

Bailout Guarantees, Banking Crises and Sovereign Debt Crises

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Preliminary and Incomplete

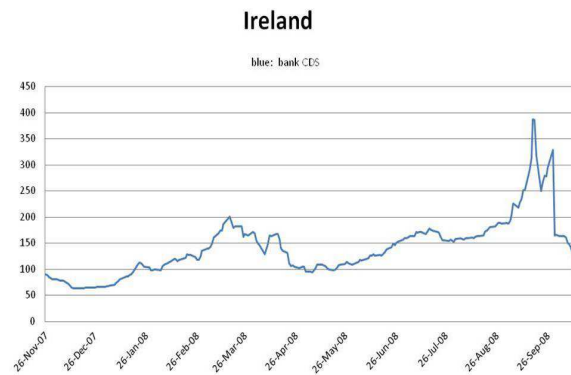
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Abstract

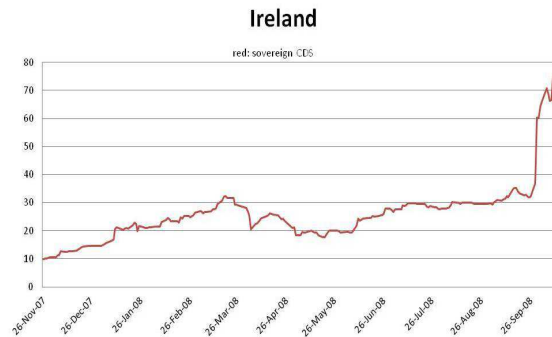
This paper studies the link between banking crises, sovereign default and government guarantees. A banking crisis can lead to a domestic credit crunch, which can be mitigated by government guarantees. However, the provision of bailout guarantees exposes the government to potentially severe losses from a banking sector failure and a sharp rise in public debt, causing sovereign default risk, and thus sovereign spreads, to increase substantially. As a result, the value of government guarantees deteriorates, deepening the crisis in the financial sector. The recent bailout in Ireland clearly illustrates the relevance of such risk transmission mechanism. An additional important contribution of our paper is to determine under which circumstances it is desirable for the government to provide bailout guarantees to the financial sector of the economy. A calibrated version of our model can mimic some of the interaction dynamics between financial sector risks and sovereign risks observed in Ireland during the crisis.

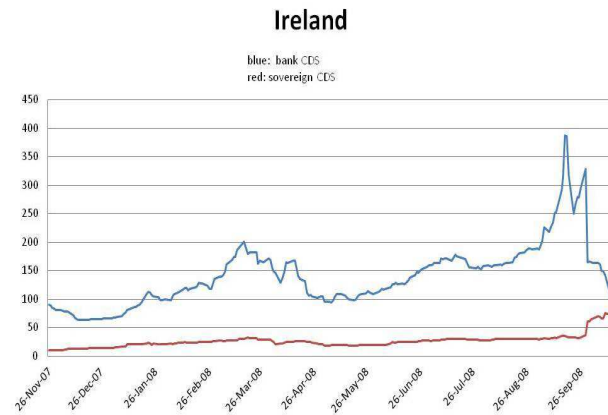
1 Introduction

The credit default swaps (CDS) on Irish banks fell almost 300 basis points from 400 basis points to 100 basis points. Good news.

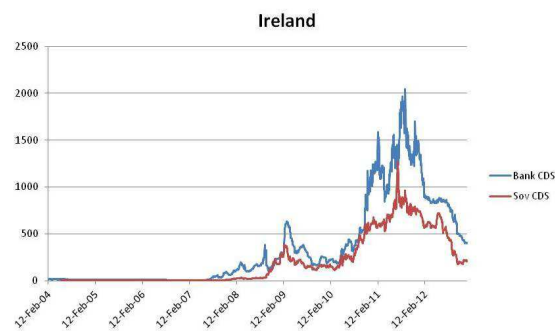


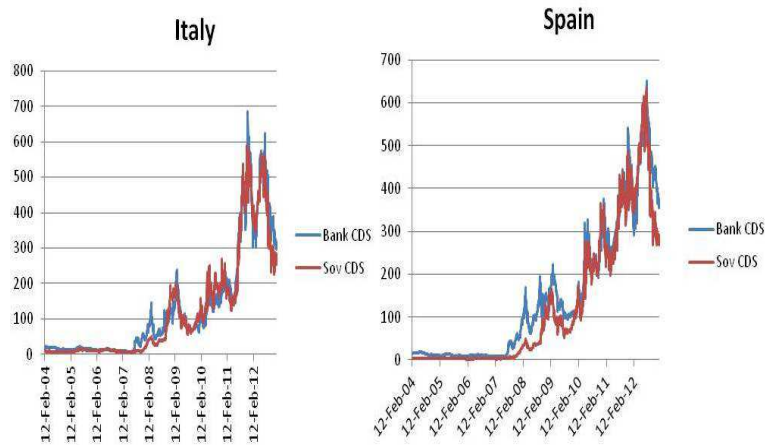
However, sovereign default risk for Ireland immediately more than doubled to more than 70 basis points! Risk transfer from banks to sovereign





and then both the sovereign and bank CDS exhibited close positive comovement, increasing significantly during the next 3 years.





Measures of government support (Moody's).

- Financial Strength Rating (Stand alone rating): franchise value, risk positioning, regulatory environment, operating environment, financial fundamentals, etc.
- Probability of government support (Deposit rating): government ownership, market share, systemic importance of the banking system, previous government bailouts, deposit guarantees, etc.

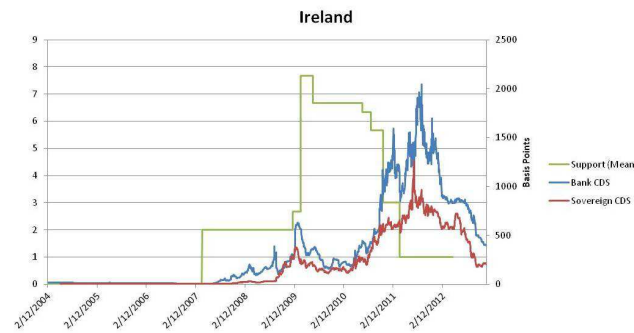
Support in rating notches Deposit Rating – Stand alone rating

Measures of government support - Rating notches: An Example. Median ratings of largest banks as of August 2011:

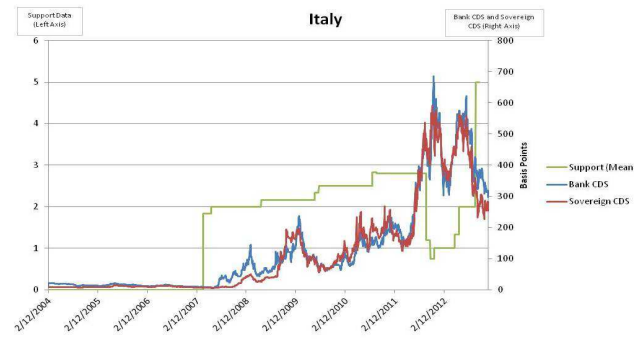
	<i>Bank financial strength</i>	<i>Deposits rating</i>	<i>Government support</i>
Greece	Caa1	B3	1
Ireland	Ba3	Ba2	1
Portugal	Ba2	Ba1	1
Spain	Baa1	A2	2

From rating agencies to probabilities of support: Following Gropp, Hakenes, and Schnabel (RFS, 2011), we compute **Probability of support** = $1 - (\text{Prob. default deposit rating} / \text{Prob. default stand-alone rating})$

Government support and credit risk-Ireland



Government support and credit risk-Italy



Government support and credit risk-Spain



This paper develops a model to study the link between banking crises, sovereign default and government guarantees. A banking crisis can generate a credit crunch in the economy, which can be alleviated by government guarantees. However, the provision of bailout guarantees exposes the government to potentially severe losses from a banking sector failure, causing sovereign spreads to increase substantially, as the recent bailout in Ireland illustrates. As a result, the value of government guarantees deteriorates, aggravating the crisis in the financial sector. A key theoretical point of this paper is to determine under which circumstances it is desirable for the government to provide bailout guarantees to the financial sector of the economy.

Our model extends the Eaton-Gersovitz (1981) framework to study how the possibility of a banking crisis interacts with sovereign default risk. Due to the possibility of default, banks are charged a default premium on their loans, causing an under provision of credit. The introduction of government guarantees to bank's bondholders contributes to reverse the under-provision of credit, as default penalties to the banking sector can be significantly reduced. While this contributes to increase the solvency of the banking sector, the guarantees introduce higher risk in the government balance sheets. Moreover, having bailouts at the government disposal worsens the time inconsistency issues that arise with debt dilution, as the government may want to bailout the banks to increase the expected value of resources, even if this entails more risk, since old bondholders would suffer the consequences of bad shocks, i.e. new bondholders can price this risk but old bondholders cannot. As a result, an increase in bank's riskiness can trigger a joint government and banking crisis, caus-

ing banks and government spreads to correlate more strongly. A default from the government reduces the value of government guarantees, feeding back to the banking sector and the real economy.

Our paper borrows from several strands of literature. It relates to studies that analyze bank bailouts, to the literature on quantitative sovereign default, and to papers investigating the effects of bank bailouts on sovereigns. The theoretical literature on bank bailouts has largely focused on the efficient structuring of bank bailouts in the presence of agency problems (see Acharya, Shin and Yorulmazer, 2008, Philippon and Schnabl, 2009, Diamond and Rajan, 2009, Acharya, Drechsler and Schnabl, 2011, among others). Instead, our work tries to determine under which circumstances it is desirable for a government to provide bailout guarantees taking into account the costs and benefits of bank bailouts. While many banking studies explore the ex-ante moral hazard cost of bank bailouts (see Mailath and Mester, 1994, Acharya and Yorulmazer, 2007 among others), and others (see Yorulmazer (2007, 2008), Philippon and Schnabl (2009), Acharya, Drechsler and Schnabl, 2011, among others) consider ex-post costs of bailouts, their approach differs from ours. Reinhart and Rogoff (2009a, b) and Reinhart and Reinhart (2010) document empirically that economic activity remains largely subdued after a financial crisis and private debt shrinks significantly while sovereign debt rises. These effects are consistent with our model of how financial sector bailouts interact with sovereign credit risk and output. Our framework also borrows from the theoretical literature on strategic sovereign defaults. Eaton and Gersovitz (1981) and Bulow and Rogoff (1989) initiated a body of work focused on ex-post costs to sovereigns of defaulting on external debt, e.g., due to reputational hit in future borrowing (see for instance Arellano, 2007, and Aguiar and Gopinath, 2006) or to the imposition of international trade sanctions (see for instance Rose, 2005). Broner and Ventura (2005) and Gennaioli, Martin and Rossi (2010), among others, consider a collateral damage to the financial institutions and bond markets when a sovereign defaults, which gives the government an incentive to pay its creditors. Our model considers both an ex-post output cost of sovereign default and a direct cost to the financial sector through bank holdings of government bonds, in a quantitative framework of strategic equilibrium default.

Finally, our work is related to a strand of literature focusing the distortionary effects of bank bailouts. For instance, King (2009) and Panetta et al. (2009) study the Euro zone bailouts, pointing out that bank creditors were backstopped reflecting a waiting game on part of bank regulators and governments. Laeven and Valencia (2010) put together a time-series of banking crises and find that the median output loss of recent banking crises accounted for about 25 percent of GDP. Finally, Acharya, Drechsler and Schnabl (2011), and Ejsing and Lemke (2011) focus on sovereign asset pricing implications, looking at the effect of bank bailouts on sovereign credit risk measured with sovereign CDS spreads.

In our framework, the sovereign government trades non contingent debt with foreign lenders and rebates back to households all the proceedings from its international credit operations in a lump sum fashion T_t . The face value of these bonds specifies the amount to be repaid in the future. The sovereign cannot commit to repay its debt. As in the Eaton-Gersovitz (1981) model, when the country defaults, it does not repay at date t and the punishment is exclusion from world credit markets in the same period. The country re-enters the credit market with an exogenous probability ψ , and when it does, it starts with a fresh record and zero debt. We extend the Eaton-Gersovitz setup by modeling an explicit link between default risk and private financing costs. Default also triggers a loss λ of the households' labor income plus their profits. The government can also promise debt guarantees to the banking sector so that if a bank becomes insolvent, the government repays to the investors that hold the bank's bonds. The government guarantees a fraction η of bank's debt. The benefit from these government guarantees are that this reduces future borrowing costs from the banking sector, which is translated into lower rates for working capital loans and higher output. There is a risk, however, as a negative risk shock π to the banking sector overburdens the government with a large private debt, increasing the default risk of the government and sovereign spreads. Additionally, in order to provide these guarantees, the government collects a labor tax τ , which distorts households' labor choice in the economy. The higher the amount of government debt, the lower the bailout guarantees will be. The government is benevolent and has to decide whether to default on its own debt and on the bailout guarantees. These two decisions are

such that the government might default in its own debt but might still guarantee the shorter term debt of the banks, or viceversa.

The paper proceeds as follows: Section 1 is this introduction; Section 2 develops the model; section 3 presents the numerical results of the paper; and section 4 concludes.

2 THE MODEL

In the model we study an small open economy whose government and domestic banks have access to international credit markets. Both, the government of the economy and the domestic banks might default in their debts with foreign lenders. This economy is populated by risk averse households that own competitive firms which undertake production subject to an aggregate productivity shock, z . The role of domestic banks in the economy is to intermediate loans to the firms in the economy. In each period each of these banks has some probability p_π of going bankrupt and the probability of going bankrupt for these banks depends on an aggregate solvency shock, π . To help smooth the functioning of the domestic financial system, the government of this economy provides guarantees to domestic banks, η .

2.1 Households

The economy is populated by identical risk averse households that maximize a standard time-separable utility function

$$E \left[\sum_{t=0}^{\infty} \beta^t u(c_t - g(N_t)) \right] \quad (1)$$

where $0 < \beta < 1$ is the discount factor and c_t is the households' consumption and N_t is the households' labor supply at time t . $u(\cdot)$ is the period utility function, which is continuous, strictly increasing, strictly concave, and satisfies the Inada conditions. $g(N_t)$ corresponds to the disutility from labor, where $g(\cdot)$ is increasing, continuously differentiable and convex. Households receive the wage rate w_t that they take as

given, profits paid by firms, and banks (Π_t^F, Π_t^B) , and government transfers T_t , and pay labor taxes τ_t . Households do not borrow directly from abroad, but the government borrows, pays transfers, and makes default decisions internalizing their utility function.

Consequently the households' optimization problem reduces to the following static problem:

$$\max_{c_t, N_t} E \left[\sum_{t=0}^{\infty} \beta^t u(c_t - g(N_t)) \right], \quad (2)$$

$$\text{s.t.} \quad c_t = (1 - \tau_t)w_t N_t + \Pi_t^F + \Pi_t^B + T_t \quad (3)$$

The optimality condition for labor supply is:

$$g'(N_t) = (1 - \tau_t)w_t \quad (4)$$

For purposes of the quantitative analysis, we define the labor disutility function in isoelastic form $g(N) = \frac{N^\omega}{\omega}$ with $\omega > 1$, so the Frisch elasticity of labor supply will be given by $\frac{1}{\omega-1}$. The period utility function takes the standard constant-relative-risk-aversion form $u(c, N) = \frac{(c - \frac{N^\omega}{\omega})^{1-\sigma}}{1-\sigma}$ with $\sigma > 1$.

2.2 Firms

Firms use labor N_t , time-invariant capital stock k , and imported intermediate inputs M_t^* to produce a tradeable final good y_t . They face Markov TFP shocks z_t , with the transition probability distribution function $\mu(z_t | z_{t-1})$. The production function is Cobb-Douglas:

$$y_t = z_t M_t^{*\alpha^M} N_t^{\alpha^N} k^{\alpha^k} \quad (5)$$

with $0 < \alpha^N, \alpha^M, \alpha^k < 1$ and $\alpha^N + \alpha^M + \alpha^k = 1$.

Imported inputs M_t^* are sold in world markets at exogenous time-invariant prices p^* defined in terms of the price of final goods. A fraction κ of the cost of imported intermediate goods $p^* M_t^*$ needs to be paid in advance using working capital loans

l_t^F . These are intra-period loans that are repaid at the end of the period are offered by domestic banks at the interest rate r_t^F . At equilibrium this interest rate is linked to the interest rate that banks obtain in the international credit markets, r_t^B . Given these features the firms problem can be expressed as:

$$\max_{N_t, M_t^*, l_t^F} \quad \Pi_t^F = y_t - w_t N_t - p^* M_t^* + l_t^F - (1 + r_t^F) l_t^F \quad (6)$$

$$\text{s.t.} \quad \kappa p^* M_t^* \leq l_t^F \quad (7)$$

The working capital constraint is captured by equation (7). This equation will always hold with equality. Taking this in account and plugging the constraint into the objective function we obtain:

$$\max_{N_t, M_t^*} \quad \Pi_t^F = y_t - w_t N_t - p^* M_t^* (1 + \kappa r_t^F) \quad (8)$$

The optimizing problem of the firms can be expressed using a static payoff so that these producers maximize date-t profits taking w_t , p^* and r_t^F as given.

The first order conditions of the firms optimization problem are:

$$\frac{\partial \Pi_t^F}{\partial N_t} = \alpha^N z_t M_t^{*\alpha^M} N_t^{(\alpha^N-1)} k^{\alpha^k} - w_t = 0 \quad (9)$$

$$\frac{\partial \Pi_t^F}{\partial M_t^*} = \alpha^M z_t M_t^{*(\alpha^M-1)} N_t^{\alpha^N} k^{\alpha^k} - p^*(1 + \kappa r_t^F) = 0 \quad (10)$$

Exploiting the static nature of the firm's problem and combining equation (4) with equations (9) and (10) it is possible to solve for the level of labor N_t and the level of imported inputs M_t^* that the firms will demand.

With this information we can solve for the production level y_t , the profits of the

firms Π_t^F , and the demand for loans l_t^F :

$$y_t = \left\{ \frac{[(1 - \tau_t)\alpha^N]^{\alpha^N} [z_t k^{\alpha^k}]^{\omega}}{\left[\frac{p^*(1 + \kappa r_t^F)}{\alpha^M} \right]^{\omega \alpha^M}} \right\}^{\frac{1}{\omega - \alpha^N - \omega \alpha^M}} \quad (11)$$

$$\Pi_t^F = \alpha^k y_t \quad (12)$$

$$l_t^F = \frac{\kappa \alpha^M}{1 + \kappa r_t^F} y_t. \quad (13)$$

According to equation (13) there is a negative relationship between r_t^F and l_t^F . The effects of κ are ambiguous due to quantity and price effects that go in opposite direction. Another thing to notice is that a positive TFP shock increases the demand for loans. A key distinction between this model and Mendoza and Yue (2011), is that in their model, the interest rate on working capital is assumed to be the same as the sovereign interest rate. In our model, the government and the banks' default decisions are independent, therefore $r_t^F \neq r_t^S$. Nevertheless in this model these two interest rates might be endogenously correlated in equilibrium.

2.3 Banks

There is a measure one of ex-ante banks that make intra-period working capital loans l^F to firms at rate r^F . Banks finance these loans by issuing intra-period bonds l^B in international financial markets at rate r^B . During the morning, banks make loans. During the night, banks are hit with an idiosyncratic bankruptcy shock. If $\epsilon = 0$, banks survive, they collect loan payments and repay lenders. If $\epsilon = 1$, banks fail, they do not collect their loans, face bankruptcy costs, and do not pay their lenders. At night, the banking sector is subject to an aggregate solvency shock $\pi \sim iid(\bar{\pi}, \sigma_\pi)$: A fraction π of the banks get $\epsilon = 1$, and a fraction $1 - \pi$ of banks get $\epsilon = 0$. The law of large numbers is assumed to hold, so that exactly π of banks go bankrupt.

Banks returns are given by:

$$\Pi^B(l^F, l^B) = \begin{cases} l^F r^F - l^B r^B - a(l^F) & \text{if } \epsilon = 0 \\ -a(l^F) & \text{if } \epsilon = 1 \end{cases}$$

where $a(l^F)$ is a strictly convex function which represents the cost of producing loans (monitoring costs, etc). Banks are protected by limited liability so that in case of insolvency, banks profits are given by $-a(l^F)$.

The problem of the Banks is to choose l^F, l^B to solve:

$$\begin{aligned} \max_{l^F, l^B} \mathbb{E} \Pi^B(l^F, l^B) \\ s.t. \quad l^F \leq l^B \end{aligned}$$

The solution to this optimization problem yields: $(1 - \bar{\pi})(r^F - r^B) = a'(l)$. That is, banks provide loans until their expected marginal benefit equals their marginal costs.

Therefore the interest rate that the banks charge to the firms r^F is given by

$$r^F = r^B + \frac{a'(l)}{1 - \bar{\pi}}.$$

Financing costs for domestic firms depend on the interest rate that banks can get in international credit markets r^B and on the efficiency of the domestic financial sector measured in here by the banks' marginal monitoring costs $a'(l)$. From the previous equation is clear that the larger is π the greater is the spread between banks funding rates and banks lending rates.

2.4 Foreign Lenders

There is a large number of deep pocket foreign lenders. These lenders buy banks' bonds and government's bonds as long as the expected benefits of those bonds exceed the cost of the funds. For the case of the banks' bonds the benefits exceed the costs as long as

$$(1 - \bar{\pi})(1 + r^B) + \bar{\pi}\eta(1 + r^B) \geq 1 + r$$

where η is fraction of banks' bonds that the government guarantees, and r is the international risk free rate. From the previous equation is clear that r^B increases with $\bar{\pi}$ and falls with η .

For the case of the sovereign government's bonds the benefits exceed the costs as long as

$$(1 - \delta)(1 + r^s) \geq 1 + r$$

where δ corresponds to the government's probability of default and r^s is the government's sovereign interest rate.¹

2.5 Government

The sovereign government trades with foreign lenders one-period, discount bonds and rebates back to households all the proceedings from its international credit operations in a lump sum fashion. The face value of these bonds specifies the amount to be repaid next period, b_{t+1} . When the country saves purchases bonds $b_{t+1} > 0$, and when it borrows $b_{t+1} < 0$.

The sovereign cannot commit to repay its debt. As in the Eaton-Gersovitz model, when the country defaults it does not repay at date t and the punishment is exclusion from the world credit market in the same period. In the following period the country re-enters the credit market with an exogenous probability ψ , and when it does it starts with a fresh record and zero debt. Default also triggers a loss λ of the households' labor income plus their profits.

The government can also promise debt guarantees to the banking sector so that if a bank becomes insolvent, the government repays to the investors that hold the bank's bonds. Every period the government announces bank guarantees η' that will be in place during the next period. The government also makes each period a decision regarding repayment or default on the sovereign bonds that have issued in international credit markets. The benefit from these government guarantees are that

¹In this model $1 + r^s$ is the inverse of the price of the one-period non-contingent bonds that the sovereign government issues in international markets.

they reduce borrowing costs from the banking sector which is translated into lower rates for working capital loans and higher output.

There is a risk from extending guarantees to the banking sector, however, as a negative risk shock ϵ to the banking sector might overburden the government with a large private debt increasing the default risk of the government and sovereign spreads. Additionally, in order to extend these guarantees the government might collect a labor tax τ , which distorts the labor choice of the households in the economy. We should obtain that the higher the amount of government debt, the lower the bailout guarantees (we get this for Ireland, it does not happen for Argentina).

The government is benevolent and has to decide whether to default on its own debt and on the bailout guarantees. This two decisions are independent, so that the government might default in its own debt but might still guarantee the shorter term debt of the banks or viceversa.

Formally, the government solves:

$$V(b, \eta, z, \pi) = \max \{V^R(b, \eta, z, \pi), V^D(\eta, z, \pi)\}$$

with

$$V^R(b, \eta, z, \pi) = \max_{x', b'} \{u(c - G(n)) + \beta \mathbb{E}_{(z', \pi')|(z, \pi)} V(b', \eta', z', \pi')\}$$

$$V^D(\eta, z, \pi) = \max_{x'} \{u(c - G(n)) + \beta [(1 - \psi) \mathbb{E}_{(z', \pi')|(z, \pi)} V^D(\eta', z', \pi') + \psi \mathbb{E}_{(z', \pi')|(z, \pi)} V(0, \eta', z', \pi')]\}$$

and $x' = \{\eta', c, n, r^F, r^B, \tau, l^F, l^B\}$. $V^R(b, \eta, z, \pi)$ is the value to the government of repaying its debt and $V^D(\eta, z, \pi)$ is the value of defaulting in the current period.

In each period the government makes some fiscal expenditure G^n to fulfill the guarantees promised to the banks in the previous period. Additionally it decides on

borrowing b' , makes its default decisions d , and makes transfers to households T .²

The government is subject to the following budget constraint if it defaults:

$$\tau_t w_t N_t = G_t^\eta + T_t$$

If the government does not default its budget constraint is given by:

$$\tau_t w_t N_t + b_t = q(b_{t+1}, \eta_t, z_t, \pi_t) b_{t+1} + G_t^\eta + T_t$$

Government expenditures to cover guarantees G^η are given by:

$$G_t^\eta = \pi_t \eta_t (1 + r_t^B) l_t^B = \pi_t \eta_t (1 + r_t^B) \frac{\kappa \alpha^M}{1 + \kappa r_t^F} y_t \quad (14)$$

Because today's guarantees η_t have been chosen in the previous period, and the solvency shock for the banks is $\sim iid$, the realized government expenditure in the guarantees differs from the forecasted government expenditure in guarantees for the current period $E_{t-1}[G_t^\eta]$ which is given by:

$$E_{t-1}[G_t^\eta] = \bar{\pi} \eta_t (1 + r_t^B) E_{t-1}[l_t^B] = \bar{\pi} \eta_t (1 + r_t^B) \frac{\kappa \alpha^M}{1 + \kappa r_t^F} E_{t-1}[y_t] \quad (15)$$

Since π might differ from the average aggregate probability of bankruptcy for the banks $\bar{\pi}$, and the expected productivity shock $E[(z_t|z_{t-1})]$ can also differ from the realized shock z_t , actual government expenditure in each period can be under-estimated or over-estimated. In the other hand the decision of repayment or defaulting in sovereign bonds is based on actual government expenditure, and therefore the current realization of the aggregate solvency shock has a direct impact on this decision. More specifically the previous equations imply that, other things given, when either $\pi_t > \bar{\pi}$ or $z_t > E[(z_t|z_{t-1})]$ the government expenditure in guarantees G_t^η is much larger than $E_{t-1}[G_t^\eta]$. This excess expenditure in guarantees to the banking sector

²Note that the government can repay guarantees with taxes, so even if it excluded, it can fulfill guarantees payments.

might overburden the government and generate a risk transfer from the banking sector to sovereign government.

The price of the government bonds q is determined (as discussed briefly in the international investors section) by the zero-profit condition in capital markets:

$$q(b', \eta, z, \pi)(1 + r) = \mathbb{E}_{(z', \pi')|(z, \pi)}(1 - d')$$

where d' represents next-period default / repayment decision

$$d = \begin{cases} 1 & \text{if } V^R(b, \eta, z, \pi) > V^D(\eta, z, \pi) \\ 0 & \text{if } V^R(b, \eta, z, \pi) \leq V^D(\eta, z, \pi) \end{cases}$$

$$d' = \hat{d}(b', \eta', z', \pi')$$

2.6 Market Clearing and Arbitrage

$$(Banks' Loans) \quad l^F = \kappa p^* M^*, \quad r^F = r^B + \frac{a'(l)}{1 - \bar{\pi}}$$

$$(Banks' Bonds) \quad (1 - \bar{\pi})(1 + r^B) + \bar{\pi}\eta(1 + r^B) = 1 + r$$

$$(Res. Const^R.) \quad c = zN^{\alpha^N} M^{*\alpha^M} - p^* M^* \{1 + \kappa[r^F + \pi\eta(1 + r^B)]\} + b - qb'$$

$$(Res. Const^D.) \quad c = \phi zN^{\alpha^N} M^{*\alpha^M} - p^* M^* \{1 + \kappa[r^F + \pi\eta(1 + r^B)]\}$$

2.7 Under provision of credit and bailout guarantees

Notice the debt overhang of the banking sector. Without limited liability, there would be a zero probability of default of a bank, which would lead a to a first order condition given by:

$$r^{F,opt} = r + a'(l^{opt}) \quad (16)$$

which compared with the expression for this condition in this model

$$r^F = r^B + \frac{a'(l)}{1 - \bar{\pi}} = \frac{r + \bar{\pi}(1 - \eta)}{1 - \bar{\pi}(1 - \eta)} + \frac{a'(l)}{1 - \bar{\pi}} \quad (17)$$

implies that the amount of credit is lower with limited liability. It is also easy to see that the amount of imported inputs, credit and output is socially inefficient due to limited liability. Under the working capital constraint given by $\frac{\kappa \alpha^M}{1 + \kappa r^F} y$, the net social benefit from one more unit of imported inputs

$$\frac{\alpha^M z M^{*(\alpha^M - 1)} N^{\alpha^N} k^{\alpha^k}}{1 + \kappa[r + a'(l)]} - p^* \quad (18)$$

Instead, in the competitive equilibrium, the net social benefit is given by:

$$\frac{\alpha^M z M^{*(\alpha^M - 1)} N^{\alpha^N} k^{\alpha^k}}{1 + \kappa\left[\frac{r + \bar{\pi}(1 - \eta)}{1 - \bar{\pi}(1 - \eta)} + \frac{a'(l)}{1 - \bar{\pi}}\right]} - p^* \quad (19)$$

It is apparent from these two expressions that the social benefit from providing one more unit of labor is higher than the private marginal costs. This is what provides the rationale for providing guarantees. By reducing r^B , this reduces this wedge between the private and social marginal costs from hiring labor. Why not provide 100% guarantees to the banking sector? The reason is that there is **trade-off** since increasing guarantees raises the average and the volatility of future resources. This might make government default even more likely, rising government spreads today.

2.8 Recursive Equilibrium

The recursive equilibrium of this model is characterized by

1. a set of value functions V, V^R and V^D ,
2. rules for default $\hat{d}$, borrowing $\hat{b}$, labor supply $\hat{n}$, consumption $\hat{c}$, government guarantees $\hat{\eta}$, bank loans $\hat{l}^F$ and bonds $\hat{l}^B$
3. a bond price function q , wages w , int. rate on banks' bonds r^B and banks' loans r^F

such that:

- i. $\hat{d}, \hat{b}, \hat{\eta}, V^R$ and V^D, V solve the Bellman equation for the government for a given bond price function q
- ii. Households choose labor and consumption optimally
- iii. Firms and banks maximize profits
- iv. q, r^B and r^F are given by expected zero-profit conditions

3 Results

3.1 Calibration strategy

The model is calibrated for Ireland as a case study and the results are compared with the results for the case of Argentina. The model follows closely the set-up in Mendoza and Yue (2011), the parameters of the households risk aversion (σ), the international risk free rate (r), the Frish elasticity of labor supply (ω), the working capital requirement (κ), the probability of exclusion post default (ψ), the discount factor (β) and the constant capital stock (k) are taken from the calibration in that model.

The process for the probability of bankruptcy of the banks (π) is taken from data for credit default swaps (CDS) for the banking sector for the period between June 2004 and December 2012 for Ireland. For Argentina there is not data in CDS for the banking sector so the process for (π) is approximated with the data for CDS for the Colombian banking sector. The process for the productivity process (z) is calibrated to match the standard deviation and the autocorrelation of the GDP for both countries, for the case of Ireland for the period $Q1 : 2004 - Q4 : 2012$ and for Argentina for the period $Q1 : 1983 - Q1 : 2002$. The labor share (α^N) and the inputs share (α^M) for Ireland are taken from the output-input matrices 2009 computed by the OECD for this country. For Argentina the share for the inputs (α^M) and the capital (α^k) are taken from Mendoza and Yue(2011).

The parameters for the simulation of the model are shown in the following table:

		<i>Ireland</i>	<i>Argentina</i>
Households' risk aversion	γ	2	2
International risk free rate	r	1.0%	1.0%
TFP autocorrelation coefficient	ρ	0.8	0.95
Standard deviation of innovations	σ_ϵ	1.5%	1.7%
Labor share in Cobb-Douglas	α_N	0.28	0.40
Inputs share in Cobb-Douglas	α_M	0.58	0.43
Frish Elasticity of Labor Supply	ω	1.46	1.46
Working Capital Requirement	κ	0.7	0.7
E[Pr(Bank-Bankruptcy Shock)]	π	0.06	0.10
Std. Dev. of Pr(Bank-Bankruptcy)	σ_π	6.0%	1.5%
Bank's Marg.Cost of Operating	$a'(l) = a$	0.05	0.05
Pr (exclusion post-default)	θ	0.08	0.08
Discount factor	β	0.88	0.88
Capital Stock	k	1.5	1.5

The following graphics show the policy functions of the model:

- Sovereign Default Thresholds are functions of Banks' Bankruptcy shocks π :
 - For example Figure 1 illustrates that whenever π is larger then for any given level of debt to be sustainable the productivity realization z has to be larger.

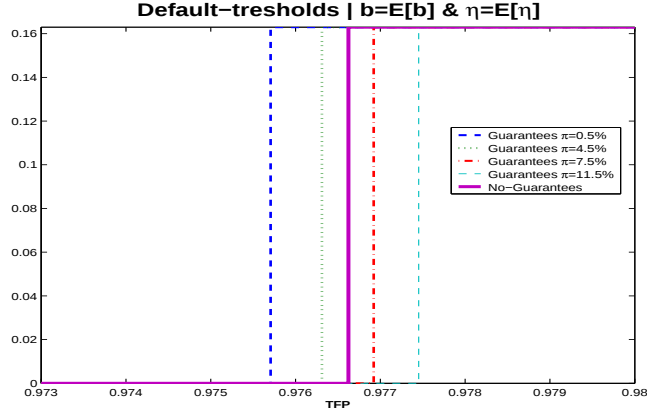


Figure 1: Default Thresholds, Solvency Shocks and Guarantees.

- Figure 2 shows that given the level of guarantees η larger levels of debt are supportable when π is smaller.

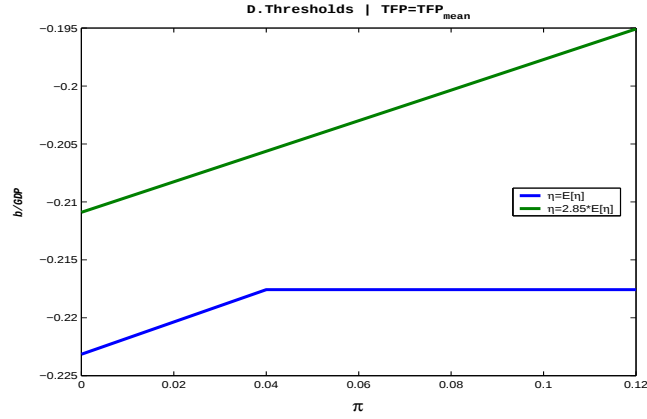


Figure 2: Default Thresholds, TFP and Solvency Shocks.

- Sovereign Default Thresholds are also functions of the Government's Guarantees η :
 - Figure 2 also shows that for a given productivity shock z and any solvency shock π different levels of government support modify the levels of debt

that are supported at equilibrium. In the example in the figure a larger level of government support implies tighter credit limits.

- Figure 3 shows that for a given level of productivity and different solvency shocks π different levels of support of the government modify the levels of debt supported at equilibrium. Specifically when the solvency shock is low larger government support increases the levels of debt that are supported at equilibrium, but when the solvency shock is high higher government support reduces the levels of debt that are supported at equilibrium.

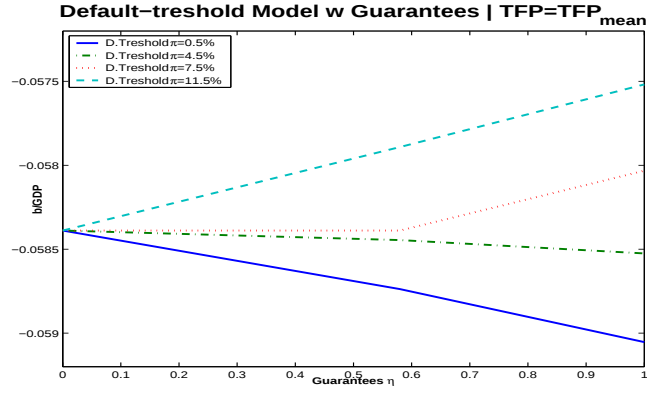


Figure 3: Default Thresholds, Government Support and Solvency Shocks.

- Figure 4 shows that government bonds' prices also change with government support. For the case of $\bar{\pi}$ and $E[z]$ higher government support reduces this prices.

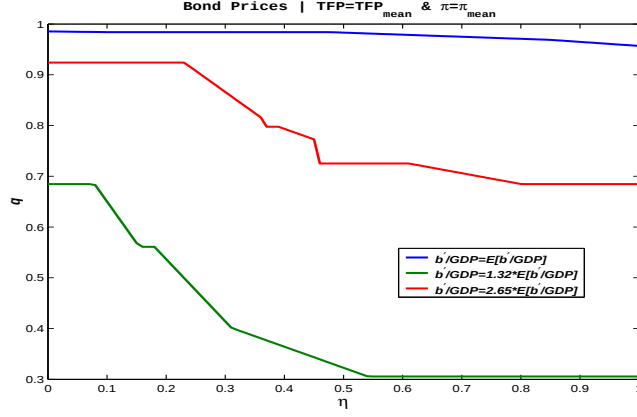


Figure 4: Bond Prices and Government Support.

- Next period government guarantees η' are larger during times in which the fundamentals of the economy are stronger:
 - Figure 5 shows that next period government guarantees η' are larger when the productivity shock to the economy z is larger.

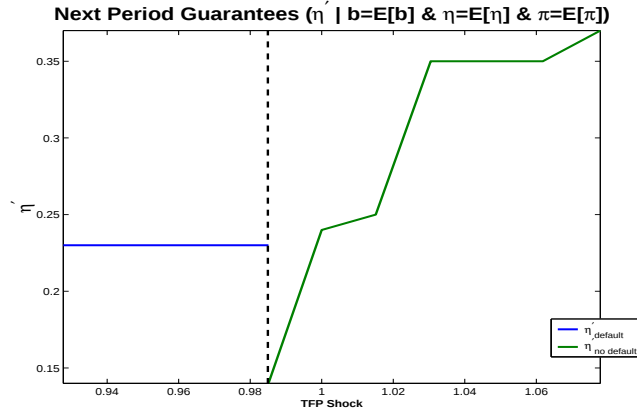


Figure 5: Next Period Guarantees η' and TFP.

- Figure 6 shows that next period government guarantees η' are larger when the level of debt of the economy $-b$ is lower.

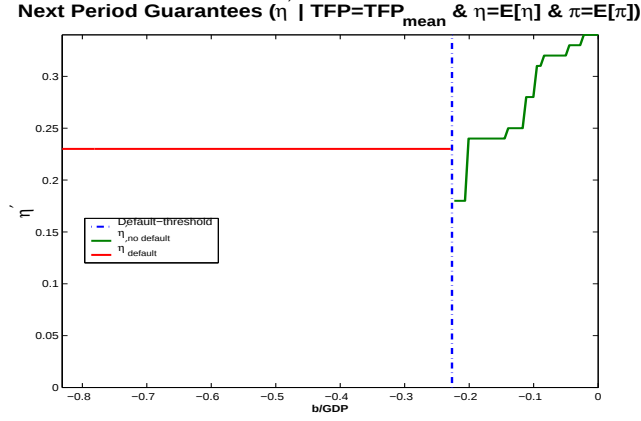


Figure 6: Next Period Guarantees η' and Debt Level $-b$.

- Figure 7 shows that government guarantees to support the banking system have in some instances a negative welfare impact:

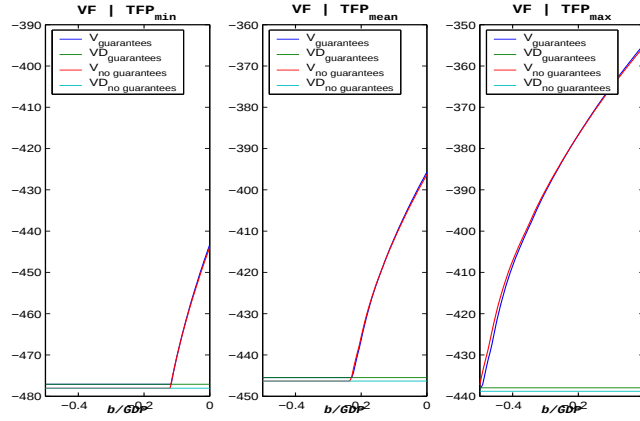


Figure 7: Value Functions and Government Guarantees.

- Inspecting VD in Figure 7 we can conclude that during default times government guarantees increase welfare.
- Inspecting V in Figure 7 we can conclude that during repayment times government guarantees increase welfare only if debt is relatively low. If

debt is large, government support to the banks reduces welfare of the households in the economy.

The results of the model are shown in the Table 1, Table 2 and Table 3. From here we observe that:

- From Table 1 we observe that in the model with guarantees the annual probability of sovereign default is smaller: 1.064% in the model without guarantees vs. 1.0433% in the model with guarantees.
- From Table 1 we observe that in the model with guarantees the levels of consumption and production are larger than in the model without guarantees: having government guarantees makes average production 0.0692% larger per quarter and average consumption 0.0628% larger per quarter than in the model without guarantees.
- From Table 2 we observe that lower volatility (i.e. standard deviation of the solvency shock going from 6.0% to 2.5%) increases the level of government guarantees (from 26.50% to 36.10%).
- From Table 2 we observe that higher average mean of the solvency shock (i.e. mean of the solvency shock going from 6.0% to 8.0%) increases the level of government guarantees (from 26.50% to 31.19%).
- From Table 2 we observe that if the government does not give any guarantees during the periods of sovereign default the level of government guarantees falls (from 26.50% to 2.07%).
- From Table 3 we observe that for countries in which their productivity shock has larger autocorrelation the average probability of default is much larger and the average level of guarantees is larger (going from 26.50% in Ireland to 58.19 in Argentina).

Table 1: Business Statistics Government Guarantees

	Data	Model	No guarantees
Mean $-\frac{b}{y}$	72.64	13.58	14.52
$\sigma(c)/\sigma(y)$	1.09	1.17	1.18
Mean r_s	2.04	2.21	2.20
$\sigma(r_s)$	2.61	2.91	2.85
Mean r_b	3.57	5.66	7.45
$\sigma(r_b)$	4.48	0.23	0.00
$\rho(r_s, r_b)$	0.93	0.08	0.00
$\rho(r_s, y)$	-0.35	-0.40	-0.42
Mean η	41.94	26.50	0.00
$[\frac{\Delta \bar{c}}{\bar{c}} (\eta > 0)]$	-	0.06	0.00
$[\frac{\Delta \bar{y}}{\bar{y}} (\eta > 0)]$	-	0.07	0.00
Default Pr.	-	1.04	1.06

Table 2: Sensitivity Analysis

	Data	Benchmark	Low σ^π	High $\bar{\pi}$	D-R
Mean $-\frac{b}{y}$	72.64	13.58	13.93	13.31	14.50
$\sigma(c)/\sigma(y)$	1.09	1.17	1.18	1.18	1.17
Mean r_s	2.04	2.21	2.17	2.23	2.21
$\sigma(r_s)$	2.61	2.91	2.80	2.93	2.87
Mean r_b	3.57	5.66	5.03	6.88	7.31
$\sigma(r_b)$	4.48	0.23	0.03	0.23	0.43
$\rho(r_s, r_b)$	0.93	0.08	-0.03	0.08	0.04
$\sigma(tb)$	4.54	1.18	1.11	1.18	1.20
$\rho(tb, y)$	-0.28	-0.42	-0.44	-0.43	-0.42
$\rho(c, y)$	0.79	0.96	0.96	0.96	0.96
$\rho(r_s, y)$	-0.35	-0.40	-0.41	-0.41	-0.42
$\rho(r_s, tb)$	0.71	0.83	0.85	0.85	0.85
Mean η	41.94	26.50	36.10	31.19	2.07
$[\frac{\Delta \bar{c}}{\bar{c}} (\eta > 0)]$	-	0.06	0.03	0.07	0.004
$[\frac{\Delta \bar{y}}{\bar{y}} (\eta > 0)]$	-	0.07	0.03	0.07	0.009
$[\Delta Def.Pr (\eta > 0)]$	-	-0.02	-0.08	-0.03	0.02

Table 3: Ireland and Argentina Comparison

	Ireland(G)	Ireland(w.o/G)	Argentina(G)	Argentina(w.o/G)
Mean debt-to-GDP	13.58	14.52	19.65	21.62
$\sigma(c)/\sigma(y)$	1.17	1.18	1.30	1.32
Mean r_s	2.21	2.20	4.41	4.40
$\sigma(r_s)$	2.91	2.85	8.61	8.66
Mean r_b	5.66	7.45	6.65	15.59
$\sigma(r_b)$	0.23	0.00	0.09	0.00
$\rho(r_s, r_b)$	0.08	0.00	0.41	0.00
$\rho(r_s, y)$	-0.40	-0.42	-0.29	-0.29
Mean η	26.50	0.00	58.19	0.00
$[\frac{\Delta \bar{c}}{\bar{c}} (\eta > 0)]$	0.06	0.00	0.02	0.00
$[\frac{\Delta \bar{y}}{\bar{y}} (\eta > 0)]$	0.07	0.00	0.01	0.00
$[\Delta Def.Pr (\eta > 0)]$	-0.02	-0.00	-0.20	0.00

The following figures illustrate the evolution of the time series of the model

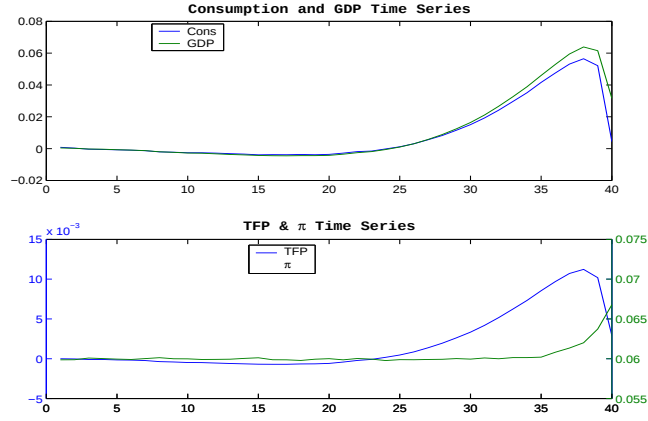


Figure 8: Consumption, Production, Productivity and Solvency.

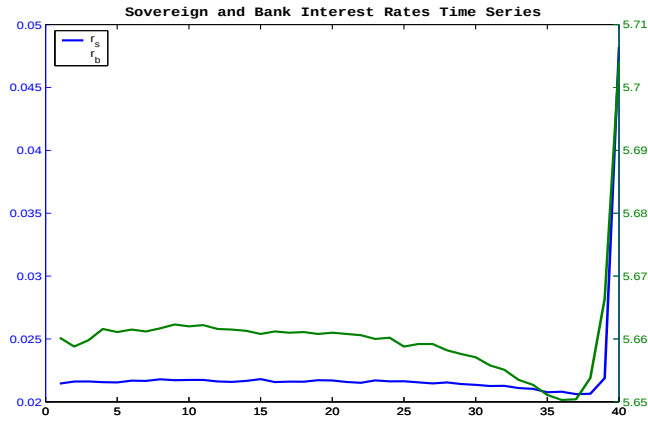


Figure 9: Sovereign and Banks' Interest Rates.

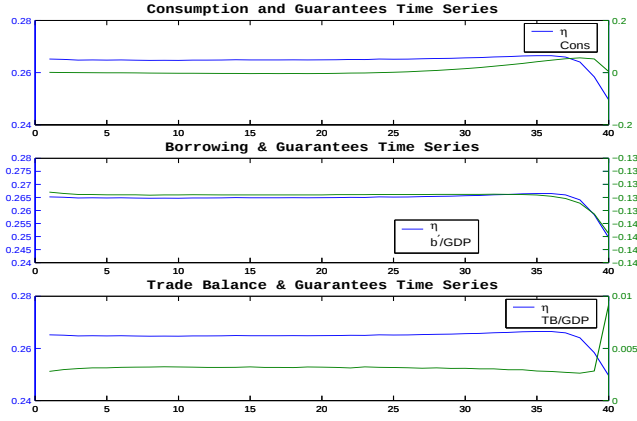


Figure 10: Consumption, Borrowing, Trade Balance and Government Guarantees.

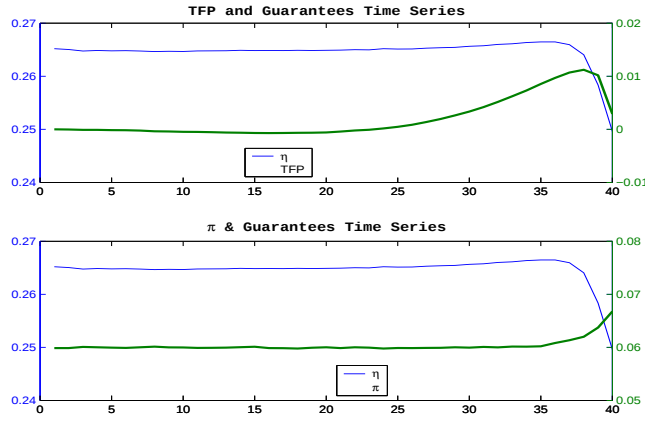


Figure 11: Productivity, Solvency and Government Guarantees.

4 Conclusions

This paper develops a model to study the link between banking crises, sovereign default and government guarantees. A banking crisis can generate a credit crunch in the economy, which can be alleviated by government guarantees. However, the provision of bailout guarantees exposes the government to potentially severe losses from a banking sector failure, causing sovereign spreads to increase substantially, as

the recent bailout in Ireland illustrates. As a result, the value of government guarantees deteriorates, aggravating the crisis in the financial sector. A key theoretical point of this paper is to determine under which circumstances it is desirable for the government to provide bailout guarantees to the financial sector of the economy.

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