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

Yusuf Soner Başkaya † Bryan Hardy ‡ Şebnem Kalemli-Özcan § Vivian Yue¶

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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 Turkey's default risk. Our theoretical model illustrates that for banks with higher exposure to government securities, a higher default risk on those assets 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 towards real economic activity.

JEL: E32, F15, F36, O16
Keywords: banking crisis, bank balance sheets, lending channel, public debt, credit supply

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†University of Glasgow, Adam Smith Business School

‡Bank for International Settlements

§Corresponding Author. University of Maryland, CEPR and NBER

¶Emory University, FED Atlanta, CEPR and NBER.

I Introduction

Financial institutions play a pivotal role on 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] 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), Arellano, Bai, and Bocola (2020)). 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.

However, quantifying the effect of sovereign risk on bank balance sheet and credit provision is a challenging task. In particular, it is difficult to identifying a casual relationship between sovereign risk and banking sector distress due to the bank-sovereign doom loop episodes which underline the well known fact of the coincidence of sovereign crises and banking crises (Reinhart and Rogoff (2009)). First, sovereign risk can also increase endogenously due to weak banks. In the presence of a financial crises, banks under financial stress face a risk of becoming insolvent and may 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 sheets shocks are mostly anticipated which 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 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

[1] Sovereign governments mostly borrow from domestic residents (Aguiar and Amador (2014), Tomz and Wright (2013), and Reinhart and Rogoff (2009)).

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. And last but not least, 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 funding constraint as the economy experiences an unexpected risk in sovereign risk. Second, we utilize the 1999 Marmara Earthquake as an unanticipated exogenous fiscal shock that elevated Turkey's sovereign risk. One can argue that unanticipated nature of the shock makes it impossible for the banks accumulate or run down government debt in expectation of sovereign risk. This hence the helps us to rule out moral hazard and/or risk shifting stories in expectation of a default. Third, we use an administrative portfolio data for the universe of banks in Turkey between 1997–2012 to analyse how exposure to sovereign debt at the time of the unanticipated exogenous shock affects banks' financial constraints and credit provision in the aftermath of the earthquake.

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 very significant. It hit on August 17, 1999 (at a Richter Scale of 7.6) in the industrial heartland of Turkey.[2] The region's population share in country total is 25 percent and GDP share is 50 percent. Total cost of the disaster is estimated to be 20 billion USD, which is 11 percent of GDP as of 2000.[3] 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. The Marmara Earthquake is listed in top ten in the U.S. NGDS Significant Earthquakes database on all earthquakes recorded in history.[4] 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 estimate the extent of the financial constraint by following Bocola (2016) to construct bank-specific Lagrange multiplier associated with the bank's financial constraint. Specifically, we allow the banks to be heterogeneous in the extent of financial constraint they face. We analyse how banks' financial constraints, derived from the model, differed 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. Furthermore, we show that banks' net worth has also been affected negatively due to their exposure to government debt at the time of the earthquake. Next, we show that banks that faced tighter financial constraints in the aftermath of the earthquake due to their government debt exposure significantly reduced lending to the private sector. 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.

[2] Composed of cities such as Kocaeli, Sakarya, Duzce, Bolu, Yalova, Eskisehir, Bursa and Istanbul.

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

[4] 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.

We next go more in depth to show a causal link from sovereign risk to bank health and lending using a differences-in-differences methodology. We find that banks' with higher exposures to government debt before the earthquake suffered a bigger shock to their net worth, faced larger financial constraints and decreased lending more than the banks with lower exposures. We show that this is not driven by changes in credit demand (from loan officer surveys), by ex-ante adjustments in sovereign bond holdings, as well as other alternative explanations.

Finally, we analyze the implications of high government debt exposure at the time of the fiscal shock on bank lending. We show that exposure to the government debt before the earthquake also affected the banks' credit provision following the earthquake. Our results are statistically and economically significant. Our estimates imply that, a bank that holds 75 percent of its assets in government bonds decreases credit provision 2 percent during regular times (a normal time crowding out effect) and 6 percent during earthquake relative to respective means. We measure credit provision by the ratio of stock of loans to total assets, whose sample mean is approximately 30 percent. Therefore, it is worth noting that these are sizeable affects. The actual decline in loan provision is 3 percentage points during the earthquake period. A bank with bond holdings equal to sample mean (i.e. 20 percent of its assets) will decrease loan supply by 1.6 percentage points and hence our estimates can explain 55 percent of the actual decline in credit provision from July to October 1999, on average.

Our paper contributes to the broad literature that relates the sovereign debt crises to private sector access to credit in novel ways. 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 company-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 (2015) 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 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 about 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. 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 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

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

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

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

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

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

and the Lagrange multiplier on the incentive constraint 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 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, the banks may be affected differently by the exogenous sovereign risk and thus the lending to firms change differently as a result. In the empirical analysis, we explore how banks with different holdings of government bonds transmit an unexpected Earthquake shock onto the credit supply in Turkey.

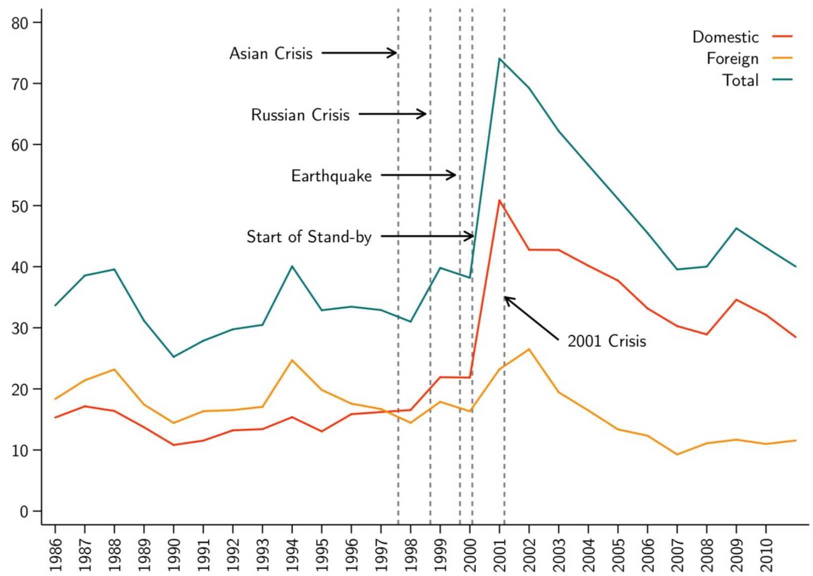
Based on this theoretical model, when the government is subject to an unexpected shock that raises the sovereign default risk, the banks' networth is reduced, tightening the financial constraint. Therefore, the demand for firms' claim reduces. We will later provide a formal empirical analysis based on 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

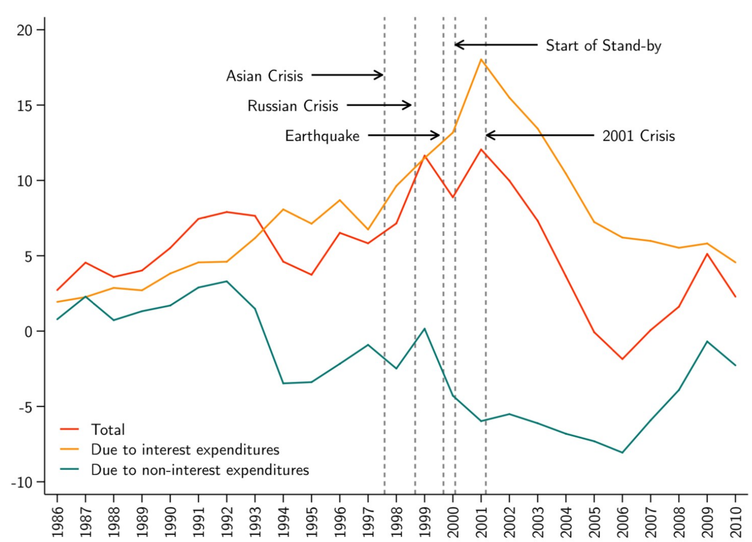
Turkey introduced a series of major structural reforms in 1980s, such as deregulating the domestic market and opening up to foreign trade in early 1980s, improving the growth performance compared to earlier decades. By the end of the decade, Turkey further liberalized the capital account, due to savings gap arising from both both private and public sector. The capital account liberalization also resulted in access for the banks to international capital markets, which would allow them to borrow from abroad and either to provide credit to non-financial sector or to finance the government by purchasing government securities. The economic and political developments in 1980s and 1990s witnessed a further deterioration in public finances, resulting in larger public sector borrowing requirement. The attempts to artificially decrease the cost of borrowing for Turkey in 1993-1994 period resulted in a major financial crises in 1994, after which the financial repression on the financial sector to finance the public debt became more visible. After this period, the banks were provided some degree of foresight in the value of Turkish lira vis-a-vis major funding currencies through a managed floating exchange rate regime, as well as the explicit guarantees given by the Savings Deposit Insurance Fund to the banks' deposit liabilities. Nevertheless, as the government failed to deliver necessary fiscal reforms and rely on the domestic banks' finance, the public sector borrowing requirement continued increase. However, a series of events in 1990s, such as Asian Crises and Russian Crises, led to an increase in public sector borrowing requirement in Turkey. Figure 1(b) plots the public sector borrowing requirement which is akin to consolidated budget deficit. In the light of growing interest liabilities, primary budget records a surplus as an attempt to keep fiscal situation sustainable. As shown in Figure 1(a), domestic debt was the culprit for high debt/GDP ratio during this period, while external debt was more manageable.

Following the Russian Crises in 1998Q3 associated with a major devaluation of Ruble, which affected Turkish economy both through foreign trade channel and also through financial flows, Turkey experienced a recession as well as a rapid increase in interest rates, including those on the government securities. This resulted in further asset relocation for the banks by holding less credit and more government debt in their assets.

The tipping point for the sustainability of the Turkish government's debt were the series of earthquakes in Marmara Region between August 1999 and November 1999. The major



(a) Debt/GDP (%)



(b) Public Sector Borrowing Requirement/GDP (%)

Figure 1: Evolution of Public Sector Debt in Turkey

one, which is one of the largest earthquakes in world history in terms of the number of causalities and as well as the economic cost, occurred in August 1999. These earthquakes played a crucial role for the perceptions on the sustainability of the public debt. 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. These costs consist of infrastructure expenditures, tax revenue losses, production losses and the contingent liabilities resulting for the government.[5] High government debt exposure of the banking sector was accompanied with almost non-existent corporate bond market and equity market exposure implied limited diversification. The August 1999 earthquake also increased the concerns on the debt sustainability and paved way to a Stand-By agreement with IMF. Indeed, on December 9, 1999, the Government and the CBRT announced the program aiming at reducing inflation and restoring the fiscal balance, which involved a 36-month Stand-By agreement with the IMF.[6]

As shown in Table I, the borrowing cost for government and default risk has increased sharply as a result of the earthquake. Table shows approximately a 10 percentage point increase in 3 month coupon yields of floating T-bills after the earthquake, Table also shows the EMBI+ spread increased 100 basis points over a 3 month period after the earthquake. The rise of 100 basis points is maybe small in an emerging market context but not in general: Italian spreads have increased 200 basis point between July and September 2011, which is the most elevated point of sovereign risk.

Figure 2 plots percentage point spread of 3-month Turkish Treasury Bill over the US Treasury Bill, again showing almost half of the rise in spread during the 2001 crisis was observed during the earthquake. Figure 3 shows an increase from 20 to 50 percent in the share of short term borrowing in total borrowing of government after the earthquake. Notice that this share gets close to 100 in the wake of the 2001 crisis, as typical in EM crisis.

A particular question regarding to the earthquake, which is important for our identi-

[5]See Akgiray and Erdik (2004) for the estimated economic cost of the earthquake.

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

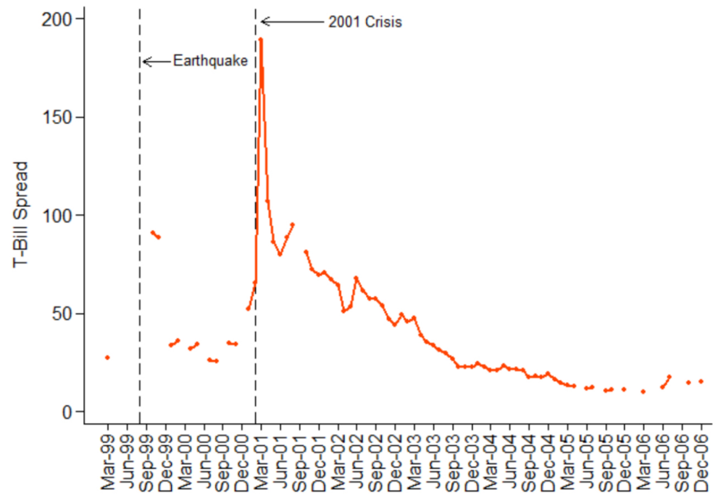


Figure 2: Spread of 3-month Turkish bill over 3-month US-T bill

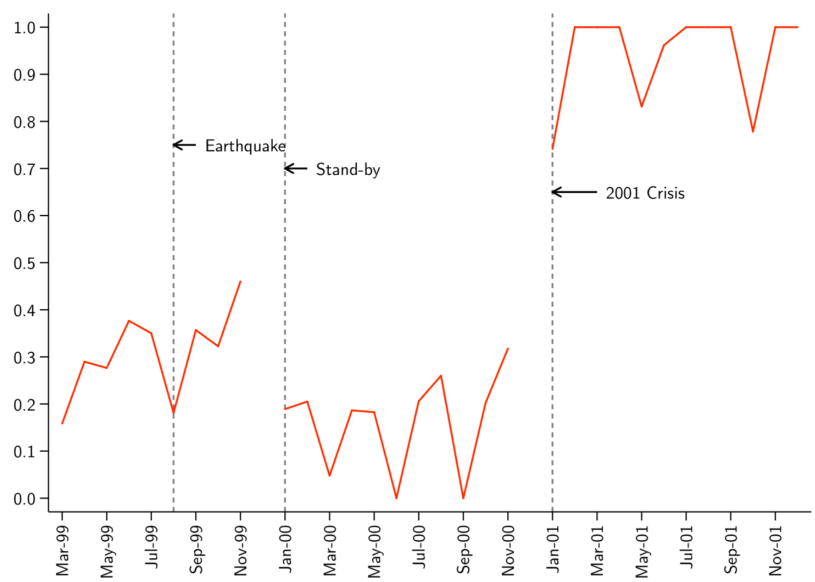


Figure 3: Ratio of Short Term Borrowing in Total Government Borrowing

fication strategy, was whether it led to significant changes in the non-performing loans in the region. According to CBRT, the estimated credit risk to the total banking sector in the earthquake region for 1999 was 1.5 billion USD, of which about 60% were private bank credits and 40% were public bank credits. Despite the perceptions of increased default probabilities and the credit rescheduling needs in the region, the total amount of rescheduling as of August 2000 was only 26 million USD in the earthquake region, i.e. only the 1.6 percent of initial estimate of the perceived risk for the earthquake region. In other words, there was no evidence of wide spread defaults in the region and neither a region wide or country wide recession as shown in Figure 4.

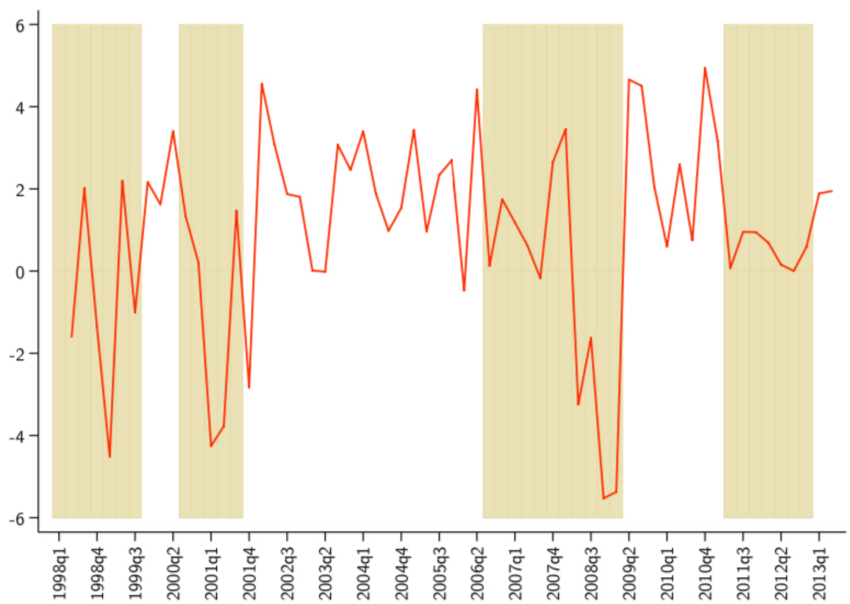


Figure 4: Quarterly GDP Growth

Finally, the Stand-By program introduced in December 1999 relied aimed at improving public finances through comprehensive structural reforms, austerity measures and extensive privatization program as well as reducing the government borrowing cost. For the latter, the rapid reduction in expected and realized inflation in the first half of 2000, due to exchange rate peg introduced as part of the Stand-By program, has been effective to some extent.

On the other hand, due to a number of factors, such as inherent problems of the banking sector, the political uncertainties undermining the credibility of the structural reform agenda and real appreciation of the Turkish lira due to sluggishness in the inflation brought about concerns on the sustainability of the program in 2000Q4. The program was first modified substantially in November 2000 after liquidity problems arising in the banking sector and then fully collapsed in February 2001. This resulted in a major financial crises due to sharp devaluation, a rapid surge in the inflation rates and nominal interest rates on government debt followed by one of the largest contraction episodes in the economic activity in Turkey and collapse of a number of private banks.

In May 2001, Turkey announced a new Stand-By Program, aiming at maintaining the discipline in fiscal and monetary policy and restructuring the banking sector. The implementation of the comprehensive reform agenda in the period afterwards resulted in a substantial improvement in the economic fundamentals thereafter.

IV Data and Descriptive Statistics

We use administrative monthly bank balance sheet data from Turkey for 1997–2012 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. As shown in Figure 5, number of banks in Turkey has shown a great variation during our sample period due to entry and exit to the banking sector. The number of banks in Turkey reached its maximum in 1999. However, between last quarter of 1999 and 2003, the number of banks has declined substantially due to poor financial performance. In particular, if a bank experienced significant operational losses which raises the risk of bank capital falling short of the regulatory minimum, the regulatory agency would ask the bank to add new capital and to improve the balance sheet quality However, if the bank fails to take necessary actions and its capital adequacy ratio falls below the legal limit, then its control is taken over by Savings Deposit Insurance Fund (SDIF) to protect the depositors and to limit the overall systemic risk. In such a way, 6 banks were taken over by SDIF in 1999, and further in 2000-2001 period.

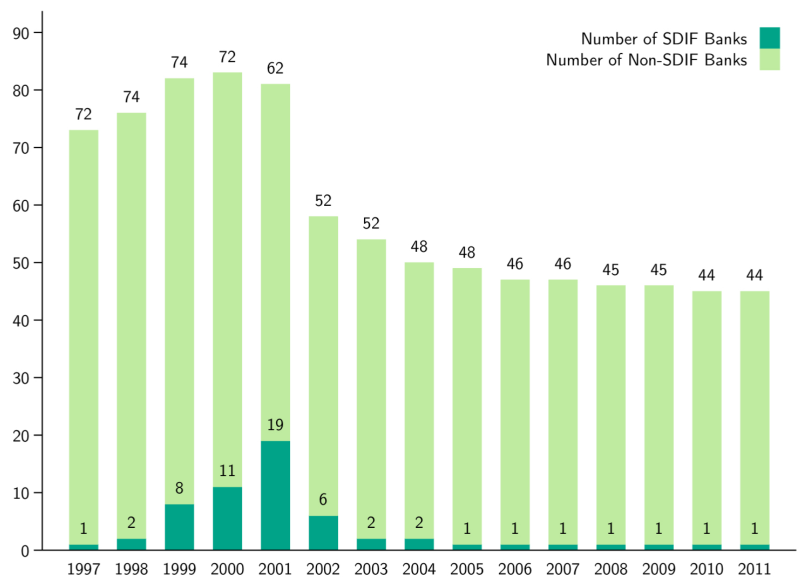


Figure 5: Bank Entry and Exit

Table II 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.[7] Table III presents key macro indicators.

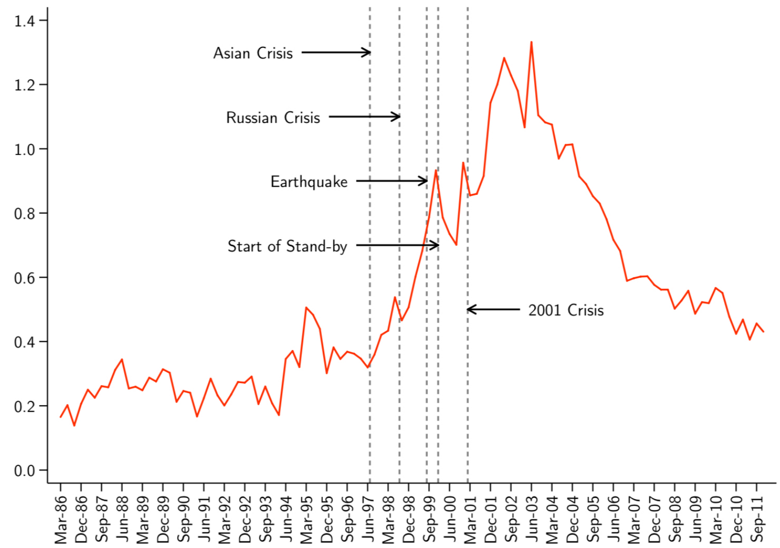


Figure 6: Government Bond Holdings/Credit to Non-Financial Sector

An interesting feature 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 6. Even during this period, the banks have shown some hetereogeneities. Figure 7 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 until the 2001 crisis, where in the eve of this crisis, both increased their exposure—large banks much more so—to government debt, consistent with moral hazard stories as in Acharya and Steffen (2014). As shown in Figures 8(a) and 8(b), there seems to be more of an increase in holdings

[7]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.

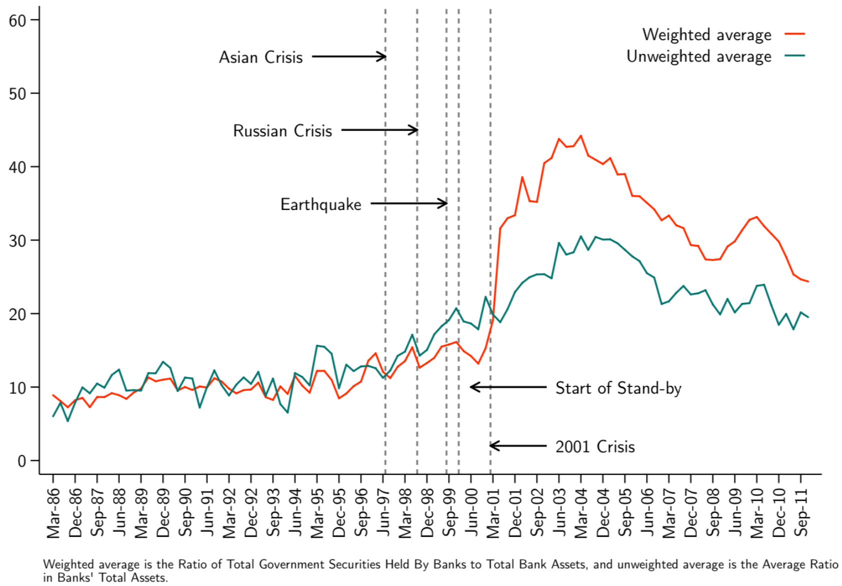
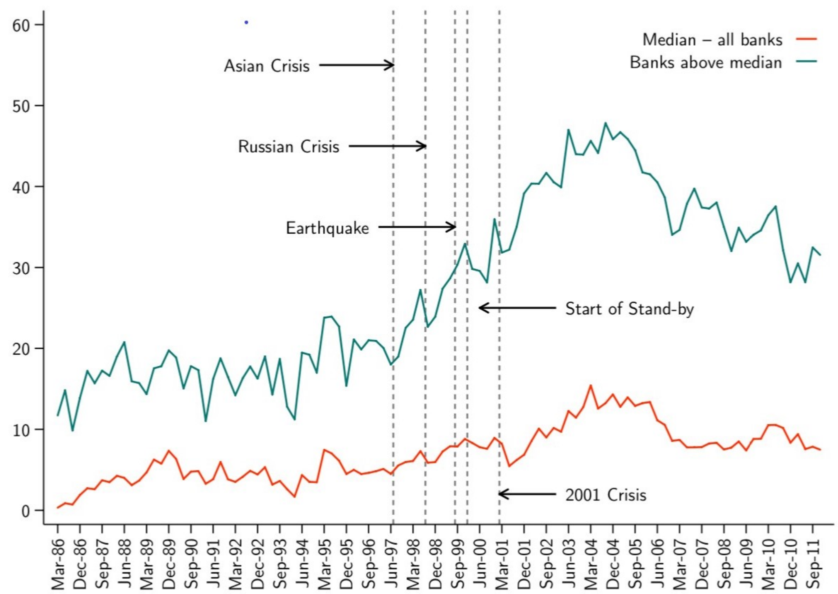


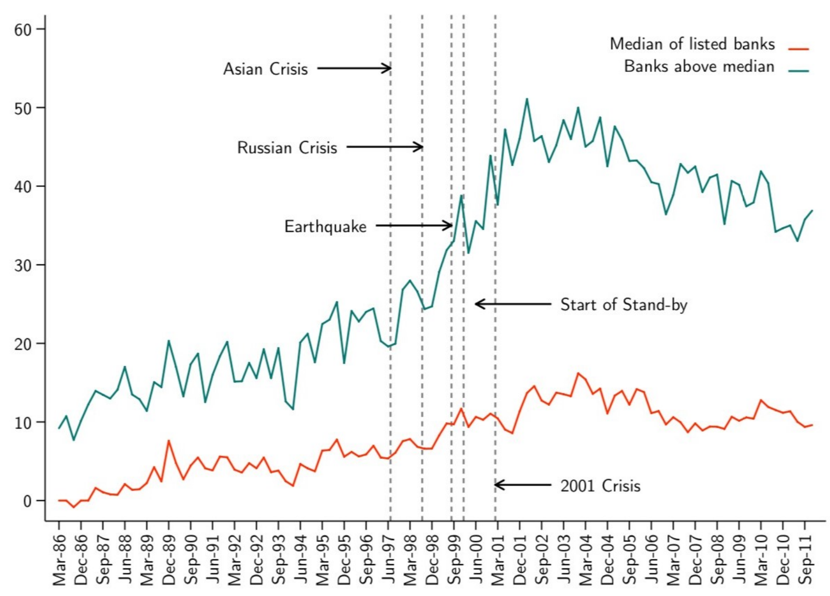
Figure 7: Government Bond Holdings/Total Assets: Aggregate vs Average

of government debt for the very large banks, which increased their exposure right up until the 2001 crisis.

Figure 9 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 6 where we show typical bank also decreases credit to non-financial sector during this period, increasing loans to government sector by similar amounts.



(a) All Banks



(b) Listed Banks

Figure 8: Government Bond Holdings/Total Assets: Listed and Non-Listed Banks

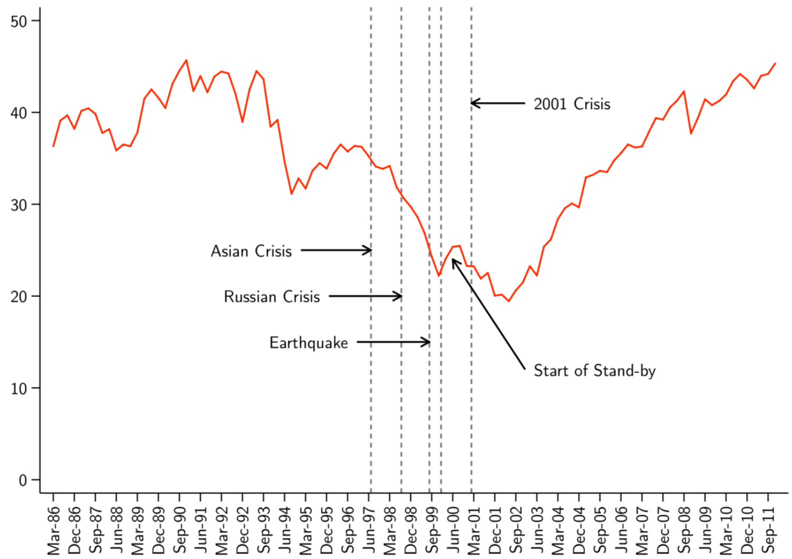


Figure 9: Lending to Private Sector as a Ratio of Financial Sector Assets

V Empirical Results

A Bank Balance Sheet Channel

In the subsequent empirical analysis, we will examine how an unanticipated sovereign risk shock affects banks' lending via the balance-sheet channel. We use the Earthquake as a natural experiment to identify the effect of government debt on banks' financial constraint. Using the framework based on Bocola (2016), we compute the bank-specific Lagrange multipliers and use this to estimate the impact of the earthquake on the financial constraints for banks with different government bond holdings. We then directly provide causal estimates of the impact of an increase in sovereign risk on bank health and lending.

We measure the lagrange multiplier for the banks incentive constraint, presented in equation (1), in two ways. The first measure, which we call IC1 in the empirical results, is calculated by using the real interest rate in Turkish Lira interbank money markets and the 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. The second measure, denoted as IC2, also uses the interest rate in Turkish Lira interbank money markets and the FED funds rate, except for being adjusted for the inflation differentials.

Figure 10 plots how the distribution of banks' financial constraints, measured by IC1, 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. 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.

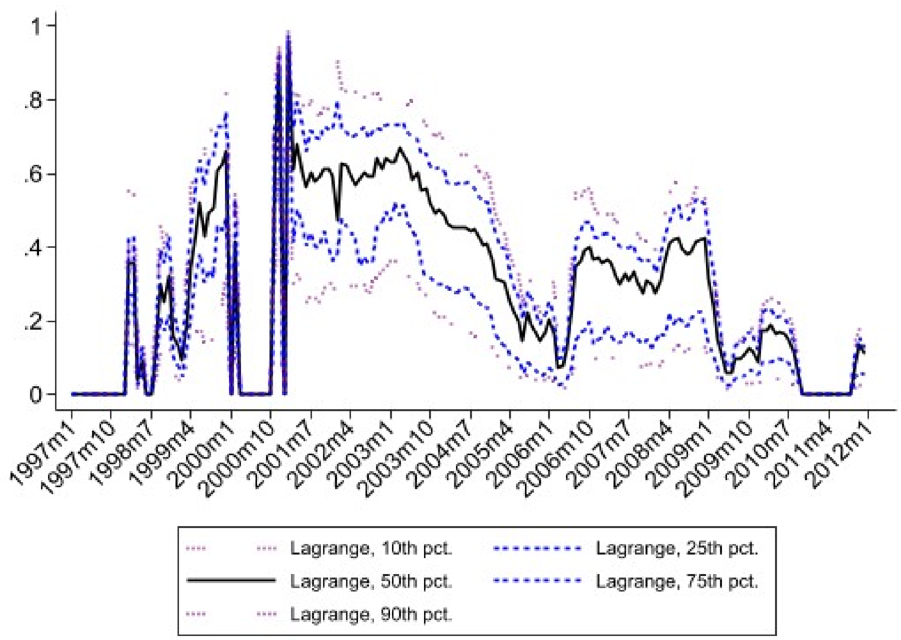


Figure 10: Banks' Financial Constraints (IC1)

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

$$\Delta\mu_{it} = \gamma\Delta\mu_{it-1} + \beta_1 Gov\ Debt\ Exp_{it-1} + \beta_2 Earthquake_t \times GovDebtExp_{it-1} + \beta_3 X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \tag{2}$$

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 whether 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 with higher government securities in their assets 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 with potential effect on Turkish economy (such as the Asian Crises, Russian Crises, 1999 Earthquake and the 2001 Crises) in our sample we summarized in earlier sections.[8] 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 heterogeneity in the change in the incentive constraints.

The results presented in Table V show that the financial constraints of the banks who had high government debt holding increased substantially during the earthquake, when the sovereign risk increased. In particular, the first line of the Table V suggest that the banks with different level of government debt holdings in their portfolio did not have significant

[8] 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.

differences in their financial constraints during normal time, i.e. when dummy variables for the crises periods take value 0. On the other hand, the differential effect of government debt holdings during the earthquake is positive and significant. However, what matters more is the total effect of the government debt holdings at the time of the earthquake, which is given in the third line of the Table V, which is significant at 1 percent significance level when we use IC2 and 10 percent significance level when we use IC1. In short, we find that the banks with higher exposure to the government securities market before the earthquake have indeed faced tighter financial constraints following the earthquake.

B Effect on Valuation and Banks' Net Worth Effect

We provide further evidence on how the earthquake driven rise in sovereign risk led to 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 balance sheet, that cause their net worth to go down.

To provide evidence on the channel, Table VI investigates the impact of the earthquake on banks' balance sheet performance by first considering the banks' financial asset valuation changes between current and previous period as a ratio to their total assets (column (1)). Next column investigates the effect on bank net worth and final column on profits. 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).[9] For the banks which hold the same government security portfolio both at time t and t-1, an increase (a decrease) in the price of the government security induces a revaluation indicating an increase (a decrease) in portfolio's monetary value. As a unique evidence, we find that the banks with higher share of government securities in their balance sheets had a decline in the value of portfolio, given the decline in the value of this asset with the fiscal shock, as shown in

[9]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.

column (1).

Columns (2) and (3) show that the same shock also constitutes a direct hit to banks net worth and profits for those banks who had higher holdings of government securities before the shock. Although there is a direct negative effect of government bond holdings on valuation and profits (which captures the general trend), this is not the case for net worth as shown in column (2). Hence, it is not necessarily the case that in the absence of the fiscal shock, banks who accumulate more government bonds over time, have declining net worths; these banks do not differ systematically from the banks which reduced their government bond holdings over time in terms of their net worth. However, the banks which accumulated more before the earthquake, suffer a bigger decline in their net worth following the exogenous increase in the sovereign risk. This is a direct evidence for our channel.

In terms of magnitudes, we find that a bank in 90th percentile, which holds almost half of its portfolio in government securities, suffers a 2 percentage point loss to the value of its portfolio as a ratio to its assets and a 3 percentage loss in its' networth as a share to its assets. For this high exposure bank, profits to assets go down by 1 percentage point. These are significant effects relative to the mean values of these variables.

C Financial Constraints and Bank Lending

Having shown that the banks' financial constraints increased due to being exposed to government securities at the time of the earthquake-driven sovereign risk shock, we further estimate the spillover of such unexpected sovereign risk onto the supply of credits to private sector through the balance-sheet channel based on the model. For this, we estimate:

$$L_{it} = \alpha \Delta \mu_{it-1} + \gamma X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \tag{3}$$

where $\Delta \mu_{it-1}$ is the change in the incentive constraint for the bank i at month t. X_{it-1} stands for all the controls, including the interactions between the $\Delta \mu_{it-1}$ and the major events with potential effect on Turkish economy (such as the Asian Crises, Russian Crises, 1999 Earthquake and the 2001 Crises) in our sample we summarized in earlier sections. λ_i and λ_t stand for bank-fixed effects and month-fixed effects, respectively.

The results corresponding to Equation 3 is presented in first two columns of Table VIII. Both the results in column 1 and 2, based on IC1 and IC2 respectively, indicate that tighter financial constraints by banks result in reduction in credit provision. Thus while Table V showed that the earthquake tightened constraints for banks with more government debt exposure, Table VIII shows that tightening our measure of the banks' constraint correlates directly with a decline in lending. In the next section below, we show directly the connection between government exposure and lending.

Further, we estimate a difference-in-difference specification to connect the change in constraints to the earthquake period of interest by estimating:

$$L_{it} = \alpha_1 \Delta\mu_{it-1} + \alpha_2 Earthquake_t \times \Delta\mu_{it-1} + \alpha_3 X_{it-1} + \lambda_i + \lambda_t + \epsilon_{it} \tag{4}$$

In Equation 4, the parameter of interest is $\alpha_1 + \alpha_2$, which gives us the effect of tighter financial constraints by banks in the aftermath of the earthquake. In particular, a negative and statistically significant value of $\alpha_1 + \alpha_2$ implies that the banks facing higher financial constraints during the earthquake reduces lending in the aftermath of the earthquake.

The results corresponding to Equation 4 is presented in Table VIII. The table also shows how much the bank lending changed following the 1998 Russian Crisis and 2001 Crisis.

The results indicate that tighter financial constraints experienced by the banks during the 1999 earthquake were later followed by a reduction in the credit supply. The heterogeneity across reduction in bank lending due to tighter financial conditions during earthquake is statistically significant. In terms of the magnitude of the effect, the results in Column 1 suggest that the banks at the median of the distribution for change in financial constraints during the earthquake reduced credit to assets ratio by 0.6 (-0.1644*0.034) percentage point after the earthquake. The banks at the 90th percentile of this distribution is almost three times as much, i.e. 1.6 (-0.1644*0.097) percentage points. The results in Column 2 also suggest that the decline in the credit significant after the earthquake for the banks with tighter financial constraints. Finally, the results also show that lending has declined following the 2001 crises more by the banks which faced tighter financial constraints.

D Evidence on Government Securities Holdings and Bank Lending

In this section, we go into more depth to causally identify the effect of an increase in government 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 exogenous increase in sovereign risk by estimating the following specification:

$$L_{it} = \alpha_i + \lambda_t + \omega_{iq} + \beta_1 Gov\ Debt\ Exp_{it-1} + \beta_2 Earthquake_t \times GovDebtExp_{it-1} + \beta_3 X_{it-1} + \epsilon_{it} \tag{5}$$

where i is bank, t is month and α_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. ω_{iq} controls for loan demand (η_{ijt} in the above framework), where q stands for quarter.[10]

We do not have loan level data and hence we do not have customer j level variation. We argue that we can capture the first order effect of bank specific customer demand η_{ijt} by ω_{iq}. Our reasoning is supported by the data from loan officer survey data provided by CBRT, as presented in Figure 16 in the Appendix. This 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 constitute the majority of bank loans. Each bank undertakes such a

[10] The Appendix provides a summary of a conceptual framework based on Khwaja and Mian (2008) that can support such regression equation.

survey since 2005 that suggests that firms' demand for loans move very slowly. We assume that this was also the case during the earthquake period. Our assumption is supported by the fact that the firm-bank relationships in general have a very sticky nature even the US that has developed financial markets.[11] Hence, given the monthly nature of our bank level data, the bank-quarter fixed effects will absorb slow moving firm-bank specific demand.

The outcome of interest, 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. We measure the government debt exposure, $Gov\ Debt\ Exp_{it-1}$, by ratio of banks' government security holdings to total banks' assets. As explained above, β_2 gives us 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 differentially, we also control 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 $Gov\ Debt\ Exp_{it-1}$, lagged 1 month, 2 month and 3 months to check robustness of our results since we will define the "Earthquake" period with a dummy equals to 1 for August-November 1999. Other bank-time varying factors are included in X.

Our analysis below recovers that during this period where credit to private sector declined as a resulting of a crowding out effect coming from government borrowing, there is an additional effect of an unanticipated fiscal shock. The banks who were exposed more to government debt and hence affected more from this shock, decreased their lending to private sector even more. We interpret this finding as the evidence for the balance sheet channel.

Another important observation for our identification is the fact that there was no visible change in government bond holdings post earthquake. Table IV present 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

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

provision declined.

D.1 The Banks' Balance Sheet Health and Credit Provision

We identify how banks' performance in terms of net worth and profits and their credit provision are affected from government debt exposure by comparing banks with different degrees of exposure before and after the earthquake, which was a sizable and unanticipated fiscal shock experienced in Turkish economy.

Table IX runs a simple cross sectional regression by collapsing the sample in two periods as pre- and post-earthquake to highlight the intuition of the exercise. 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 1997 to July 1999. This simple cross sectional regression shows a clear reduction in loan supply after the earthquake by the banks who have higher exposure to government bond market before the earthquake. This effect is robust to excluding state owned banks and foreign owned banks as shown in columns (2) and (3) and also robust to excluding both type banks as shown in column (4).

The coefficient varies between -0.4 and -0.6, getting stronger when state and foreign owned banks are dropped from the sample. This of course can be due to variety of selection issues in a cross sectional regression of this sort. In fact, given the cross sectional nature of this exercise, one cannot tell whether the effect is driven by unobserved time-invarying bank characteristics, the inherent negative relation between the loans to government and loans to private sector, that is the crowding out nature of lending to government. We also cannot tell whether our channel, i.e., the balance sheet effect, works via the lower value of government bonds as a result of increased spreads reducing banks' net worth. In fact the estimated coefficient is very high since this estimate probably includes all these effects: A coefficient of -0.6 suggests that a bank who holds 20 percent of its portfolio in government assets (the mean), reduces credit supply defined as loan to asset a mere 12 percentage points, which represents a 60 percent decline in the loan to asset ratio relative to its mean value.

Next, in Table X, in order to control unobserved time-invariant bank characteristics and also shocks to all the banking system, we run a differences-in-differences specification with bank and month fixed effects, where we keep the bond holdings constant at their level in the month of July 1999, one month prior to the earthquake. Given the bank fixed effects, the non time-varying nature of bond holdings will not allow us to estimate their direct average impact but we can estimate their impact after the earthquake, as shown by the interaction term with an "Earthquake" dummy. This dummy takes a value of one from August 1999 to November 1999, and zero otherwise. Table X shows that there is a strong negative effect of government debt holdings of pre-earthquake, on credit provision post-earthquake. An estimated coefficient of -0.2 implies a 4 percentage point reduction in loan to asset ratio, which represents a 20 percent decline in this ratio relative to its mean.

Columns (2) and (3) add interaction terms of bond holdings as of July 1999 with Asian crisis and Russian crisis dummies to make sure our "Earthquake" dummy does not proxy effects of these events that took place earlier. "Asia" is a dummy that takes a value of one from July 1997 to October 1997. "Russia" is a dummy that takes a value of one from August 1998 to November 1998. The "Earthquake" dummy effect is robust to these other events. However these other events, though they are not domestic events, also have a negative effect on the loan provision of banks who hold high levels of government debt in July 1999. These events happened before and will not have a direct impact on the value of the domestic debt. Hence they must be proxying for the general crowding out effect, that is the tendency to have less and less private sector loan provision with more and more lending to government over time due to an increase in the fiscal needs of the government as a result of these external shocks.

In order to deal with this concern, Table XI runs a full panel differences-in-differences specification. This specification allows us to control the direct crowding out effect over time by entering time varying bond holdings into the regression. We introduce other events and their interactions with lagged government bond holdings in addition to earthquake, such as

Asian crises, Russian Crises, and the 2001 crises as controls for exploring the differential loan supply effect of fiscal shock induced by the earthquake with respect to banks' government debt exposure. Regardless of whether we control for these events or not, we observe that the banks with higher exposure to the treasury bills faced higher declines in loan supply after the earthquake.

The effect of bond holdings during other events is very intuitive. As conjectured, now there is no significant impact of pre Asian crisis bond holdings during Asia crisis, as opposed to the previous tables since we control the direct effect of bond holdings. We obtain the same result with Russian crisis. These events are external shocks and 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. Columns (5) and (6) introduces a "2001" crisis dummy that takes a value of one from December 2000 to December 2001. These columns show a similar negative effect of holding government bonds during the 2001 crisis, where the estimated coefficient is bigger than that of the "Earthquake" dummy interaction, as expected. These columns will be a typical representation of the regression that is run in the literature as we argued above (both historical emerging market sovereign debt crisis and recent European sovereign debt crisis), where the crisis is endogenous. Although both the "Earthquake" period and "2001" Turkish crisis period constitute fiscal shocks and cause a decline in the value of government bonds with the heightened sovereign risk, the earthquake allows us to estimate the causal impact given the exogenous and unanticipated nature of this event.

The last three columns of Table XI control for bank specific demand with bank-quarter effects. As argued above, these effects can capture bank specific demand that moves slower, from quarter to quarter and hence if a certain banks clientele is specifically located in the earthquake region, these effects will capture such 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. Of course, bank-quarter fixed effects make the specification extremely restrictive, absorbing a lot of variation, which is why the estimated coefficients are now much smaller.

The first five columns Table XI define the earthquake period as August-November 1999, whereas column (6) defines it as 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. This naturally raises the question of whether our results hold even when we disregard this direct tax implication of the earthquake on banks' balance sheets. Hence we define the "Earthquake" dummy in the last column to make sure the tax imposed afterwards.

Our estimates imply that, a bank with the mean holdings, that is 20 percent of its assets are in government bonds decreases credit provision almost 1 percentage point during earthquake. If we add the regular time crowding out effect, the total effect of bond holdings for the bank with the mean holdings becomes 1.5 percentage point. These are much smaller magnitudes than before but given the fact that they are conditional on controlling demand effects and they are still sizeable representing a 5 percent decline in loan to assets relative to the mean. If we focus on a bank at the 90th percentile, who holds almost half of its assets in government bonds, then the total effect of holdings becomes 2.5 percentage point. The actual decline in loan provision is 3 percentage points.[12]

[12]Note that in theory there can be yet another differential effect depending on the maturity structure but all the bonds are less than 14 month maturity in our data given the specifics of that period where Turkish government can only borrow short term both externally and domestically.

VI Robustness

A Threats to Identification

A.1 Non-Random Nature of Bond Holdings

Government bond holdings are not random. Certain banks, like small in size, might hold more government bonds. In this section, we try to understand both the time in-varying and time variant determinants of government bond holdings. As shown in Table XII most determinants of government bond holdings are time invarying such as being a state bank, as shown in column (1). Columns (2) and (3) absorb these time in-varying determinants by using bank fixed effects and column (3) does double clustering for standard errors both at bank and month level to allow for serial correlation. Column (3) still shows that banks who increase their capital ratio over time hold less government bonds in their portfolio over time. Same is true for interbank balances since banks who accumulate higher surpluses on their interbank balances need less government bond holdings as collateral. Banks who accumulate more non performing loans over time also tend to accumulate less government bond holdings over time, which must be due to the fact that these banks lend more to private sector. Banks with more cash also decrease their government holdings over time.

Of course what is important for our identification is whether these determinants of government bond holdings at bank-time level vary systematically at the time of earthquake. Table XIII investigates this possibility. As shown in column (2), once we account for all the fixed effects, banks with higher cash holdings than average are the only ones who increase their government 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 stronger banks. Nevertheless we will control for cash holdings at the time of earthquake below for robustness when we investigate the effect of government bond holdings on private sector credit provision. It is clear from this table that, there are no "usual-suspect" determinant of bond holdings that change over the "Earthquake" period that can explain our results due to an omitted variable bias.

To make sure, in Table XIV, we control for all of these potential determinants of government bond holdings that may be correlated with loan provision at regular times and at crisis times. Although we know that the most important determinant of government bond holdings during earthquake is cash holdings, we still control each determinant one by one in respective columns. In this table we also use banks that are not taken over by State Deposit Insurance Fund (SDIF) to make sure we guard against the claim that "bad bank will fail anyway." This exercise is important especially if there are concerns 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 will be taken care for by bank fixed effects and bank-quarter effects, we still run our regressions in a sample of surviving banks throughout the sample period in order not to bias our results.[13] In this table we show that this is not the case. In fact upon using survivors and controlling for bank-time level determinants, we still find the same size coefficient as in our benchmark table.

A surprising result from Table XIV is the fact that non-performing loans seem to have no effect. This is due to the fact that neither on aggregate nor at the average level, non-performing loans were increasing during the earthquake period; on the contrary, they were on a decline as shown below in Figures 11 and 12 respectively.

A.2 Placebo Tests

Table XV, column (1) 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

[13]Only 8 banks are taken over in 1999, so this is not likely to affect our results. 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.

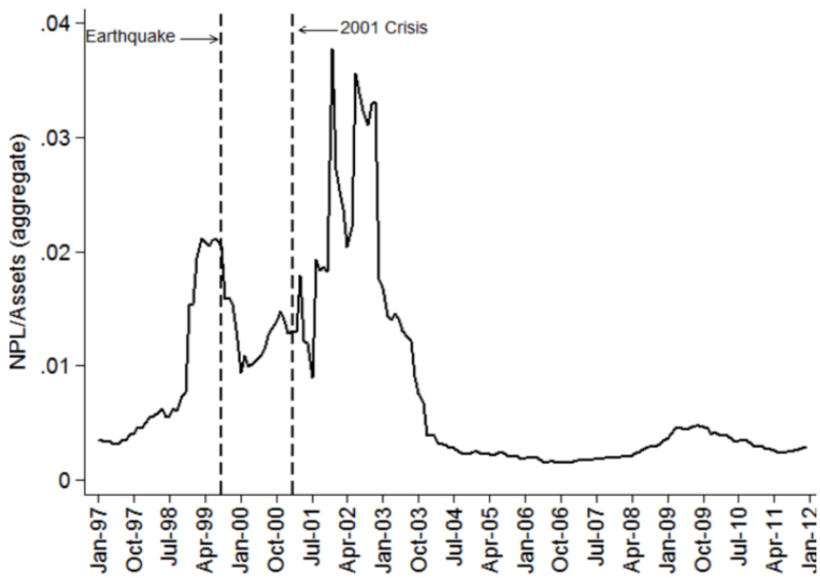


Figure 11: Non-performing Loans to Assets: Aggregate

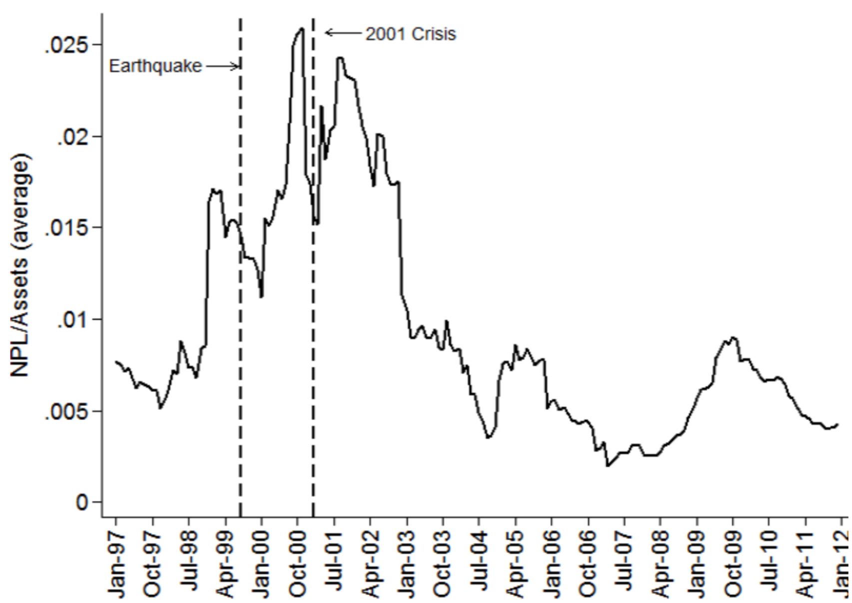


Figure 12: Non-performing Loans to Assets: Average

find with the earthquake are a result of 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.

The second column of this table uses the shorter sample until the end of 2002 showing that our results stay intact, though here we obtain a larger coefficient given less time series observations that prevent us from using bank-quarter fixed effects.

A.3 Prior Trends in Outcomes

A key threat to identification is existence of differential prior trends in our dependent variable. In particular, in order to attribute the corresponding changes in lending to the role of the differences in government debt exposure at the time of the exogenous fiscal shock, one of the issues that we need to check is the parallel movement of the outcome variables for the banks with high and low government debt exposure. The placebo exercise we showed earlier confirms that this is not the case but we still show here the actual trends in the data.

In Figure 13, 14 and 15, we present respectively the time series behavior of the net worth, profits and the loan provision of banks with above and below median exposure to the government debt. These clearly indicate that there were no differential prior trends in our key outcome variables, loan provision, net worth, and profits, across high and low government debt exposure banks. In other words, the estimated negative and significant coefficient on the interaction between the government debt exposure and the earthquake variable does not reflect the already existing deterioration in profits, net worth and loan provision of the banks with higher exposure, but rather the impact of the earthquake on the banks' balance sheet performance and the loan provision.

B IV Regressions for Spreads

In this section, we run IV regressions to link the increase in spreads to our exogenous shock, that is the earthquake. The spreads are measured as shown in Figure 6 by the CBRT Auction

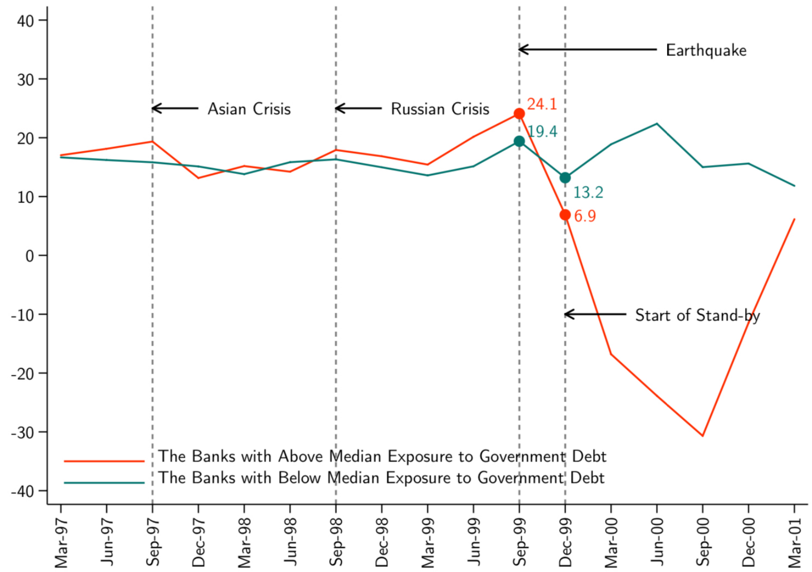


Figure 13: Net Worth of Banks with High-Low Exposure to Government Bond Market

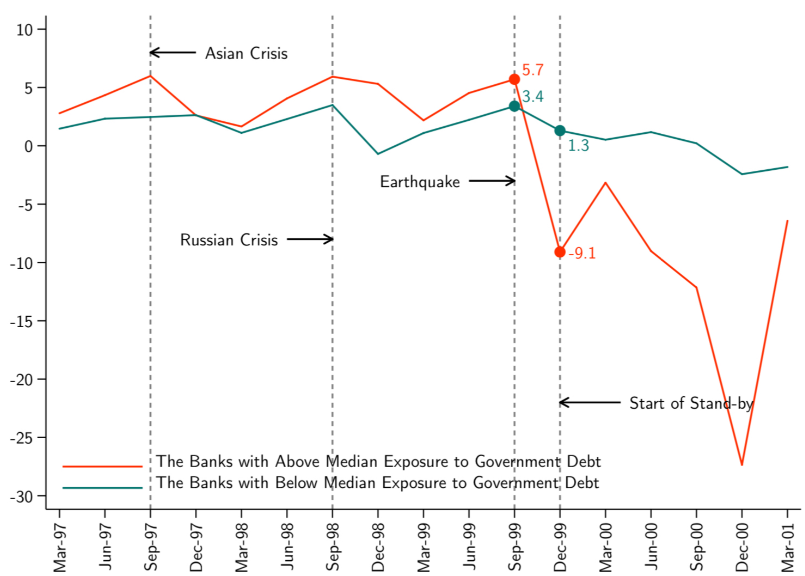


Figure 14: Profits of Banks with High-Low Exposure to Government Bond Market

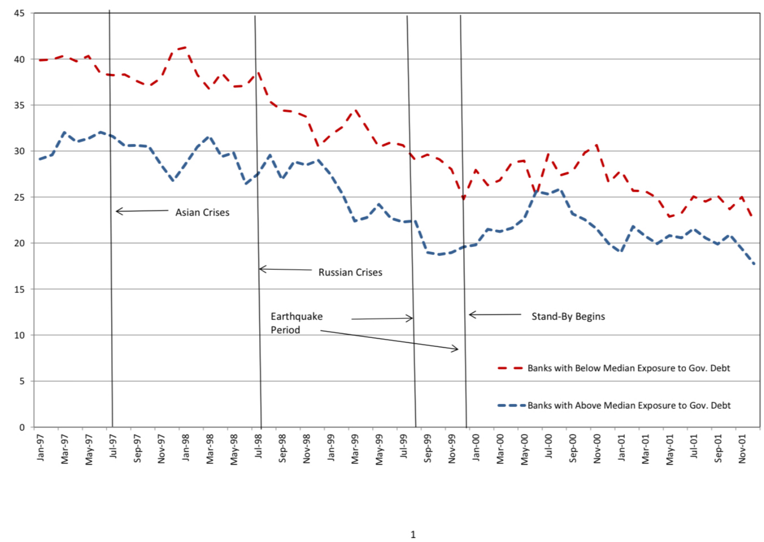


Figure 15: Loan Provision of Banks with High-Low Exposure to Government Bond Market

data compound rate in short term T-bills, minus the US T-Bill rate taken from the IMF.

In the first stage regression, as shown in Table XVI we regress "government bonds×spreads" on "government bonds×earthquake" and use the residuals in the second stage regression of loan to assets, as shown in Table XVII. The first stage regression is very strong, especially when bank-quarter fixed effects are added in second column in its predictive power. The second stage regression gives a strong negative effect of instrumented "holdings×spread" on credit supply.

In terms of the magnitudes, a 100 basis point spread implies a 1.6 percentage point decline in loan to asset ratio for a bank who has the mean level of government bond holdings ex-ante. This amount is 55 percent of the actual decline in loan to asset ratio during this period.

Overall, we show the strong positive effect of an exogenous fiscal shock on spreads and the strong negative effect of the same shock on loan provision, driven by banks who had higher ex-ante exposures to these bonds, which became toxic after the shock. Banks' net worth and profits got hurt as a result of the shock and hence their credit provision have declined.

VII 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. Everyone agrees on the policy urgency for the break-up of this vicious circle or doom loop/diabolic loop.[14] 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.[15] 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 1997–2012. 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 the government debt matter for the effect of fiscal shock on differences in out-

[14]See Farhi and Tirole (2016); Brunnermeier, Garicano, Lane, and Pagano (2015).

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

comes, such us banks' balance sheet health and loan provision.

Our empirical results indicate that high government debt exposure resulted in tighter financial constraints following the earthquake and a differential decline in credit provision. We show that the negative differential effect of fiscal shock on the credit provision of the banks with higher government debt exposure works via the balance sheet channel. We trace the effect of earthquake to a 100 basis point increase in spreads and that to a decline in loan provision through the decline in banks' net worth for the banks who had higher exposure to government bond market before the fiscal shock.

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 the financial sector and credit provision. Although our identification is clear, valid and policy relevant, it works only for the link from the government debt to banks' balance sheet health and loan provision. 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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Table I: Sovereign risk

	(1)	(2)	(3)
	Compounded Interest Rates on Government T-Bill 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.

Table II: Descriptive Statistics

	January 1997 - December 2011						
	count	mean	sd	p25	p50	p75	p90
Gov Bond Holdings	10203	0.2145	0.1776	0.0829	0.1698	0.2974	0.4602
Capital Ratio	10199	0.2238	0.2559	0.0943	0.1385	0.2855	0.6311
Loans to Private Sector	10203	0.3161	0.2148	0.1318	0.3106	0.4807	0.6142
Non-Performing Loans	10193	0.0073	0.0131	0.0000	0.0011	0.0076	0.0233
Bank Size	10203	12.4164	2.2023	10.8247	12.4399	13.9221	15.4404
Cash Holdings	10193	0.0065	0.0079	0.0002	0.0046	0.0093	0.0159
Interbank Balances	10193	-0.0892	0.2802	-0.2187	-0.0688	0.0417	0.2155
Valuation	10141	0.1398	0.3823	0.0000	0.0000	0.0377	0.5316
Profits	10199	0.0109	0.0515	0.0016	0.0104	0.0251	0.0564

	January 1997 - December 2002						
	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

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 III: 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 IV: 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.

Table V: Government Securities Holdings and Banks' Incentive Constraints (IC)

	IC1	IC2
Gov Bond Holdings$_{t-1}$	-0.0023	0.0020
	(0.010)	(0.006)
Gov Bond Holdings$_{t-1}$*Earthquake	0.0350*	0.0254**
	(0.0204)	(0.0124)
Total effect for Earthquake period	0.0327*	0.0274***
	(0.0195)	(0.011)
Observations	9644	9644
R^2	0.879	0.879
Bank Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes

Dependent variables in column (1) and column(2) are the banks' incentive constraint calculated using Equation 1. The dependent variable in column (1), IC1, is the banks' incentive constraint measure calculated using real interest rates in Turkish lira interbank money market and real Fed Funds Rate. The dependent variable in column (1), IC2, is the banks' incentive constraint measure calculated using nominal interest rates in Turkish lira interbank money market and Fed Funds Rate. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank and time levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VI: Valuation, Net Worth and Profits

	Valuation	Net Worth	Profits
Gov Bond Holdings$_{t-1}$	-0.0425***	-0.0221	-0.00403***
	(0.0123)	(0.0154)	(0.0009)
(Gov Bond Holdings$_{t-1}$)*(Earthquake)	-0.0455***	-0.0640***	-0.0159***
	(0.0106)	(0.0103)	(0.00373)
Observations	10107	10107	10107
Bank Fixed Effects	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes
Bank Quarter Fixed Effects	Yes	Yes	Yes

Dependent variable in column (1) is financial assets valuation difference as a ratio to total assets. Dependent variable in columns (2) is networth s a ratio total assets, and in (3) is Profits in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank, month, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VII: Banks' Incentive Constraints (IC) and Credit Supply

	Credit to Assets	Credit to Assets
$IC1_{t-1}$	-0.0407***	-
	(0.011)	-
$IC2_{t-1}$	-	-0.087***
	-	(0.021)
Observations	9766	9766
R^2	0.703	0.704
Bank Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes

Dependent variable in column (1) and column (2) are the ratio of credit to non-financial sector to the banks' total assets. The IC1 is the banks' incentive constraint measure calculated using real interest rates in Turkish lira interbank money market and real Fed Funds Rate. The IC2 is the banks' incentive constraint measure calculated using nominal interest rates in Turkish lira interbank money market and Fed Funds Rate. Standard Errors are clustered at bank and time levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table VIII: Banks' Incentive Constraints (IC) and Credit Supply

	Credit to Assets	Credit to Assets
$IC1_{t-1}$*Earthquake	-0.164**	-
	(0.076)	-
$IC2_{t-1}$*Earthquake	-	-0.334***
	-	(0.097)
$IC1_{t-1}$*Russian Crisis	0.0581	-
	(0.134)	-
$IC2_{t-1}$*Russian Crisis	-	-0.910***
	-	(0.355)
$IC1_{t-1}$*2001 Crisis	-0.161**	-
	(0.040)	-
$IC2_{t-1}$*2001 Crisis	-	-0.188***
	-	(0.059)
Observations	9652	9652
R^2	0.707	0.707
Bank Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes

Dependent variable in column (1) and column (2) are the ratio of credit to non-financial sector to the banks' total assets. The IC1 is the banks' incentive constraint measure calculated using real interest rates in Turkish lira interbank money market and real Fed Funds Rate. The IC2 is the banks' incentive constraint measure calculated using nominal interest rates in Turkish lira interbank money market and Fed Funds Rate. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank and time levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table IX: Average Bond Holdings and Credit Supply After EQ

	(1) All	(2) Drop State	(3) Drop Foreign	(4) Drop State and Foreign
Avg Gov Bond Holdings Before EQ	-0.378***	-0.400***	-0.597***	-0.641***
	(0.0167)	(0.0170)	(0.0182)	(0.0185)
Constant	0.306***	0.309***	0.387***	0.399***
	(0.00360)	(0.00375)	(0.00399)	(0.00419)
R^2	0.047	0.053	0.127	0.150

Dependent variable is the average value of loans to the private sector in ratio to total assets for each bank over the period from August 1999 to November 1999. Independent variable is the average value of Government bond holdings in ratio to total assets for each bank over the period from January 1997 to July 1999. Sample in column (1) is all banks. Sample in column (2) drops banks that were ever owned by the state. Sample in column (3) drops banks that were majority foreign owned at the time they entered the sample. Column (4) drops both state owned and foreign owned banks. Standard errors are robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table X: Government Bond Holdings in July 1999 and Credit Supply After EQ

(Gov Bond Holdings$_{J99}$)*(Earthquake)	-0.232***	-0.238***	-0.243***
	(0.0118)	(0.0125)	(0.0126)
(Gov Bond Holdings$_{J99}$)*(Asia)		-0.159***	-0.165***
		(0.0216)	(0.0217)
(Gov Bond Holdings$_{J99}$)*(Russia)			-0.119***
			(0.00311)
Observations	9880	9880	9880
R^2	0.683	0.683	0.683
BankFixedEffects	Yes	Yes	Yes
MonthFixedEffects	Yes	Yes	Yes

Dependent variable is loans to the private sector, in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Asia is a dummy that takes a value of one from July 1997 to October 1997. Russia is a dummy that takes a value of one from August 1998 to November 1998. Gov Bond Holdings is the T-Bill holdings of each bank in July 1999. Standard Errors are clustered at bank, month, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XI: Lagged Government Bond Holdings and Credit Supply After EQ

	(1)	(2)	(3)	(4)	(5)	(6)
Gov Bond Holdings$_{t-1}$	-0.336***	-0.336***	-0.336***	-0.0242***	-0.0182***	-0.0183***
	(0.0118)	(0.0116)	(0.0113)	(0.00151)	(0.00187)	(0.00160)
(Gov Bond Holdings$_{t-1}$)*(Earthquake)	-0.0681***	-0.0689***	-0.0698***	-0.0324***	-0.0331***	-0.0304***
	(0.0243)	(0.0246)	(0.0252)	(0.00884)	(0.00814)	(0.00576)
(Gov Bond Holdings$_{t-1}$)*(Asia)		-0.0590	-0.0608	0.0354	0.0336	0.0336
		(0.0412)	(0.0421)	(0.0287)	(0.0282)	(0.0313)
(Gov Bond Holdings$_{t-1}$)*(Russia)			-0.0333	-0.0102	-0.0108	-0.0108
			(0.0238)	(0.0204)	(0.0202)	(0.0194)
(Gov Bond Holdings$_{t-1}$)*(2001 Crisis)					-0.0421***	-0.0420***
					(0.00413)	(0.00591)
Observations	10119	10119	10119	10119	10119	10119
BankFixedEffects	Yes	Yes	Yes	Yes	Yes	Yes
MonthFixedEffects	Yes	Yes	Yes	Yes	Yes	Yes
BankQuarterFixedEffects	No	No	No	Yes	Yes	Yes

Dependent variable is loans to the private sector, in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Column (6) defines Earthquake as August 1999 to October 1999, for robustness. Asia is a dummy that takes a value of one from July 1997 to October 1997. Russia is a dummy that takes a value of one from August 1998 to November 1998. 2001 Crisis is a dummy that takes a value of one from December 2000 to December 2001. Standard Errors are clustered at bank, month, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XII: Determinants of Government Bond Holdings on Average and Over Time

	(1)	(2)	(3)
Capital Ratio$_{t-1}$	-0.0892***	-0.143***	-0.143***
	(0.0108)	(0.0126)	(0.0509)
Non-Performing Loans$_{t-1}$	-0.964***	-1.175***	-1.175**
	(0.129)	(0.136)	(0.558)
Bank Size$_{t-1}$	0.00491***	-0.0288***	-0.0288*
	(0.000997)	(0.00344)	(0.0168)
Cash Holdings$_{t-1}$	-0.839***	-2.398***	-2.398*
	(0.220)	(0.318)	(1.263)
Interbank Balances$_{t-1}$	-0.127***	-0.127***	-0.127***
	(0.00710)	(0.00934)	(0.0395)
Domestic Bank	-0.0269***		
	(0.00435)		
State Owned Bank	0.121***		
	(0.00754)		
Observations	10107	10107	10107
Bank Fixed Effects	No	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes
Double Cluster	No	No	Yes

Dependent variables is Government Bond holdings in ratio to total assets. Domestic bank is a dummy that takes a value of 1 if the bank was majority domestic owned at the start of the sample. State bank is a dummy that takes a value of one if the bank was ever state owned. Double clustered regressions are clustered at the bank and month levels. Otherwise, standard errors are robust. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XIII: Determinants of Government Bond Holdings During EQ

Capital Ratio_{t-1}	-0.148***	-0.0157
	(0.0494)	(0.0353)
Non-Performing Loans_{t-1}	-1.123**	-0.194
	(0.538)	(0.309)
Bank Size_{t-1}	-0.0284*	0.0178
	(0.0162)	(0.0150)
Cash Holdings_{t-1}	-2.608**	0.0300
	(1.214)	(0.270)
Interbank Balances_{t-1}	-0.127***	-0.0238
	(0.0369)	(0.0255)
(Capital Ratio_{t-1})*(Earthquake)	0.186**	0.0321
	(0.0828)	(0.0486)
(Non-Performing Loans_{t-1})*(Earthquake)	-0.732	0.191
	(0.613)	(0.204)
(Bank Size_{t-1})*(Earthquake)	-0.0106	-0.000984
	(0.00717)	(0.00273)
(Cash Holdings_{t-1})*(Earthquake)	3.802***	2.263***
	(0.918)	(0.730)
(Interbank Balances_{t-1})*(Earthquake)	-0.0616	-0.0142
	(0.0485)	(0.0402)
Observations	10107	10107
Bank Fixed Effects	Yes	Yes
Month Fixed Effects	Yes	Yes
Bank Quarter Fixed Effects	No	Yes

Dependent variables is Government Bond holdings in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard errors are clustered at the bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XIV: Government Bonds and Credit Supply: Survivors and Controls

	(1)	(2)	(3)	(4)
Gov Bond Holdings$_{t-1}$	-0.0178***	-0.0176***	-0.0178***	-0.0182***
	(0.00208)	(0.00216)	(0.00233)	(0.00318)
Capital Ratio$_{t-1}$		-0.0187***	-0.0188***	-0.0183***
		(0.00164)	(0.00216)	(0.00212)
Non-Performing Loans$_{t-1}$				-0.609***
				(0.188)
Cash Holdings$_{t-1}$			0.258***	0.252***
			(0.0753)	(0.0774)
(Gov Bond Holdings$_{t-1}$)*(Earthquake)	-0.0202**	-0.0207***	-0.0202***	-0.0189***
	(0.00802)	(0.00736)	(0.00718)	(0.00526)
(Capital Ratio$_{t-1}$)*(Earthquake)		0.00774	0.00794	0.00754
		(0.0100)	(0.00856)	(0.00884)
(Non-Performing Loans$_{t-1}$)*(Earthquake)				0.0798
				(0.309)
(Cash Holdings$_{t-1}$)*(Earthquake)			0.123	0.0983*
			(0.101)	(0.0585)
Observations	8590	8586	8578	8578
Bank Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Bank Quarter Fixed Effects	Yes	Yes	Yes	Yes

Dependent variable is loans to the private sector, in ratio to total assets. Sample consists of all banks, except those that have ever been taken over by the central bank. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank, time, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XV: Government Bonds and Credit Supply: Placebo Earthquake and Short Sample

	(1) Placebo	(2) Short Sample
Gov Bond Holdings$_{t-1}$	-0.0185***	-0.215***
	(0.00179)	(0.00982)
(Gov Bond Holdings$_{t-1}$)*(Earthquake)		-0.0592***
		(0.0124)
(Gov Bond Holdings$_{t-1}$)*(Placebo)	-0.00878	
	(0.00543)	
Observations	10119	5069
Bank Fixed Effects	Yes	Yes
Month Fixed Effects	Yes	Yes
Bank Quarter Fixed Effects	Yes	No

Dependent variable is loans to the private sector, in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Placebo is a dummy that takes a value of one from April 1999 to July 1999. Short sample is from 1997-2002. Standard Errors are clustered at bank, month, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XVI: IV Regression First Stage: Gov Bond Holdings*Spread

(Gov Bond Holdings$_{t-1}$)*(Earthquake)	75.61***	29.11***
	(5.723)	(8.715)
Observations	10119	10101
R^2	0.567	0.954
BankFixedEffects	Yes	Yes
MonthFixedEffects	Yes	Yes
BankQuarterFixedEffects	No	Yes

Dependent variable is holdings of Gov Bonds (in ratio to total assets) interacted with the spread over the US of the Gov Bond interest rate. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank and month levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table XVII: IV Regression Second Stage: Spreads and Loans

(Gov Bond Holdings$_{t-1}$)*(Spread$_t$)	-0.00453***	-0.000892**
	(0.000966)	(0.000374)
Observations	10119	10119
R^2	0.707	0.986
BankFixedEffects	Yes	Yes
MonthFixedEffects	Yes	Yes
BankQuarterFixedEffects	No	Yes

Dependent variable is loans to the private sector, in ratio to total assets. Earthquake is a dummy that takes a value of one from August 1999 to November 1999. Standard Errors are clustered at bank, month, and state-bank levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A 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:

$$\overline{D}_{it+1} = \overline{D}_{it} + \bar{\delta} + \delta_i \tag{6}$$

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:

$$\text{marginal return on loans in } t+1 = r - \alpha_L L_{it} + \bar{\eta} + \eta_{ij} \tag{7}$$

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:

$$\alpha_B B_{it} = r - \alpha_L L_{it} \tag{8}$$

$$\alpha_B B_{it+1} = r - \alpha_L L_{it+1} + \bar{\eta} + \eta_j \tag{9}$$

$$\bar{D}_{it} + B_{it} \equiv L_{it} \tag{10}$$

$$\bar{D}_{it+1} + B_{it+1} \equiv L_{it+1} \tag{11}$$

$$\overline{D}_{it+1} = \overline{D}_{it} + \bar{\delta} + \delta_i \tag{12}$$

For the two period, subtracting the FOCs 8 and 9 we obtain:

$$-\alpha_B \Delta B_i = \alpha_L \Delta L_i - \bar{\eta} - \eta_{ij} \tag{13}$$

And we replace with the identities 10 and 11:

$$-\alpha_B \left(\Delta L_i - \Delta D_i\right) = \alpha_L \Delta L_i - \bar{\eta} - \eta_{ij} \tag{14}$$

Using 12 and rearraging terms, we obtain:

$$\Delta L_i = \frac{\alpha_B}{\alpha_B + \alpha_L}\left(\bar{\delta} + \delta_i\right) + \frac{1}{\alpha_B + \alpha_L}\left(\bar{\eta} + \eta_{ij}\right) \tag{15}$$

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

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

Or alternatively:

$$\Delta L_i = \frac{1}{\alpha_L + \alpha_B}\bar{\eta} + \frac{\alpha_B}{\alpha_L + \alpha_B}\Delta D_i + \frac{1}{\alpha_L + \alpha_B}\eta_{ij} \tag{17}$$

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

$$L_{it} = \frac{1}{\alpha_L + \alpha_B}\bar{\eta} + \frac{\alpha_B}{\alpha_L + \alpha_B}D_{it} + \frac{1}{\alpha_L + \alpha_B}\eta_{ijt} + \frac{1}{\alpha_L + \alpha_B}\alpha_i \tag{18}$$

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.

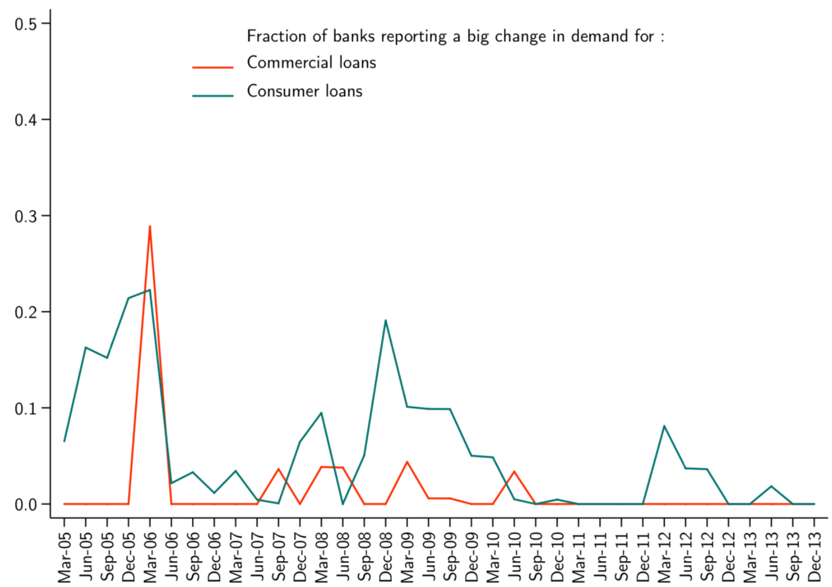

Figure 16: Fraction of Banks Reporting a 25 Percent Change in Credit Demand