

Sovereign Default Risk and Bank Balance Sheets*

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*****PRELIMINARY and INCOMPLETE*****

Abstract

The banks and their balance sheets have been in the epicenter of the recent European sovereign debt crisis. This paper studies sovereign risk by explicitly modeling its connection to bank capital and balance sheets. Higher sovereign risk worsens bank balance sheets by squeezing their profits and thereby tightening their capital requirements. In turn, banks' lending to firms fall and output declines since firms require working capital to produce. Lower output increases sovereign risk further, creating a negative feedback loop.

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1 Introduction

In light of the recent developments in Europe, once again, sovereign debt and default climbed to the top of the global economic agenda. The discussions of the repercussions of high levels of sovereign debt centered on bank balance sheets not only within the territories of the highly indebted sovereigns but also those outside those territories that hold the debts of these sovereigns.

This paper provides a framework to understand the interlinkages between sovereign risk and bank balance sheets. In order to do so, we model endogenous sovereign default where heightened sovereign risk and a potential default lead banks to post losses and to a deterioration in bank balance sheets. The credit creation of these banks is hampered, i.e. there is a credit crunch, with reduced capital since banks need to satisfy capital requirements. Firms that need working capital to produce, have to cut back in production with smaller loans available from the banks. This leads to output declines and, in turn, increasing sovereign default risk. This feedback mechanism is the main focus of this paper.

Our paper connects two strands of literature. The first is the sovereign debt literature in international finance that focuses mostly on building models with endogenous sovereign default with the aim of accounting for emerging markets business cycle characteristics. In this literature, the studies that relate closely to ours include Arellano (2008), and Mendoza and Yue (2008). Mendoza and Yue (2008) is particularly related to our framework in that these authors' goal is to build a model that can generate an endogenous output declines in response to an increase in sovereign risk which, in turn, further increases the sovereign risk.

The second strand of literature is on the role of bank capital on macroeconomic fluctuations. In this vein, Van den Heuvel (2002) and Van den Heuvel (2008) are the most related since both of these studies assume a regulatory bank capital requirement and analyze its macroeconomic implications as well as its welfare costs. Mendoza and Quadrini (2009) also build a framework with capital requirements to study the role of financial integration.

Finally, our paper relates to Neumeyer and Perri (2005), who study the role of working capital requirements in conjunction with interest rate fluctuations to account for output declines. In Neumeyer and Perri's setup the transmission from an adverse shock to lower output involves *higher prices*, i.e. interest rates, for working capital loans. In our setup, we emphasize *lower quantity*, i.e., smaller loans available to firms because the capital requirements of the banks bind.

In a recent work Bolton and Jeanne (2010) study sovereign risk in connection with the recent

waive of sovereign debt crises in Europe. They emphasize cross border spillovers of sovereign risk in an environment with financial integration. Similar to us, they also think about banks in connection with sovereign default risk.

2 Empirical Evidence

The stress test on the European banking system conducted in Summer 2010 was able to account for about 30 percent of the existing sovereign debt stock of all European Union sovereigns.¹ The results of this test suggest that, on average, slightly more of the sovereign debt was being held by foreign banks (foreign banks narrowly defined as other sovereigns' banks participating in the stress test) than domestic banks. The ratio of foreign bank holdings to domestic bank holdings varies significantly across countries. For Germany and Spain, the majority is domestically held (72 and 77 percent of total debt accounted in the exercise, respectively) while the opposite is true for Irish debt with only 18 percent held by domestic banks. The distributions of Greek, Italian and Portuguese debt are more or less even between domestic and foreign banks. This observation motivates our modeling strategy to consider a domestic as well as a foreign banks/lenders that hold the sovereign's debt. In the Irish case, it would have been a sensible approach to only model a foreign bank. However, as mentioned above, this would not necessarily generalize to other European countries being frequently discussed in the popular press in the context of their sovereign debt problems.

The stress test focused largely on the capital adequacy of the banks under investigation. In addition to a benchmark scenario, it analyzed an adverse scenario that incorporated a sovereign debt shock. (See CEBS (2010).) This suggests that sovereign risk constituted an important factor in determining the healthiness of the banking system.

Basel II, implemented in many countries around the world including the Eurozone, levies a framework in which the riskiness of bank assets are determined not only by the institutional nature of its borrowers but also by the riskiness of each borrower. For example, the capital requirement when a bank holds sovereign debt in its balance sheet varies depending on the credit rating of the sovereign. This is formalized in Basel II using a risk weighting scheme for bank assets in which sovereign debt holdings have zero weight if it is rated above a certain rating. As the sovereign debts of a few countries were being downgraded after the sovereign debt crises were set in motion, the risk weight went up from zero to 100 percent for Greek debt, as it was gradually downgraded by credit

¹The remaining unaccounted portion must be held by European banks that did not participate in the test, banks outside the European Union, non-bank institutions or individuals inside or outside of Europe.

rating agencies. These developments and the existing regulatory framework motivate our modelling strategy of emphasizing bank capital requirements to link sovereign risk to the macroeconomy.

Empirical evidence for the case of the U.S. establishes that poorly capitalized banks in the face of adverse shocks cut their lending more compared to well-capitalized banks (Kishan and Opiela (2000), Kishan and Opiela (2006)). In addition, the same line of literature also finds that the lending rates for poorly capitalized banks are higher even after controlling information costs and borrower characteristics (Hubbard et al. (2002)). Both of these findings suggest that the poorer the bank capitalization, the larger the output declines due to less and more expensive lending by the banks.

3 Model

The model incorporates representative households, firms, domestic banks, a sovereign and foreign banks/lenders. The interest rate on sovereign borrowing is determined endogenously depending on the default probability of the sovereign that lacks a commitment technology and defaults when it finds it optimal to do so.

3.1 Households

Households provide an elastic supply of labor to the firms. They are assumed to own the firms as well as the domestic banks. The households' debt and default decisions are made by the benevolent sovereign. They choose consumption and labor supply to maximize expected present discounted value of utility:

$$\max_{c_t, l_t} E[\beta^t u(c_t, l_t)]$$

subject to the following household budget constraint:

$$c_t = w_t l_t + \pi_t^b + \pi_t^f + T_t,$$

where w_t denotes wages, π_t^b and π_t^f denote the profits of the domestic banks and firms, respectively. Finally, T_t stands for lump sum transfers from the government as will be explained further below. The presence of π_t^b in the household budget constraint and the assumption that the sovereign is benevolent maximizing households' utility imply that the sovereign takes into account the domestic banks' profitability when it makes debt and default decisions.

3.2 Firms

Firms maximize their profits by choosing their demand for labor in a perfectly competitive environment. They also face a working capital requirement in the form of a constraint that requires them to pay in advance part of their wage bill similar to the one utilized by Neumeyer and Perri (2005). To make this advance payment, they borrow from the domestic banks at the time invariant risk free interest rate.² The profits of the firms are defined as:

$$\pi_t^f = y_t - w_t l_t - L_t r_t$$

where L_t is the size of the working capital loan. This optimization problem can be shown to be equivalent to a more general intertemporal optimization using the households' marginal utilities to discount the future as shown by Uribe and Yue (2006). The working capital constraint implies an "effective wage rate" that is higher than w_t by a magnitude that depends on the level of the interest rate. Denoting θ as the share of the wage bill firms are required to pay in advance, the working capital requirement implies that:

$$L_t^d = \theta w_t l_t.$$

In other words, the firms demand a loan that is just enough to satisfy the working capital, i.e. firms have no incentives to borrow beyond the working capital requirement.

The production technology uses labor as the only input and is in standard Cobb-Douglas form:

$$y_t = e^{z_t} l^\alpha$$

where z_t captures the stochastic shocks to TFP and follows an AR(1) process.

3.3 Domestic Banks

Domestic banks are subject to a capital requirement that limits the loans granted to firms and sovereign debt holdings. This capital requirement is *regulatory* and we do not provide micro foundations as to why/when such a capital requirement would be optimal. This requirement is in the form of:

$$L_t + q_t b_t \leq \kappa k_t$$

²See domestic banks' problem below for a discussion of this assumption.

where L_t is the working capital loans provided to firms, k_t stands for the capital of the banks and $\kappa > 1$ controls the tightness of the capital requirement.³ Note here the implicit assumption that risk weights of loans to firms and the sovereign are equal and set to 100 percent.

In an extension, we consider time varying capital requirements. Put differently, as in Basel II, the tightness of the capital requirement is specified to be a function of sovereign risk. We conjecture that this kind of a structure would further strengthen the downward amplification generated by the model because as sovereign risk increases, not only that the market value of banks assets decline but also the amount of capital required for a given level of assets would go up due to a tighter capital requirement.

Banks' capital evolves according to:

$$k_{t+1} = (1 - \delta)k_t + \pi_t^b.$$

The banks are assumed to pay out zero dividends and retain all of their earnings to accumulate capital.⁴ Banks' capital depreciates at a rate of δ . In real world, bank capital is financial and therefore would not wear and tear unlike firm capital which is physical. We assume a non-zero depreciation rate in our model to prevent the banks from accumulating an infinite amount of capital given the calibrated probability of negative profits needs to be low to be consistent with the data. $\delta \neq 0$ is necessary because on average banks make positive profits. To see this, remember that the returns on loans to firms are positive and also given the pricing of sovereign debt, as will be explained below, the returns from sovereign debt holdings will also be on average equal to the risk free rate. Another modelling strategy to avoid nonstationary bank capital dynamics could be to assume that with a constant probability banks exit a la Gertler and Kiyotaki (2010).

Banks' profits are defined as:

$$\pi_t^b = L_t r - q_t b_{t+1} + b_t$$

and they consist of returns from loans made to the firms and returns from purchases of government bonds. Remember that loans to firms are risk free since we do not model a default risk on the side of the firms. This assumption reverses the usual perception that banks typically solve an optimization problem to allocate its assets into risk free sovereign bonds and risky loans to firms. In our framework, as a first pass, we study the quantitative power of the declines in the loan size to

³In Basel II the capital requirement is 8 percent for Tier II capital which would translate into a κ of $100/8=12.5$.

⁴This assumption is innocuous during downturns when banks make losses. If profits are negative, banks set dividends to zero due to limited liability on the side of the shareholders.

firms during downturns and shut down any movements in the interest rate. In our extensions, we look at cases in which 1) firm default occurs at the same time with sovereign default a la Mendoza and Yue (2008); 2) firm default is triggered by an exogenous shock that is correlated with the TFP shocks therefore implying a positive but less than one correlation between firm default and sovereign default.

When the sovereign defaults, banks write off sovereign debt by setting $b_t = 0$ and therefore potentially making losses (or lower profits compared to non-default scenario). These losses impact consumption instantaneously through the households' budget constraint who are assumed to own the banks and output with a one period lag since the banks' capital in the following period declines reducing the size of the loans to firms.

The balance sheet identity of the banks is:

$$L_t + b_{t+1} = d + k_t.$$

The left hand side of the equation includes the assets and the right hand side has the liabilities of the banks. On the liability side, deposits are assumed to be exogenous and constant.⁵

Note that with this formulation of the banks' problem, banks do not solve an optimization problem. Every period they start off with a pre-determined liability side of their balance sheet (capital is a state variable and deposits are constant) and on the asset side the allocation into loans and sovereign debt is dictated by a regulatory liquid asset requirement in periods when the sovereign is not in default:

$$b_t = \gamma(b_t + L_t^s).$$

The above equation pins down the loan supply. Note that it is inelastic since the interest rate that the banks charge to the firms has no impact on the supply of the loan. In fact, as a first pass, we assume that this interest rate is equal to the risk free rate. Therefore, the price in this case will not equilibrate loan supply and demand. The size of the loan in equilibrium then is $L_t = \min(L_t^s, L_t^d)$.

3.4 Sovereign

The sovereign makes debt and default decisions in order to maximize the households' objective function if it has access to capital markets. During exclusion from the capital markets, it has no

⁵Deposits would be interesting to look at in a framework with bank runs but is beyond the scope of this paper.

decision to make. Note that since part of the sovereign debt is held by domestic banks which in turn are owned by households, the sovereign will internalize the adverse effects of a default decision on the domestic economy. The ratio of domestic banks to foreign lenders' holding of sovereign debt is entirely determined by the domestic banks' capital. The level of banks' capital determine the size of the asset side of the banks' balance sheet. The liquidity requirement dictates the amount of sovereign debt held domestically. The residual is assumed to be held by foreign banks/lenders.

An interesting extension to study is a bank bailout. In times when banks post negative profits, the sovereign can bail them out, increasing further the sovereign risk and worsening the bank balance sheet. This would generate yet another negative feedback loop.

3.5 Foreign Banks/Lenders

Foreign banks/lenders are risk neutral and are assumed to hold the residual sovereign debt, i.e. those not purchased by domestic banks.

4 Quantitative Analysis

4.1 Equilibrium

5 Conclusion

This paper provided a framework to understand the connections between sovereign risk, bank capital and the macroeconomy. This framework can be utilized to study the normative implications of the new proposals to redesign the existing regulatory framework for banks (Basel III). Some of these proposals include capital requirements that are more relaxed during downturns whose welfare implications can be studied in the laboratory environment provided in this paper.

References

- [1] Arellano, Cristina, 2008, "Default Risk, the Real Exchange Rate and Income Fluctuations in Emerging Economies," *American Economic Review*, vol. 98, pp. 690-712.
- [2] Bolton, Patrick and Olivier Jeanne, 2010, "Sovereign Default Risk in Financially Integrated Economies," paper presented at the IMF Annual Research Conference.
- [3] Boz, Emine, 2011, "Sovereign Default, Private Sector Creditors and the IFIs," *Journal of International Economics*, vol. 83/1, pp. 70-82.
- [4] Committee of European Banking Supervisors, 2010, "Aggregate outcome of the 2010 EU wide stress test exercise coordinated by CEBS in cooperation with the ECB" available at: stress-test.c-ebs.org/documents/Summaryreport.pdf
- [5] Gertler, Mark and Nobuhiro Kiyotaki, 2010, "Financial Intermediation and Credit Policy in Business Cycle Analysis," prepared for the *Handbook of Monetary Economics*.
- [6] Hubbard, G, K Kuttner and D Palia, 2002, "Are There Bank Effects in Borrowers' Cost of Funds? Evidence From a Matched Sample of Borrowers and Banks," *Journal of Business*, vol. 74, pp. 559-81.
- [7] Kishan, R, and T Opiela, 2000, "Bank Size, Bank Capital, and the Bank Lending Channel," *Journal of Money, Credit and Banking*, vol. 32, pp. 121-41.
- [8] Kishan, R, and T Opiela, 2006, "Bank Size and Loan Asymmetry in the Transmission of Monetary Policy," *Journal of Banking and Finance*, vol. 30, pp. 259-85.
- [9] Mendoza, Enrique, and Vincenzo Quadrini, 2009, "Financial Globalization, Financial Crises and Contagion," *Journal of Monetary Economics*, vol. 57, pp. 24-39.
- [10] Mendoza, Enrique, and Vivian Yue, 2008, "A Solution to the Default Risk-Business Cycle Disconnect," NBER Working Paper No. 13861.
- [11] Neumeyer, Pablo and Fabrizio Perri (2005), "Business Cycles in Emerging Economies: the Role of Interest Rates," *Journal of Monetary Economics*, Vol. 52, pp. 345-380.
- [12] Uribe, Martin and Vivian Yue, 2006, "Country Spreads and Emerging Countries: Who Drives Whom?," *Journal of International Economics*, vol. 69, pp. 6-36.

- [13] Van den Heuvel, Skander J., 2002, “The Bank Capital Channel of Monetary Policy,” The Wharton School, University of Pennsylvania, mimeo.
- [14] Van den Heuvel, Skander J., 2008, “The Welfare Cost of Bank Capital Requirements,” *Journal of Monetary Economics*, vol. 55, pp. 298-320.