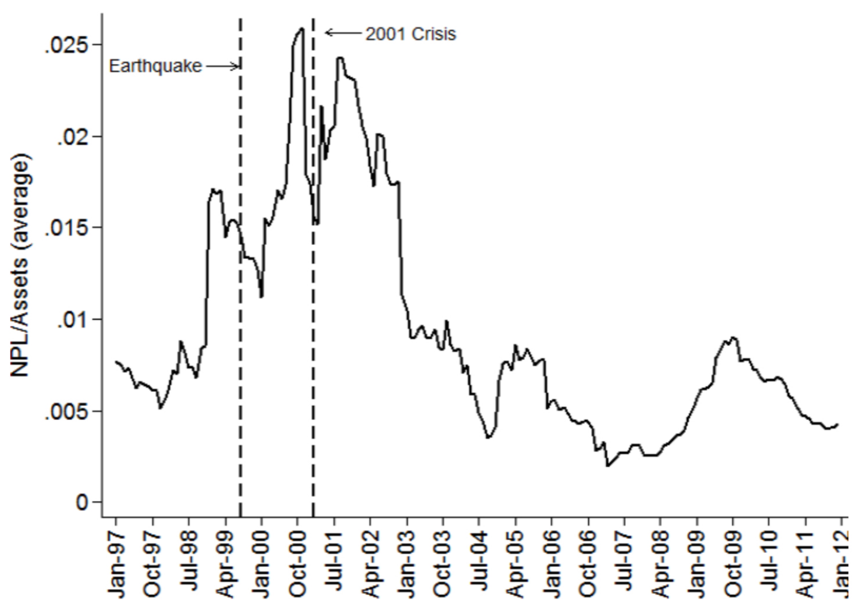

Figure 14: Non-performing Loans to Assets: Average

constitute the majority of bank loans. The survey which has been conducted regularly since 2005 suggests that firms' demand for loans move very slowly. We assume that this was also the case during the earthquake period. The fact that the firm-bank relationships in general have a sticky nature even in developed financial markets like the US supports our assumption.[22] Hence, given the monthly nature of our bank level data, the bank-quarter fixed effects will absorb slow moving firm-bank specific demand. For instance, if a certain banks' clientele is located in the earthquake region, these effects will capture the clients' lower demand during the last quarter of 1999. We can still identify the balance sheet effect thanks to the monthly data where the value of the bonds will be marked down and affect the banks' balance sheets quicker than the changes in demand.

Table C8 confirms this relationship. In column 1, we show the standard regression after adjusting the earthquake window to August-October 1999. The main reason for this alternative definition of the earthquake is that the government unexpectedly imposed a tax on banks' income on government securities holdings on November 26, 1999 to cover the fiscal burden due to the earthquake. We find our results become stronger with this adjustment. In columns 2 and 3, we add bank-quarter fixed effects (and drop SDIF takeover banks, discussed next). The magnitude drops considerably, but remains significant at the 10% level. Nevertheless, including bank-quarter fixed effects is an extremely stringent exercise, which absorbs a significant amount of variation in the data and thus lowers the estimated coefficients. Hence, one should not expect all valid relationships to remain statistically significant and of the right magnitude after their inclusion.

Also, one may be concerned about the unobserved confounding features of the banks taken over by the SDIF, which would affect these banks' performance even in the absence of a fiscal shock. Although most of these factors are taken care for by bank (or bank-quarter) fixed effects, we run our regressions on a sample of banks who survived throughout the sample period in order not to bias our results. The results (Table VII column 5) are stronger

[22] For example, see Chodorow-Reich (2014).

in this case.[23]

We examine further robustness to the sample window and timing of the effects. First, Table C9 runs placebo tests, where we define a "Placebo Earthquake" as a binary variable equal to 1 between April 1999 and July 1999. Despite the existence of a negative relation between high government debt exposure and lending in normal times, there is no additional effect at the time of our pseudo earthquake. This suggests that the effects we find with the earthquake are a result of the increased default risk on the part of government which deteriorated the balance sheet health of banks with high ex-ante exposure and hence negatively affected their lending.

Next, Table C10 examines alternative timings for the bond exposure. Column 1 uses a time invariant measure of bond holdings, the average of bond holdings over Jan 1997-Jul 1999. Since the bond holdings are fixed, we restrict the time period to a shorter window (1999-2000). In columns 2-3, we use the time varying bond holdings lagged by two periods. And in columns 4-5, we use time varying bond holdings lagged by three periods. Results remain robust and similar in magnitude.

Finally, Table C11 examine the sample window more generally, as well as an alternative dependent variable. Columns 1 and 2, show the results with narrower and narrower windows around the earthquake. Columns 3-5 change the dependent variable to the change in lending. While the fixed effect specification naturally examines the change in lending (i.e. deviations from bank specific means), the results nevertheless hold when we examine the change in lending with those same fixed effects. Columns 4-5 show this specification for a narrowing sample window too.[24]

[23]Only 8 banks are taken over in 1999. Note that if the claim "bad banks will fail anyway" is true and we fail to control for this, then a diff-in-diff strategy should not give us any result since this strategy identifies off of the relative difference between bad and good banks at the time of the earthquake.

[24]Note that the 2001 crisis still has an estimated coefficient with the 1999-2000 sample because this crisis starts in Dec 2000.

C The Role of Sovereign Bond Yields

The impact of the earthquake works through its impact on increasing the sovereign yields, which drive the value of the bonds down. This subsection quantifies the impact of an increase in sovereign yields on private lending, given the banks' government bond exposure. Specifically, we employ the same regression structure as before, but interact the yield with holdings (instead of earthquake and other crises).

$$L_{it} = \beta_1 Gov\ Debt\ Exp_{it-1} + \beta_2 GovDebtExp_{it-1} \times Yield_t + \beta_3 X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \quad (5)$$

The Yield is the 3-month yield on Turkish government debt.[25] However, the yield is endogenous to macroeconomic conditions that can also affect bank health, loan demand, etc. The health of the banking sector itself can affect sovereign yields. Thus, we exploit the earthquake to construct an instrumental variable (IV) to help us analyze the impact of rising yields. The first stage regression of the IV approach is:

$$GovDebtExp_{it-1} \times Yield_t = \beta_1 Gov\ Debt\ Exp_{it-1} + \beta_2 GovDebtExp_{it-1} \times Earthquake_t + \beta_3 X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \quad (6)$$

The predicted value $\widehat{GovDebtExp_{it-1} \times} Yield_t$ is then used in the second stage regression.

Turning to the results, we first examine the OLS relationship. Column 1 of Table VIII reveals that there is no clear relationship over this period between the yield and lending, given the sovereign bond exposure. This highlights the endogenous nature of the sovereign-bank nexus and the importance of finding exogenous variation to estimate causal impacts in one direction. Column 2 removes the general effect and adds interactions with the different shock periods. This is equivalent to replacing the dummies defining the shock periods with

[25] This series is not continuously available. When it is missing, we use the 2-year yield, which is similar, and interpolate.

the value of the yield during those periods. This reveals that the earthquake period is the main period where we see a strong, negative connection between the yield and lending via bond holdings. Adding the direct effect back in for column 3 confirms this. Thus, the earthquake period shows the expected relationship in OLS for sovereign risk to affect bank lending via the balance sheet channel.

Table VIII: Earthquake, Yield and Lending

	(1)	(2)	(3)
Gov Bond Holdings$_{it-1}$ × Yield$_t$	-0.0736		-0.0590
	(0.0941)		(0.101)
Gov Bond Holdings$_{it-1}$	-0.173**	-0.199***	-0.166**
	(0.0703)	(0.0389)	(0.0684)
Gov Bond Holdings$_{it-1}$ × Yield$_t$ × Earthquake$_t$		-0.0965*	-0.0829*
		(0.0503)	(0.0467)
Gov Bond Holdings$_{it-1}$ × Yield$_t$ × Asia$_t$		0.000488	0.0227
		(0.0942)	(0.0840)
Gov Bond Holdings$_{it-1}$ × Yield$_t$ × Russia$_t$		0.00410	0.0272
		(0.0504)	(0.0426)
Gov Bond Holdings$_{it-1}$ × Yield$_t$ × 2001 Crisis$_t$		-0.0696	-0.0577
		(0.0541)	(0.0627)
Observations	5059	5059	5059
R^2	0.122	0.123	0.123
Banks	82	82	82
BankFE	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Dependent variable is private lending. Yield is the yield on 3 month government bonds (or when missing, the yield on 2 year government bonds). Controls include lagged values of interbank assets, cash holdings, and capital. All variables are normalized by assets. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To examine the causal impact, Table IX presents the results of the IV regression. The first stage regression in the top half of the table shows that the earthquake is a significant predictor of the yield (both interacted with bond holdings), along with a reasonable F-stat. Thus, the instrument appears to be relevant and sufficiently strong. We have argued above that the earthquake is exogenous and materially impacted only sovereign risk, but not bank health or demand except through sovereign risk, so it is plausibly excludable. We have also previously shown that Gov Bond Holdings did not adjust around the time of the earthquake, and the earthquake was unanticipated, so the lagged holdings can be taken as given. Column 1 shows that an increase in government bond yields is associated with a larger decline in bank lending for banks with greater exposure to government bonds. This estimate represents the local average treatment effect (LATE) of yield movements induced by the earthquake (i.e. an exogenous fiscal shock). Column 2 adds bank-quarter fixed effects, which (as argued above) controls for slow moving bank-specific factors, including loan demand, though may soak up additional relevant variation. Nevertheless, our IV results are robust to their inclusion.

These estimates suggest that the increase in sovereign bond yields has a significant impact on the lending. If the yield increased by one standard deviation over this period (27 pp), the estimate in column 1 implies a 2.7 percentage point decline in lending to assets ratio for a bank with average bond holdings (0.18% of assets in 1999). For the earthquake itself (with a 6.8 percentage point increase in the yield from July to September 1999), the impact is a 0.7 percentage point decline in lending to assets for the average bank (with 18% exposure), 0.9 percentage point for the 75th percentile bank (with 24% exposure in 1999), and 1.4 percentage point for the 90th percentile (with 37% exposure). To make these figures more accessible, our local average treatment effect suggests that 10 percentage point yield spike driven by fiscal shocks will cause a bank with 20% exposure to the shock to decrease its lending to assets ratio by 1.1 pp.

VI Conclusion

The "diabolic loop" between sovereign and bank credit risk was at the center of the 2009–2012 sovereign debt crisis in the periphery of the euro area. In Greece, Ireland, Italy, Portugal, and Spain, the deterioration of sovereign creditworthiness reduced the value of banks' holdings of domestic sovereign debt. Bank and sovereign CDS spreads started to move together. The presumed solvency of domestic banks was reduced, which directly impacted their lending activity. The resulting bank distress increased the chances that banks would have to be bailed out by their own government, which increased sovereign distress even further. There is broad

Table IX: IV Regression: Spreads, bond holdings, and lending

First Stage: LHS = Gov Bond Holdings X Yield	(1)	(2)
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	0.112***	0.122***
	(0.0388)	(0.0383)
Gov Bond Holdings$_{it-1}$	0.609***	0.614***
	(0.0268)	(0.0350)
F-Stat	8.33	10.16
Second Stage: LHS = Private Lending		
Gov Bond Holdings$_{it-1}$ × Yield$_t$	-0.550*	-0.276*
	(0.326)	(0.148)
Gov Bond Holdings$_{it-1}$	0.121	0.150
	(0.209)	(0.0963)
Observations	5059	5042
Banks	82	82
BankFE	Yes	Yes
TimeFE	Yes	Yes
BankQuarterFE	No	Yes
Controls	Yes	Yes

Dependent variable in the second stage is private lending. Gov Bond holdings × Yield is instrumented by Gov Bond Holdings × Earthquake. Controls include lagged values of interbank assets, cash holdings, and capital, the latter two winsorized at 1%. All variables are in ratio to total assets. Sample spans 1997-2012. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

agreement on the policy urgency for the break-up of this vicious circle or doom loop/diabolic loop.[26] The Covid-19 pandemic posed another threat on the stability of sovereign debt market for both advanced and emerging economies. Due to the unprecedented scale of the public health crisis, many countries had to increase public spending at a time of lower economic activity.[27] As a result, sovereign default risks are on the rise and point again to the importance of understanding the "diabolic loop" between sovereign and bank credit risk.

In this paper, we identify the effect of government debt on banks' balance sheet health and credit provision. We provide a theoretical model to back our measure of bank financing constraints. We use data from the universe of banks in Turkey during 1997–2002 to demonstrate the financial constraint on banks and identify and quantify the impact of a sovereign shock on the banking sector. For identification, we use a rare disaster, the 1999 Marmara Earthquake—one of the largest earthquakes in world history, as a major unanticipated fiscal shock. Using a differences-in-differences methodology, we investigate whether the differences in the degree of banks' exposure to government debt matter for the effect of fiscal shock on differences in outcomes, such us banks' balance sheet health and loan provision.

Our empirical results validate the models formulation of the bank's financial constraint, showing that lending fell as this constraint tightened, and that the earthquake shock led to balance sheet effects and tightened this constraint. We then provide causal evidence for this balance sheet channel on lending, as high government debt exposure during the earthquake resulted in lower private lending than similar banks with low exposure, including by driving up government yields. We quantify these effects, estimating that exposure to sovereign debt accounted for nearly half of the observed lending decline following the earthquake.

Our results provide evidence on the link between fiscal distress and financial imbalances, where the causality goes from fiscal to financial stress, impacting the real sector. Using an exogenous rare event which triggered a fiscal shock and an increase in sovereign risk, we identify that the fiscal imbalances has important causal implications for the performance of

[26]See Farhi and Tirole (2018); Brunnermeier et al. (2016).

[27]See Arellano, Bai, and Mihalache (2021)

the financial sector and credit provision. These results are important for policy, particularly in the context of the large increase in government debt due to the Covid-19 pandemic.

Although our identification is clear, valid, and policy relevant, it works only for the link from government debt to banks' balance sheet health and loan provision. It does not capture the feedback of bank risk back to the sovereign or account for any general equilibrium amplification of the shock due to fire sales or cliff effects in the financial sector. Hence, our results are important for one direction of the sovereign-bank doom loop, but leave the equally important task of identifying the impact of a banking crisis on sovereign defaults to future research.

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Appendix

A Summary Statistics

Table A1: Descriptive Statistics

	count	mean	sd	p25	p50	p75	p90
Gov Bond Holdings	5153	0.1824	0.1566	0.0690	0.1436	0.2451	0.3975
Capital Ratio	5153	0.1678	0.2511	0.0742	0.1172	0.2306	0.5022
Loans to Private Sector	5153	0.2709	0.1779	0.1270	0.2644	0.3908	0.5063
Non-Performing Loans	5147	0.0091	0.0156	0.0000	0.0012	0.0096	0.0407
Bank Size	5153	12.1259	2.0483	10.6258	12.2497	13.5374	14.8369
Cash Holdings	5147	0.0083	0.0096	0.0005	0.0057	0.0124	0.0198
Interbank Balances	5147	-0.0858	0.2824	-0.2373	-0.0601	0.0588	0.2234
Valuation	5095	0.1068	0.3529	0.0000	0.0000	0.0000	0.1652
Profits	5153	0.0121	0.0636	0.0010	0.0128	0.0348	0.0777

Sample spans 1997-2002. Gov Bond Holdings is defined as the bank's holdings of government bonds in ratio to Total Assets. Capital Ratio is defined as the ratio of Shareholder Equity to Total Assets. Loans to Private Sector is defined as Total Loans to Private Sector in ratio to Total Assets. Non-Performing Loans is defined as (Non-Performing Loans - Provisions on Non-Performing Loans) in ratio to Total Assets. Bank Size is defined as the log value of total assets deflated to 2000 USD using PPI. Cash Holdings is the banks cash holdings in ratio to total assets. Interbank Balances are defined as (Receivables-Payables) from banks (except the Central Bank), in ratio to Total Assets. Valuation is financial assets valuation difference (i.e. loss provision) as a ratio to total assets. Profits are the bank profits in ratio to total assets.

Table A2: Selected Macroeconomic Statistics (%)

	1997-2002	1997-2011
Average Annual GDP Growth Rate	2.50	4.29
Average Investment to GDP Ratio	20.55	22.19
Credit to Private Sector to GDP	15.30	19.60
Bank Assets to GDP	53.40	59.10
Public Debt to GDP	48.47	47.50

Table A3: Loans to Private Sector and Government-Bond Holdings Before and After EQ

	Government-bond holdings	Loans to Private Sector
April-July 1999 Average	18.7	26.8
August-October 1999 Average	19.0	24.8

Note: Measures are expressed as a percent of Total Assets.

B Conceptual Framework for the Effect of Government Securities Holdings on Bank Lending

We will adopt a multi-period version of the two-period model of bank lending by Khwaja and Mian (2008). In period t, bank i's lending is L_{it}. The bank funds itself via deposits, D_{it} and also via other instruments such as bonds, B_{it}, with a marginal cost of α_B. Deposits until an amount $\bar{D_{it}}$ are costless. Bank has a marginal return on loan given by $r - \alpha_L L_{it}$. This captures increasing monitoring costs with each loan. r is the fixed interest rate. Hence the bank's balance sheet is given by $D_{it} + B_{it} = L_{it}$.

In the next period, bank faces a deposit supply shock and a credit demand shock. Hence deposits in the next period are:

$$\overline{D}_{it+1} = \overline{D}_{it} + \bar{\delta} + \delta_i \tag{7}$$

where $\bar{\delta}$ represents a common shock to all banks and δ_i represents a bank-specific supply shock. The credit demand shock will affect the marginal return on loan as:

$$\text{marginal return on loans in } t+1 = r - \alpha_L L_{it} + \bar{\eta} + \eta_{ij} \tag{8}$$

where $\bar{\eta}$ represents a common shock to all demand and η_{ij} represents a bank-specific demand shock from its customer j.

The equilibrium is characterised by the following equations:

$$\alpha_B B_{it} = r - \alpha_L L_{it} \tag{9}$$

$$\alpha_B B_{it+1} = r - \alpha_L L_{it+1} + \bar{\eta} + \eta_j \tag{10}$$

$$\bar{D}_{it} + B_{it} \equiv L_{it} \tag{11}$$

$$\bar{D}_{it+1} + B_{it+1} \equiv L_{it+1} \tag{12}$$

$$\overline{D}_{it+1} = \overline{D}_{it} + \bar{\delta} + \delta_i \tag{13}$$

For the two period, subtracting the FOCs 9 and 10 we obtain:

$$-\alpha_B \Delta B_i = \alpha_L \Delta L_i - \bar{\eta} - \eta_{ij} \tag{14}$$

And we replace with the identities 11 and 12:

$$-\alpha_B \left(\Delta L_i - \Delta D_i\right) = \alpha_L \Delta L_i - \bar{\eta} - \eta_{ij} \tag{15}$$

Using 13 and rearraging terms, we obtain:

$$\Delta L_i = \frac{\alpha_B}{\alpha_B + \alpha_L}\left(\bar{\delta} + \delta_i\right) + \frac{1}{\alpha_B + \alpha_L}\left(\bar{\eta} + \eta_{ij}\right) \tag{16}$$

Which can be re-grouped into economy-wide shocks and idiosyncratic shocks:

$$\Delta L_i = \frac{1}{\alpha_B + \alpha_L}\left(\alpha_B \bar{\delta} + \bar{\eta}\right) + \frac{1}{\alpha_B + \alpha_L}\left(\alpha_B \delta_i + \eta_{ij}\right) \tag{17}$$

Or alternatively:

$$\Delta L_i = \frac{1}{\alpha_L + \alpha_B}\bar{\eta} + \frac{\alpha_B}{\alpha_L + \alpha_B}\Delta D_i + \frac{1}{\alpha_L + \alpha_B}\eta_{ij} \tag{18}$$

In a multi period version we can write the above equation as:

$$L_{it} = \frac{1}{\alpha_L + \alpha_B}\bar{\eta} + \frac{\alpha_B}{\alpha_L + \alpha_B}D_{it} + \frac{1}{\alpha_L + \alpha_B}\eta_{ijt} + \frac{1}{\alpha_L + \alpha_B}\alpha_i \tag{19}$$

The first term represents common shocks for all banks, such as the aggregate macroeconomic shocks, and hence can be captured in the empirical analysis by a time fixed effect. The second term is idiosyncratic to the bank and time varying in a multi-period setting. The interpretation of this term is a bank specific change to net worth or deposits. Third term is bank specific demand effect from customer j, which can also vary across time and finally last term is a bank fixed effect.

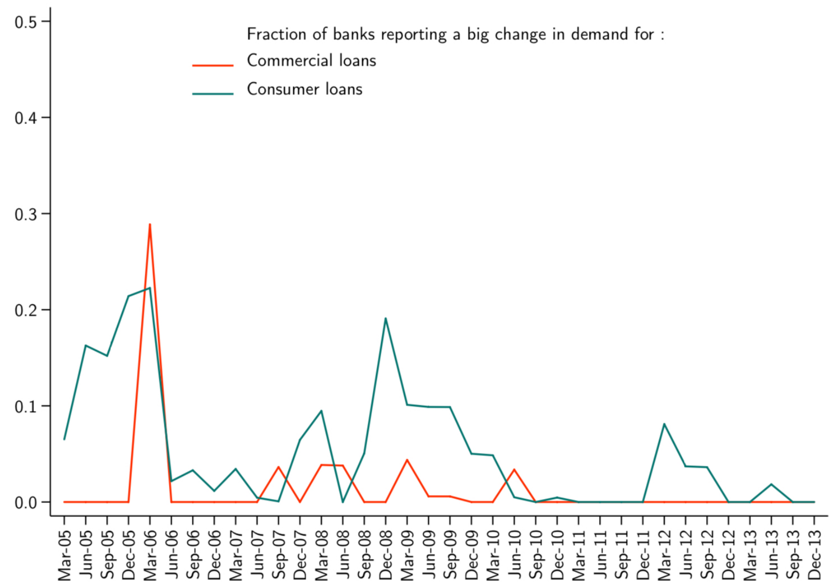

Figure B1: Fraction of Banks Reporting a 25 Percent Change in Credit Demand

C Further results

Table C4: Bank financial constraints and lending - Robustness levels

	(1)	(2)	(3)	(4)	(5)
Lagrange1_{it}	-0.0562**	-0.0795***			
	(0.0275)	(0.0280)			
Lagrange1_{it-1}			-0.0555***		
			(0.0160)		
Lagrange2_{it}				-0.0535*	
				(0.0276)	
Lagrange2_{it-1}					-0.0467*
					(0.0241)
Observations	2986	2976	2968	4157	4090
R^2	0.0107	0.0186	0.00860	0.00664	0.00326
Banks	82	82	82	82	82
BankFE	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes
BankQuarterFE	Yes	Yes	Yes	Yes	Yes
Controls	No	Current	Lagged	Current	Lagged

Dependent variable is private lending. Lagrange is defined in the text. Controls include interbank assets, cash holdings, and bank capital. In columns 3 and 5, these are lagged one period. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C5: Earthquake and bank financial constraints - Robustness changes

	(1) ΔLagrange1	(2) ΔLagrange1	(3) ΔLeverage	(4) ΔLeverage
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	0.0903*	0.160***	2.600*	6.749**
	(0.0485)	(0.0495)	(1.390)	(2.805)
Gov Bond Holdings$_{it-1}$	-0.0541*	-0.146	-0.201	-1.857
	(0.0306)	(0.0942)	(2.196)	(2.117)
Gov Bond Holdings$_{it-1}$ × Russia$_t$	0.0581	0.174*	2.861*	-0.476
	(0.0396)	(0.0995)	(1.671)	(3.536)
Gov Bond Holdings$_{it-1}$ × Asia$_t$			0.919	0.660
			(3.118)	(4.548)
Gov Bond Holdings$_{it-1}$ × 2001 Crisis$_t$	0.0245	0.244**	1.192	1.220
	(0.0271)	(0.111)	(3.089)	(5.577)
Observations	3037	2932	5054	5037
R^2	0.00876	0.0371	0.00168	0.00788
Banks	82	82	82	82
BankFE	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes
BankQuarterFE	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes

Dependent variable is listed in the column title. The Lagrange is defined as in the text. Controls include interbank assets, cash holdings, and lending, all lagged by one period, in ratio to assets, and including also their interaction with the major crisis events. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C6: Earthquake and bank financial constraints - Robustness levels

	(1)	(2)	(3)
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	0.0564*	0.0607**	0.0586*
	(0.0300)	(0.0298)	(0.0303)
Gov Bond Holdings$_{it-1}$	-0.0302	-0.0666	-0.0625
	(0.0419)	(0.0451)	(0.0390)
Gov Bond Holdings$_{it-1}$ × Russia$_t$		0.0347	0.0273
		(0.0493)	(0.0483)
Gov Bond Holdings$_{it-1}$ × 2001 Crisis$_t$		0.0934**	0.0375
		(0.0419)	(0.0466)
Observations	2977	2977	2969
R^2	0.00159	0.00381	0.0355
Banks	82	82	82
BankFE	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes
BankQuarterFE	Yes	Yes	Yes
Controls	No	No	Yes

Dependent variable is Lagrange1, as defined in the text. Controls include interbank assets, cash holdings, and bank capital, all in ratio to assets and lagged one period. Sample spans 1997-20012. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C7: Earthquake, Net Worth, and Profits

	(1) Lagrange2	(2) Lagrange2	(3) Net Worth	(4) Net Worth	(5) Profits	(6) Profits
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	0.0447**	0.0400**	-0.0472*	-0.0523*	-0.0376**	-0.0378*
	(0.0179)	(0.0194)	(0.0243)	(0.0274)	(0.0183)	(0.0193)
Gov Bond Holdings$_{it-1}$	-0.0271	-0.0299	0.0383	0.0394	-0.0182	-0.0223
	(0.0330)	(0.0338)	(0.0443)	(0.0447)	(0.0149)	(0.0154)
Observations	4448	4447	4729	4728	4729	4728
R^2	0.000973	0.00283	0.000852	0.00113	0.00177	0.00784
Banks	77	77	77	77	77	77
BankFE	Yes	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes	Yes
BankQuarterFE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes

Dependent variable is shown in the column headers. Controls include interbank assets, cash holdings, and bank capital (bank capital excluded for columns 1 and 2), each lagged by one period, and also including their interactions with the earthquake dummy. All variables are normalized by assets (except for Lagrange2). Banks that were ever state-owned are dropped. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the month level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C8: Earthquake and lending: Earthquake Window and Bank-Quarter Fixed Effects

	(1)	(2)	(3) No State
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$	-0.0989***	-0.0332*	-0.0350*
	(0.0332)	(0.0190)	(0.0199)
Gov Bond Holdings$_{it-1}$	-0.198***	-0.00953	-0.0118
	(0.0385)	(0.0146)	(0.0151)
Gov Bond Holdings$_{it-1}$ × Russia$_t$	-0.0649	-0.0107	-0.0173
	(0.0580)	(0.0351)	(0.0354)
Gov Bond Holdings$_{it-1}$ × 2001 Crisis$_t$	-0.0539	-0.0457*	-0.0452*
	(0.0365)	(0.0229)	(0.0244)
Observations	4290	4275	4057
R^2	0.148	0.00571	0.00599
Banks	82	82	78
BankFE	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
BankQuarterFE	No	Yes	Yes

Dependent variable is private lending. Controls include interbank assets, cash holdings, and capital. All variables are as a ratio to total assets. Earthuake period defined as Aug-Oct 1999. Sample spans 1998-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C9: Earthquake and lending: Placebo test

	(1)	(2)	(3)
Gov Bond Holdings$_{it-1}$	-0.236***	-0.219***	-0.191***
	(0.0360)	(0.0368)	(0.0386)
Gov Bond Holdings$_{it-1}$ × Placebo$_t$	-0.00699	-0.0200	-0.0486
	(0.0471)	(0.0475)	(0.0535)
Gov Bond Holdings$_{it-1}$ × Russia$_t$		0.0166	-0.00336
		(0.0563)	(0.0556)
Gov Bond Holdings$_{it-1}$ × Asia$_t$		-0.0205	-0.00376
		(0.101)	(0.0973)
Gov Bond Holdings$_{it-1}$ × 2001 Crisis$_t$		-0.0509	-0.0589
		(0.0350)	(0.0362)
Gov Bond Holdings$_{it-1}$ × Earthquake$_t$			-0.0809*
			(0.0422)
Observations	5069	5069	5061
R^2	0.0948	0.0962	0.123
Banks	82	82	82
BankFE	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes
Controls	No	No	Yes

Dependent variable is private lending. Controls include lagged values of interbank assets, cash holdings, and bank capital. All variables are normalized by assets. Placebo takes a value of 1 between April 1999 and July 1999. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C10: Earthquake and lending: Timing Robustness

	(1)	(2)	(3)	(4)	(5)
Gov Bond Holdings$_i$ × Earthquake$_t$	-0.170**				
	(0.0640)				
Gov Bond Holdings$_{it-2}$		-0.189***	-0.166***		
		(0.0360)	(0.0400)		
Gov Bond Holdings$_{it-2}$ × Earthquake$_t$		-0.0735**	-0.0878**		
		(0.0330)	(0.0397)		
Gov Bond Holdings$_{it-2}$ × Asia$_t$			-0.00628		
			(0.147)		
Gov Bond Holdings$_{it-2}$ × Russia$_t$			-0.0137		
			(0.0632)		
Gov Bond Holdings$_{it-2}$ × 2001 Crisis$_t$			-0.0390		
			(0.0374)		
Gov Bond Holdings$_{it-3}$				-0.167***	-0.142***
				(0.0349)	(0.0411)
Gov Bond Holdings$_{it-3}$ × Earthquake$_t$				-0.0671*	-0.0842*
				(0.0400)	(0.0448)
Gov Bond Holdings$_{it-3}$ × Asia$_t$					-0.0767
					(0.0959)
Gov Bond Holdings$_{it-3}$ × Russia$_t$					-0.0372
					(0.0635)
Gov Bond Holdings$_{it-3}$ × 2001 Crisis$_t$					-0.0380
					(0.0400)
Observations	1856	4979	4979	4898	4898
R^2	0.125	0.110	0.159	0.0995	0.152
Banks	79	82	82	82	82
BankFE	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes
ControlsXCrises	Yes	Yes	Yes	Yes	Yes

Dependent variable is private lending. In column 1, Gov Bond Holdings (and other controls) is time invariant, the average of holdings (to assets) over Jan 1997-Jul 1999. Controls include interbank assets, cash holdings, and capital. Controls in columns 2 and 3 are lagged by 2 periods, and in columns 4 and 5 lagged by 3 periods. All variables are as a ratio to total assets. Sample spans 1997-2002. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C11: Earthquake and lending: Robustness to sample period and lending measure

	Lending		Δ Lending		
	(1) 1998-2001	(2) 1999-2000	(3) 1997-2002	(4) 1998-2001	(5) 1999-2000
Gov Bond Holdings$_{it-1}$ $\times$ Earthquake	-0.0891***	-0.128***	-0.0148*	-0.0189**	-0.0219**
	(0.0332)	(0.0402)	(0.0074)	(0.0078)	(0.0089)
Gov Bond Holdings$_{it-1}$	-0.229***	-0.182***	0.00717	0.0200***	0.0215***
	(0.0440)	(0.0565)	(0.0049)	(0.0069)	(0.0076)
Gov Bond Holdings$_{it-1}$ $\times$ Asia$_t$			-0.0166***		
			(0.0061)		
Gov Bond Holdings$_{it-1}$ $\times$ Russia$_t$	-0.0451		-0.0156	-0.0252	
	(0.0546)		(0.0210)	(0.0213)	
Gov Bond Holdings$_{it-1}$ $\times$ 2001 Crisis$_t$	-0.0235	-0.0257**	-0.0184**	-0.0287***	0.0155
	(0.0451)	(0.0122)	(0.0091)	(0.0105)	(0.0094)
Observations	3629	1903	5057	3629	1903
R^2	0.164	0.147	0.013	0.015	0.008
Banks	82	82	82	82	82
BankFE	Yes	Yes	Yes	Yes	Yes
TimeFE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Dependent variable in columns 1-2 is private lending (over assets); in columns 3-5 is the change in private lending (over lagged assets). Earthquake takes a value of 1 for Aug-Oct 1999. Controls include interbank assets, cash holdings, and capital, the latter two winsorized at 1%. All variables are as a ratio to total assets. Sample period indicated in the column title. R^2 is within R^2. Errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$