A Positive Analysis of Deposit Insurance Provision: Regulatory Competition Among European Union Countries*

Merwan Engineer, Paul Schure, and Mark Gillis

University of Victoria, Canada

6 January 2012

Abstract

Abstracting from normative efficiency rationales for deposit insurance, we consider the provision of deposit insurance as the outcome of a non-cooperative policy game between nations. Nations compete for deposits in order to protect their banking systems from the destabilizing impact of potential capital flight. Policy is chosen to attract depositors who optimally respond to expected returns to deposits, which depend on both stability and deposit insurance levels. We use the model to understand the European banking crisis of 2008. In this fractious crisis, individual nations ratcheted up their deposit insurance levels in response to their neighbors doing so.

JEL: D78, G21, G28.

Keywords: Banking, Deposit Insurance, Regulatory Competition, European Union.

*For helpful comments we would like to thank Itai Agur, Harjoat Bhamra, Chris Edmond, Iain Hardie, Eelke de Jong, Ian King, David Mayes, Hajime Tomura, and participants at conferences and seminars at Ben Gurion University, Simon Fraser University, University of Melbourne, University of Victoria, Atlantic Economics Association Meeting in Boston 2009, Canadian Economics Association Meeting in Toronto 2009, the Joint DNB/EBC Banking and the Globalization of Finance Conference in 2011, and the 2011 Annual Meeting of the Financial Management Association. We are grateful to the Social Science and Humanities Research Council for financial assistance.

1 Introduction

> Germany's surprise decision to guarantee retail deposits came after it loudly denounced Ireland's beggar-thy-neighbour decisions to guarantee the liabilities of its banks. Germany's *volte-face* may have been prompted by a large number of electronic withdrawals of deposits at the weekend, said Nigel Myer, an analyst at Dresdner Kleinwort in London.
>
> The Economist (Lifelines), 9 October 2008.

On 30 September 2008, in the midst of the recent global financial crisis, the government of Ireland unexpectedly guaranteed all deposits at their six largest banks. Within a few days several other European Union (EU) member states responded by also increasing their deposit insurance. In particular, on 5 October 2008 Germany guaranteed all deposits held at their domestic banks. The lead quote strongly suggests that noncooperation in setting deposit insurance appears to have contributed, at least temporarily, to destabilizing European banking.

Motivated by this recent European banking crisis, this paper develops a positive theory of deposit insurance provision. Abstracting from normative efficiency rationales for deposit insurance, we consider the provision of deposit insurance as a non-cooperative policy outcome of a game between nations. In particular, we develop a two-country model in which countries compete for deposits by non-cooperatively setting deposit insurance levels. Depositors invest in the country that offers the highest expected return on deposits, which depends on the level of deposit insurance besides the return on banking.

Our analysis starts with a scenario similar to the leading quote. First, the foreign country (e.g. Ireland) exogenously declares full deposit insurance. The home country's (e.g. Germany) government anticipates a loss of deposits to the foreign country were it not to respond. A loss of deposits would stress the home country's banking system putting it at a greater probability of failing. When the probability of failing is sufficiently high, it is optimal to respond by raising the level of the home deposit insurance. The home government chooses partial deposit insurance if the banking system can be stabilized without having to fully match the foreign countries coverage.

Deposit insurance involves a net cost to society in our model. In the absence of international competition for deposits, insurance would not be provided. Interestingly, with symmetry between nations, non-cooperation leads to an unique symmetric equilibrium without (effective) deposit insurance. This non-cooperative equilibrium is welfare maximizing. We argue that this equilibrium roughly describes the initial situation in the EU where depost guarantees were deliberately set quite low (at €20,000 per depositor). Arguably, the low rate would involve little or no need for government funds as, even in a major crisis, the residual value of bank assets could cover this amount.

The remaining puzzle is to explain why the foreign country would, in the first place, unilaterally increase its deposit insurance from a low level to full deposit insurance. We find that shocks that impact the home and foreign countries asymmetrically or that affect whether depositors coordinate on the efficient equilibrium can indeed rationalize the increase to move to high levels of insurance. However, in our model, these changes need not be associated with a beggar-thy-neighbour policy as Ireland is accused of in the lead quote. Instead, the foreign government may increase its insurance to ensure that their citizens deposit domestically. Attracting foreign deposits may actually be a negative side effect of high levels of deposit insurance, because it makes providing deposit insurance more expensive. The only potential way to capture the beggar-thy-neighbour rationale is by a liquidity shock in which some depositors withdraw and hold cash which leads to competition for the remaining depositors. However, this story cannot explain Ireland's move to full deposit insurance if it anticipated Germany's *volte-face*.

Research in the area of regulatory competition points to the increasing importance of international competition. Dalen and Olsen (2003) find that the international scope of banking has made the competitiveness of banks increasingly dependent on the financial regulations and policies of the countries in which they operate.[1] They point to deposit insurance as a policy that gives one

[1] Issues regarding regulatory competition are highly relevant to the EU due to the required mutual recognition of member state products, including financial services. The 1994 EU deposit-guarantee directive required that Eurozone members cover bank deposits of at least 20,000 Euros per individual (European Union, 1994). This directive, however, imposed no upper limit on the level of deposit insurance members states can provide. This lack of specification created room, above and beyond the minimum, for inter-member deposit insurance competition to exist. This and other problems with cross-border banking in Europe have been extensively discussed by Eisenbeis

country's banks a competitive advantage over others. If the competitive advantage is sufficiently large it may entice governments to set regulations that promote the international competitiveness of domestic industries. Likewise, if a country is sufficiently disadvantaged due to another country's regulations, that country may be forced to level the playing field by responding with similar regulations.

Several empirical papers have directly addressed the area of regulatory competition via deposit insurance. Huizinga and Nicodème (2006) examine how national deposit insurance schemes affect the location of international deposits. They find that non-bank depositors are attracted to countries with explicit deposit insurance schemes. Demirgüç-Kunt, Kane and Laeven (2008) attempt to identify the key factors that influence the adoption and shape of deposit insurance. They find that internal politics and external pressures play a large role in the adoption and shaping of deposit insurance schemes.

The theoretical literature on cross-border banking competition concentrates almost entirely either on capital adequacy assuming no deposit insurance[2], or on multi-national banking assuming complete deposit insurance[3]. An exception is Hardy and Nieto (2011). In their analysis, national regulators competively choose the levels of deposit insurance and levels of bank supervision. Supervision reduces the probability of bank failure but also reduces bank profits. Deposit insurance reduces the *ex post* severity of bank losses. However, higher levels of deposit insurance

---

and Kaufman (2008) and the Forum on Cross-Border Financial Groups (2009). Meanwhile deposit insurance has been harmonised to 100,000 Euros per individual in a directive amending the 1994 EU deposit-guarantee directive (European Union, 2009).

[2] Capital adequacy regulation has received considerable attention. Acharya (2003) and DellAriccia and Marquez (2006) examine international bank regulator competition in models with capital adequacy regulation but without deposit insurance and multinational banks. DellAriccia and Marquez (2006) examine the gains from international cooperation on capital adequacy regulation. Acharya (2003) shows that cooperation on capital requirements can result in non-cooperation in extending forbearance to banks that should be closed.

[3] In Dalen and Olsen (2003) and Calzolari and Loranth (2005) prudential regulation is chosen to minimize the cost of providing full deposit insurance. Dalen and Olsen (2003) show that non-cooperation between nations leads to regulation with lower capital adequacy requirements but higher bank asset quality. Multinational banks are more likely to fail when organized with foreign bank branches versus foreign subsidiaries. The form of bank organization is important because foreign subsidiaries operate under the host country regulation and deposit insurance whereas foreign branches operate largely under the originating countrys regulations and deposit insurance. Under complete information, Calzolari and Loranth (2005) show that the host country regulator of a subsidiary-organized bank has less incentive to intervene than the originating country regulator of a branch-organized multinational bank. With incomplete information the results are complicated by the fact that intervention may impede good quality bank projects rather than just limit losses of bad quality investments.

increase the probability of bank failure, the presumed effect of deposit insurance inducing moral hazard. Externalities connect the countries. An increase in the home level of deposit insurance increases the probability of losses in the foreign country, an assumption based on the observation that a crisis in one country often spills over to other countries. Supervision generates a positive externality. With these assumed externalities, Hardy and Nieto (2011) find that greater international cooperation results in lower levels of deposit insurance and higher levels of supervision than non-cooperation.

Our paper contributes to the literature by developing a positive theory of deposit insurance that is based on the strategic interaction between competing regulators who take into account depositor behavior.[4] We analyse the level of deposit insurance as the key policy variable affecting the optimal location choice of deposits and possible herding behavior. The level of deposits affects the stability of the banking systems and hence the insurance policies that maximize welfare in each country. Although our focus is on the positive analysis of deposit insurance competition, our model with optimizing depositors permits a normative analysis of welfare.

The paper proceeds as follows. Section 2 presents the framework. Section 3 examines the equilibrium response of the home government to a shock from the foreign government implementing full deposit insurance. Section 4 solves the general model. Section 5 documents the relevant events that occurred during the financial crisis in 2008. Section 6 applies the model to analyse the European case. Section 7 concludes.

[4] There is a large literature studying normative rationales for deposit insurance. An interesting recent contribution is that of Morrison and White (2011) who conclude, based on an adverse selection rationale, that governments are to subsidize banks through cheap recapitalizations. In our model governments can subsidize banks through cheap deposit insurance. In contrast to Morrison and White such subsidies are inefficient, yet, under some circumstances they come into play as a result of regulatory competition.

2 The Framework

2.1 Overview

There are two countries, Home and Foreign, and each chooses their deposit insurance policy, d and d^*, respectively.[5] Depositors choose whether to deposit at home or abroad given these insurance policies. The timing of actions and events is as follows.

Stage 1: Home and Foreign governments simultaneously set deposit insurance policies d and d^*.

Stage 2: Banking subgame; depositors choose whether to deposit in the Home or Foreign banking sector. Banking returns are realised.

In order to keep the analysis tractable, we keep the banking subgame as simple as possible. Like Acharya (2009) depositors are risk neutral and invest in one-period bank debt contracts because they have no other opportunities.[6] There is no liquidity risk intermediation in our model, and no interim period in which information is revealed about the fitness of assets, banks or managers. These features would would only complicate the analysis while obscuring the general character of our results.

2.2 Depositors

There is a unit mass of risk-neutral depositors in each country. Each depositor is endowed with one unit of a homogenous good and can either invest in a home bank or a foreign bank. A depositor choosing to invest abroad incurs a transaction cost, which captures the extra costs of holding savings aboard, including the shoe-leather costs of maintaining savings in a system that is dissimilar and remote.

[5] Foreign variables are distinguished with a * superscript. Under our assumptions it is sufficient to model just the one foreign country, the one with the highest level of deposit insurance.

[6] The lack of viable alternative investments could be justified by banks having expertise in investments, or by investments being lumpy and too large for individual investors. Diamond and Dybvig (1983) suggest that introducing an alternative investment, storage, will generate additional equilibria that make the banking system potentially more fragile.

We distinguish a depositor's type according to the transaction cost they face. The home country's population is divided into two groups: *bound* depositors ("homebound"), and *loose* depositors ("footloose"). Bound depositors consist of proportion $B \in (0,1)$ of the home population and the remaining $1-B$ depositors are loose depositors. Bound depositors face a sufficiently large transaction cost that they never move their deposits abroad. They will invest in a domestic bank because they have no other investment opportunities. Loose depositors face a relatively low transaction cost $\varepsilon > 0$ of holding deposits abroad.[7] Transactions costs differ between bound and loose depositors because they differ in sophistication (e.g. computer abilities) or different opportunities (e.g. access to banks and lawyers). The population in the foreign country is similarly described.

2.3 Banks

There are a large number of identical banks in the home country. Each bank invests its deposits in an uncertain home productive investment project that has two possible outcomes. With probability P it yields a low gross return of r, and with probability $1-P$ the project yields a high gross return $R > r$. The high return state will be called "success" and the low return state "failure"; however, we do not rule out $r \geq 1$, that is, absolute losses need not drive our results. Our results depend on expected returns, $Pr + (1-P)R$, and not the correlation of returns.[8]

Banks are perfectly competitive and we assume there are no bankruptcy cost or operating costs. As depositors are risk-neutral, there is a competitive equilibrium in which the gross returns are paid to investors. Thus, assume banks issue debt contracts promising gross return R. With success a bank pays in full, and with failure depositors claim the residual r.

The European banking crisis was characterized by the banking systems of several countries facing the sudden possibility of large withdrawals. Large withdrawals may necessitate a large liquidation of assets immediately. Longer term they necessitate a large reduction in the scale of

[7] The holding cost is a marginal cost. A fixed cost of changing deposit location may lead to a first mover advantage.

[8] Since depositors are risk neutral they are unconcerned with the correlation of realized returns among banks. Deposit insurance is funded in a way that correlation of returns does not matter.

the banking system. Both the immediate and longer term effects stemming from large withdraws would likely substantially increase the rate of bank failure (for reasons we elaborate on below). Thus, we postulate an inverse relationship between the probability of failure, P, and the aggregate level of deposits, denoted D. Specifically, we assume:

$$P'(D) \leq 0 \quad \text{and} \quad 0 < P(D \geq 1) = p < P(B) = b \leq 1$$

where p and b are probabilities of bank failure and satisfy $0 < p < b \leq 1$. Here b is the probability of bank failure when only home bound agent desposit in the home country, $D = B$. We allow the special case $b = 1$ which corresponds to all banks failing. In our analysis the ratio $\frac{b}{p}$ will often appear and we refer it to as the *stress ratio*. The higher is the stress ratio the greater is the relative increase in bank failure from the home loose depositing abroad.

The assumption of a constant positive probability of failure, $P(D) = p > 0$, beyond a certain scale $D = 1$ simplifies the analysis and also avoids that one country's banking system dominates the international market due to economies of scale. The broader idea here is that greater levels of deposits become less important beyond a certain scale, here corresponding to size of the domestic economy. Still, $P(D \geq 1) = p > 0$ — banks may fail due to internal causes such as mismanagement, "bad luck", etc.

The foreign banking system is treated symmetrically. We assume $R^* = R$ and $r^* = r$. The foreign failure function is $P^* = P^*(D^*)$, where D^* is the level of deposits held at the foreign bank. Differences in the functions $P(.)$ and $P^*(.)$ drive possible differences in the expected return of the home and foreign banking sector, which is what depositors care about in this risk-neutral world.[9] Specifically, p^* may differ from p, and b^* to differ from b.

Since depositors must deposit either domestically or abroad, total world deposits satisfy $D +$

[9] Because our depositors are risk neutral, they do not care about the correlation of failures across countries. Risk adverse agents would diversify their deposit holdings across countries when failures are imperfectly correlated and transactions costs are small. We view the movement of funds following Ireland's increase in deposit insurance as attracting funds for higher expected returns rather than for reasons of portfolio diversification, *per se*.

$D^* = 2$. Thus, when for example only home bound agents deposit in the home country we have $D = B$ and $D^* = 2-B$, and the probabilities of bank failure become $P(B) = b$ and $P^*(2-B) = p^*$.

Above immediate and longer term rationales were appealed to when postulating the inverse relationship $P(D)$. In the immediate term large withdrawals may necessitate immediate large liquidation of assets. This would likely increase bank failures for two reasons. First, banks may be forced to sell or write down traditionally illiquid assets at a large discount ("a firesale"). Second, even traditionally liquid assets might also be heavily discounted when a large proportion of banks simultaneously are forced to dump assets to raise funds. Marking-to-market losses will result in the discounting of even unsold assets. In the longer term a reduction in the scale of the banking system will likely lead to bank failures when there are economies of scale external to individual banks. Economies of scale may arise within the banking system because economies to inputs such as well trained banking staff as well as of synergies from having larger networks of banks. A bigger banking system will be better able to diversify asset risks, vet troubled banks, and provide interbank liquidity. Further, as the banking system is the conduit for saving to investment, we suppose there are economies to scale from the better selection as well as greater levels of domestic investment in which domestic banks may have a native advantage over foreign banks.

Our immediate term rationale for $P(D)$ allows for an interpretation of our model that similar to Diamond and Dybvig (1983). Their model implicitly has no failures when patient types do not withdrawal early. This is analogous to our model when $D = 1$ so no banks fail $P(1) = p = 0$ and the return is R. Conversely, the case when all patient depositors withdraw early is like our case $D = B$ where all the banks fail $P(B) = b = 1$ and the return is $r = 1$. Like our model, the important aspect is the determination of the level of deposits D. In Diamond and Dybvig it is determined by a sunspot where agents possibly coordinate on the alternative asset "storage". In our model, the alternative investment is foreign deposits and frictions limit the range of multiple equilibria. Diamond and Dybvig have a two-period model. However, they assume agents deposit in banks in period 0; their agents do not consider the possibility of a bank run in period 1.[10] Similarly, agents in our model do not anticipate the banking crisis. It is too remote or ignored. We do not explicitly model illiquidity or liquidity preferences as they are not essential to our results. The banking subgame is kept simple in order to readily solve the deposit insurance game.

2.4 Deposit Insurance

In our model governments only choose deposit insurance coverage. In reality there are quite a few design features of deposit insurance schemes (Demirgüç-Kunt, Kane and Laeven, 2008), including some that may affect international deposit flows. Governments are not allowed to discriminate between depositors by nationality, an assumption that fits the situation in the EU. For example, if loose depositors at home decided to deposit abroad they receive the same insurance payout, if any, as citizens of the foreign country.

Deposit insurance coverage d is expressed as a fraction of the bank contracted gross return R. Thus, deposit insurance promises a repayment of dR and is said to be *effective* when it yields depositors more than what they can get from their failed bank, i.e. when $dR > r$. Then $d > \frac{r}{R}$ and in case of failure the government provides a supplement of $dR - r$, so that depositor obtains a return of dR. By contrast, if $d \leq \frac{r}{R}$ then $dR \leq r$ and depositors of a failed bank are paid out r from only the banking proceeds. Overall, deposit insurance provides $\max[0, dR - r]$ additional funds on top of r, such that the depositors receive $\max[r, dR]$. However, henceforth we restrict deposit insurance to the range $\frac{r}{R} \leq d \leq 1$ and represent the *ineffective deposit insurance rate* by $d = \frac{r}{R}$. This allows us to drop the maximum operator in our calculations. The construction is the same for the foreign deposit insurance rate: $\frac{r}{R} \leq d^{*} \leq 1$.

[10] Cooper and Ross (1998) extend Diamond and Dybvig to explicitly model bank panic equilibrium as coordinated by an indicator that is described by a probability. When the probability of a bank run is small, the results in Diamond and Dybvig are robust.

2.5 Utility

All depositors are risk neutral. Home loose depositors maximize their expected utilities (or expected return) by choosing between investing either in a home bank or in a foreign bank:

$$U^{\mathrm{L}} = \max\{(1-P(D))R + P(D)dR,\ (1-P^*(D^*))R + P^*(D^*)d^*R - \varepsilon\} - T$$

where T is the tax paid by each home citizen and is independent of individual investment behaviour.

Home bound depositors have a similar objective and face the same choice, however by assumption their costs of moving abroad are so high that investing at home dominates for all possible parameters. Hence their utility becomes:

$$U^{\mathrm{B}} = (1-P(D))R + P(D)dR - T$$

2.6 Government

We assume the home government chooses d to maximize the sum of the expected utilities of home depositors, subject to their anticipated choices and the government budget constraint:

$$\max_d W = BU^{\mathrm{B}} + (1-B)U^{\mathrm{L}} \quad \text{subject to} \quad T = (1+c)P(D)D(dR-r)$$

where $c \geq 0$ in the budget constraint is the deadweight loss from taxation expressed as a rate.[11] It is the net cost of financing deposit insurance. Observe that the tax is positive, $T > 0$, only if deposit insurance is effective ($d > \frac{r}{R}$).

The government budget constraint above has been expressed in expected terms. The budget constraint ensures that the (expected) tax revenue matches the (expected) cost of providing

[11] Costs and benefits that are external to the individual are not modeled but could be included. For example, the efficiency of the payment system might be thought to fall with D. Similarly, a reduction in the size of the home banking system might reduce the level of home financial expertise and also profits. These factors could be modeled as an external net benefit to individuals $X(D)$ where $X'(D) > 0$. They provide government with additional reasons to compete for deposits.

deposit insurance. The tax is consistent with either an actuarially fair insurance payment.[12] Note that the tax is a general revenue tax. It is not financed by a direct deposit insurance premium which would influence agents actions and allow for more control. This makes the analysis easier, yet it is more realistic to the extent that existing funded bank insurance pools are inadequate to handle banking system crises.

3 Equilibria Given Full Foreign Deposit Insurance

In this section we solve the basic model assuming that the foreign country has somehow credibly committed to full deposit insurance $d^* = 1$ in Stage 1.

3.1 Stage 2: Banking Subgame Given Deposit Insurance Levels

In this subgame $d^* = 1$ and $d \geq \frac{r}{R}$ are given. A Nash equilibrium in the banking subgame, involves all depositors optimizing given the behavior of other depositors. In our basic model, the proportion B^* foreign and B domestic bound depositors trivially deposit domestically. Thus, we need to consider only foreign loose depositors and home loose depositors.

The $1 - B^*$ foreign loose depositors either invest domestically or in the home country. Their gross return (before taxes) from investing domestically is $(1-P(D^*))R+P(D^*)d^*R = R$. Foreign loose depositors have a dominant strategy to deposit domestically rather than in the home country because

$$U^{*\mathrm{L}} = \max\Big\{R,\ (1-P(D))R + P(D)dR - \varepsilon^*\Big\} - T^* = R - T^*$$

Overall, we have $D \geq B$ and $D^* \geq 1$.

Now consider home loose depositors. Their net return from investing in the foreign country

[12] Alternatively, we could have specified a tax that is only levied when there is a failure. Using this tax doesn't change the government's problem because agents are risk neutral. Of course, if bank returns are independent of each other, then expected and actual period insurance costs are the same as we have a large number of banks.

is $R - \varepsilon - T$. Investing domestically (weakly) dominates depositing abroad when

$$\begin{aligned} U^{\mathrm{L}} &= \max\Big\{(1 - P(D))R + P(D)dR,\ R - \varepsilon\Big\} - T \\ &= (1 - P(D))R + P(D)dR - T \end{aligned}$$

which implies $\varepsilon \geq P(D)R(1 - d)$. The home loose deposit at home when the cost of having deposits abroad, ε, is at least as large as the net benefits i.e. the probability $P(D)$ of failure domestically times the difference in the returns on deposits held abroad and domestically in case of failure, $R - dR$. Observe that the net benefit of investing abroad is largest when home deposit insurance is ineffective, $d = \frac{r}{R}$.

The interesting case is when the transaction cost ε is sufficiently small that the home loose always invest in a foreign bank (where $d^* = 1$) in the absence of effective home deposit insurance:

$$\varepsilon < p(R - r) \equiv \overline{\varepsilon} \tag{1}$$

where $\overline{\varepsilon} > 0$ as $p > 0$ and $R > r$. Henceforth $0 < \varepsilon < \overline{\varepsilon}$ is assumed.

The condition for the home loose investing domestically can now be rewritten in terms of the deposit insurance level d satisifying the following threshold. The Home loose deposit at home if and only if

$$d \geq d_{P(D)} \equiv 1 - \frac{\varepsilon}{P(D)R} \tag{2}$$

The restriction $0 < \varepsilon < \overline{\varepsilon}$ implies that the threshold involves effective deposit insurance, $d_{P(D)} > \frac{r}{R}$. The individual decision whether to deposit at home described in equation (2) generally depends on the amount of deposits D, and hence on the decisions of the other depositors as detailed in the following proposition.

Proposition 1 *Given policies d and $d^* = 1$, Nash equilibrium deposit behaviour is as follows:*

(i) *Home Loose Leave (HLL) Equilibrium. An equilibrium exists in which the home loose depos-*

itors invest abroad and other depositors invest domestically, $D = B$ *and* $D^* = 2 - B$, *if and only if the deposit insurance rate is sufficiently low* $d \in [\frac{r}{R}, d_b)$, *where* $d_b = 1 - \frac{\varepsilon}{bR}$.

(ii) *Domestic Banking (DB) Equilibrium. An equilibrium exists in which all depositors invest domestically,* $D = 1$ *and* $D^* = 1$, *if and only if the deposit insurance rate is sufficiently high* $d \in [d_p, 1]$, *where* $d_p = 1 - \frac{\varepsilon}{pR}$.

Proof. If all home loose invest in foreign deposits then $D = B$ and $D^* = 2 - B$. Hence $P(D) = P(B) = b$ and by equation (2) depositing in the foreign country is optimal when home deposit insurance is below $d_b = 1 - \frac{\varepsilon}{bR}$. This is the HLL Equilibrium.

Conversely, suppose all the home loose invest in home deposits. Then, $D = 1$ and $D^* = 1$, and $P(D) = P(1) = p$. The home loose are optimizing if home deposit insurance is effective and exceeds d_p. ■

Table 1 arranges these equilibria into intervals using the fact that $\frac{r}{R} < d_p < d_b < 1$. If $d < d_p$, then the HLL Equilibrium is unique. At the other end of the range, $d \geq d_b$, the DB Equilibrium is unique. In the intermediate interval, $d \in [d_p, d_b)$, the equilibria coexist. The range of this interval, $d_b - d_p = \frac{\varepsilon}{bR}(\frac{b}{p} - 1)$, is increasing in the stress ratio $\frac{b}{p}$ and the transaction cost, and the interval disappears as $\frac{b}{p} \to 1$ or $\varepsilon \to 0$. Also observe that as the transaction cost decreases the range over which the HLL Equilibrium is unique increases and completely dominates in the limit: $\varepsilon \to 0$ implies $d_p \to 1$.

In Table 1 expected utility is net of taxes. In the HLL Equilibrium the tax is $T_{\text{HLL}} = Bb(1 + c)(dR - r)$. When deposit insurance is ineffective, the tax is zero and welfare W_{HLL} is at its maximium:

$$\overline{W}_{\text{HLL}} = (1 - bB)R + bBr - (1 - B)\varepsilon = (1 - b)R + br + (1 - B)[b(R - r) - \varepsilon]$$

Observe that $\overline{W}_{\text{HLL}}$ can be written as the expected return on deposits invested at home plus a term that represents the utility boost of the loose depositors from moving abroad, i.e. $[b(R - r) - \varepsilon]$, times the fraction of loose depositors. In contrast, in the DB Equilibrium the tax is $T_{\text{DB}} =$

$p(1+c)(dR-r)$, and since both the bound and the loose deposit domestically they have the same utility.

Table 1: Nash Equilbria for d and $d^*=1$

Interval	Equilibria	Expected Utility	Welfare
$[\frac{r}{R}, d_p)$	HLL	$U^{\text{B}}_{\text{HLL}} = (1-b)R + bdR - T_{\text{HLL}}$ $U^{\text{L}}_{\text{HLL}} = R - \varepsilon - T_{\text{HLL}}$	$W_{\text{HLL}} = \overline{W}_{\text{HLL}} - bBc(dR-r)$
$[d_p, d_b)$	HLL and DB	$U^{\text{B}}_{\text{HLL}}, U^{\text{L}}_{\text{HLL}}$ $U_{\text{DB}} = U^{\text{B}}_{\text{DB}} = U^{\text{L}}_{\text{DB}}$	W_{HLL} W_{DB}
$[d_b, 1]$	DB	$U_{\text{DB}} = (1-p)R + pdR - T_{\text{DB}}$	$W_{\text{DB}} = U_{\text{DB}}$

The presence of multiple equilibrium is problematic when it comes to modeling the government's choice of the deposit insurance rate. Following Allen and Gale (2007) we use a refinement to identify a unique equilibrium. Specifically, we assume home loose depositors coordinate on the *essential equilibrium,* the equilibrium that gives home loose depositors greater utility in the intermediate interval $[d_p, d_b)$. The home loose depositors choose the DB Equilibrium if and only if d is sufficiently high that they are no worse off in that equilibrium, $U^{\text{L}}_{\text{DB}} \geq U^{\text{L}}_{\text{HLL}}$. The essential equilibrium refinement yields a level of deposit insurance $\widetilde{d}$ that separates the equilibria.

Proposition 2 *Given policies d and $d^*=1$, the essential banking equilibrium is:*

(i) *Home Loose Leave (HLL) Equilibrium if and only if $d \in [\frac{r}{R}, \widetilde{d})$.*

(ii) *Domestic Banking (DB) Equilibrium if and only if $d \in [\widetilde{d}, 1]$.*

Here $\widetilde{d} = \max\{d_p, \min\{d^\tau, d_b\}\}$ and $d^\tau \equiv \frac{r}{R} + \frac{\bar{\varepsilon}-\varepsilon}{R[bB+(bB-p)c]}$ is the home insurance level that equates $U^L_{HLL} = U^L_{DB}$. The level of $\widetilde{d}$ depends on taxes or, equivalently, the stress ratio $\frac{b}{p}$ as follows:

(a) *$\widetilde{d} = d_p$ if and only if $T_{DB} \leq T_{HLL}$ or, equivalently, $\frac{b}{p} \geq \frac{1}{B}$.*

(b) *$\widetilde{d} > d_p$ if and only if $T_{DB} > T_{HLL}$ or, equivalently, $\frac{b}{p} < \frac{1}{B}$, where $\widetilde{d} < d_b$ is decreasing in $\frac{b}{p}$.*

Proof. For given d we have $T_{\text{DB}} \leq T_{\text{HLL}}$ if and only if $\frac{b}{p} \geq \frac{1}{B}$. We can also verify that $d^{\tau} \leq d_p$ if and only if $\frac{b}{p} \geq \frac{1}{B}$. Therefore, if $\frac{b}{p} \geq \frac{1}{B}$, then $d^{\tau} \leq d_p$ and $\widetilde{d} = d_p$. Conversely, if $\frac{b}{p} < \frac{1}{B}$, then $d^{\tau} > d_p$ and $\widetilde{d} = \min\{d^{\tau}, d_b\}$. In this later case d^{τ} increases continously over the interval with a decrease in b or an increase in p, changes that continuously decrease the stress ratio. ■

The proposition reveals the importance of the stress ratio or, equivalently, taxes. Taxes play a decisive role in the essential equilibrium because home loose depositors internalize the cost of the taxes they pay toward funding domestic deposit insurance. For stress ratios high enough, $\frac{b}{p} \geq \frac{1}{B}$, the taxes the home loose pay are higher in the HLL Equilibrium, even though their own deposits would be covered by foreign insurance. Thus, they deposit domestically when $\frac{b}{p} \geq \frac{1}{B}$. This yields $\widetilde{d}$ at the lower bound d_p. Since d_p is the lower bound on the DB (Nash) Equilibrium in Proposition 1, we have the following result.

Corollary 1 *If a Domestic Banking (DB) Equilibrium exists, then it is the essential equilibrium whenever the stress ratio is high enough $\frac{b}{p} \geq \frac{1}{B}$.*

3.2 Stage 1: The Home Government's Choice of d Given $d^* = 1$

We assume the home government chooses d to maximize welfare while anticipating the banking equilibria described in Stage 2. In particular, consider the government's choice of d to achieve an essential equilibrium described in Proposition 2. The government can uniquely choose a DB Equilibrium over the range $d \geq \widetilde{d}$. Among this range of choices $d = \widetilde{d}$ maximizes welfare $W_{\text{DB}}(\widetilde{d})$ because it minimizes the deadweight loss from taxation. The government can also choose a HLL Equilibrum by setting $d < \widetilde{d}$. Among this range of choices ineffective deposit insurance $d = r/R$ maximizes welfare at $\overline{W}_{\text{HLL}}$ since it minimizes the deadweight loss from taxation.

The government's problem therefore reduces to a binary choice. The DB Equilibrium is chosen if and only if $W_{\text{DB}}(\widetilde{d}) \geq \overline{W}_{\text{HLL}}$, or equivalently, the transaction cost ε satisfies:

$$\frac{B[\frac{1+c}{B} - \frac{b}{p}]\overline{\varepsilon} - cp(1-\widetilde{d})R}{1-B} \leq \varepsilon < \overline{\varepsilon} \tag{3}$$

Observe that a "high stress ratio" $\frac{b}{p} \geq \frac{1+c}{B}$ is sufficient for the left-hand side of this equation to be nonpositive and hence for the DB Equilibrium to be chosen. Here the damage from the loose leaving is so high that the DB Equilibrium with full insurance (including the deadwight loss of taxation) is preferrable to the HLL Equilibrium without insurance: $W_{\text{DB}}(1) \geq \overline{W}_{\text{HLL}}$. The following proposition describes how the stress ratio and other parameters determine the home government's optimal choice of d in response to the foreign government setting full insurance $d^* = 1$.

Proposition 3 *Assume $d^* = 1$ and the bank subgame is determined by the essential banking equilibrium.*

1. *High stress ratios $\frac{b}{p} \geq \frac{1+c}{B}$. The home government chooses $d = d_p$ to realize the Domestic Banking Equilibrium.*

2. *Medium stress ratios $\frac{1}{B} \leq \frac{b}{p} < \frac{1+c}{B}$. The home government chooses $d = d_p$ to realize the Domestic Banking Equilibrium when either the stress ratio is near the upperbound $\frac{1+c}{B}$, the deadweight loss $c > 0$ is sufficiently small, or the transaction cost $\varepsilon < \overline{\varepsilon}$ is sufficiently high; otherwise, it chooses $d = \frac{r}{R}$ (ineffective deposit insurance) to realize the Home Loose Leave Equilibrium.*

3. *Low stress ratios $\frac{b}{p} < \frac{1}{B}$. The home government chooses $d = \widetilde{d} > d_p$ to realize the Domestic Equilibrium when $\varepsilon < \overline{\varepsilon}$ is sufficiently high; otherwise it chooses the Home Loose Leave Equilibrium. Holding ε constant, the Home Loose Leave Equilibrium obtains when the stress ratio is near the lower bound $\frac{b}{p} \to \frac{1}{B}$ or $c \geq 0$ is sufficiently large.*

Proof. If $\frac{b}{p} \geq \frac{1+c}{B}$ then we can also observe directly that (3) is satisfied and the DB Equilibrium obtains. For medium stress ratios, $\frac{1}{B} \leq \frac{b}{p} < \frac{1+c}{B}$, Proposition 2 requires $\widetilde{d} = d_p$ and the numerator in (3) becomes $B[\frac{1+c}{B} - \frac{b}{p}]\overline{\varepsilon} - c\varepsilon = B[\frac{1}{B} - \frac{b}{p}]\overline{\varepsilon} + c(\overline{\varepsilon} - \varepsilon)$. This expression is nonpositive when approaching the upperbound, $\frac{b}{p} \to \frac{1+c}{B}$, or when $c > 0$ is small enough. In both cases, (3) is satisfied. Conversely, for $\frac{b}{p} \to \frac{1}{B}$, $\varepsilon \to 0$ and c sufficiently large (3) is violated and the HLL

Equilibrium obtains. For low stress ratios, $\frac{b}{p} < \frac{1}{B}$, Proposition 2 requires $\widetilde{d} > d_p$. If $\varepsilon \to \overline{\varepsilon}$, the numerator reduces to $B[\frac{1}{B} - \frac{b}{p}]\overline{\varepsilon}$ so (3) is satisfied. The numerator also reduces to $B[\frac{1}{B} - \frac{b}{p}]\overline{\varepsilon}$ when $c = 0$. Then (3) can be satisfied with ε small when $\frac{b}{p} \to \frac{1}{B}$. The numerator is bounded below when evaluated at $\widetilde{d} \to d_p$ yielding $B[\frac{1}{B} - \frac{b}{p}]\overline{\varepsilon} + c(\overline{\varepsilon} - \varepsilon) > 0$ for any $c \geq 0$. Thus, ε sufficiently small, c sufficiently large, or $\frac{b}{p} \to 1$ violate (3). ■

Medium and low stress ratios lie below $\frac{1+c}{B}$. Over this range a relatively large c favours the HLL Equilibrium because the cost of funding deposit insurance is otherwise large. Here, the government prefers not to compete for deposits and lets the home loose deposit abroad. Intuitively, home welfare is maximized by "free riding" on foreign deposit insurance. Interestingly, the proposition implies that for low stress ratios free riding on foreign deposit insurance may be the best policy even when $c = 0$.[13]

Proposition 3 helps us identify when the home government (Germany in our leading quote) would respond with complete deposit insurance, $d = 1$. The home government only provides effective deposit insurance when it chooses the DB Equilibrium. Then it chooses $d = \widetilde{d} \geq 1 - \frac{\varepsilon}{pR}$. Observe that $d \to 1$ as $\varepsilon \to 0$. Thus, the home government would response with very high deposit insurance when the transaction cost ε is sufficiently small and the conditions for the DB Equilibrium are satisfied. This is summarized in the following corollary.

Corollary 2 *Assume $d^* = 1$ and the bank subgame is determined by the essential banking equilibrium. The home government responds by choosing the deposit insurance rate to be very high (near complete deposit insurance $d \to 1$) when the transactions cost ε is very small ($\varepsilon \to 0$) for:*

(1) High stress ratios $\frac{b}{p} \geq \frac{1+c}{B}$.

(2) Medium stress ratios, $\frac{1}{B} \leq \frac{b}{p} < \frac{1+c}{B}$, where either the stress ratio is near the upperbound $\frac{1+c}{B}$ or the deadweight loss rate $c > 0$ is sufficiently small.

(3) Low stress ratios, $\frac{b}{p} < \frac{1}{B}$, where the stress ratio approaches the upperbound $\frac{1}{B}$, and the

[13] To see this observe that when $c = 0$ the home government could establish the DB Equilibrium by offering complete deposit $d = 1$ to achieve $W_{\mathrm{DB}}(1) = (1-p)R + pr$. However, for sufficiently low ε it could even do even better with ineffective deposit insurance, $d = r/R$, to achieve the HLL Equilibrium: if $\varepsilon = 0$ we have $W_{\mathrm{HLL}} = B\{(1-b)R + br\} + (1-B)R = (1-bB)R + bBr$, which exceeds $(1-p)R + pr$ for low stress ratios.

deadweight loss rate $c \geq 0$ is near or at zero.

Overall, we conclude that very low transactions costs and relatively large stress ratios are most conducive to a rational home government responding with very high deposit insurance to almost match $d^* = 1$.[14] Not competing by raising deposit insurance in these circumstances results in a greater probability of banking failure, and homebound depositors suffer sufficiently to reduce home country welfare.

4 The General Analysis

In this section we analyze the choice of home and foreign deposit insurance levels.

4.1 Stage 2: Banking Subgame Equilibrium

In this subgame the policy pair (d^*, d) is given. First consider home loose depositors. They choose to deposit domestically rather than deposit in the foreign country if and only if

$$(1 - P(D))R + P(D)dR \geq (1 - P^*(D^*))R + P^*(D^*)d^*R - \varepsilon \quad \text{or}$$

$$d \geq 1 - \frac{\varepsilon}{P(D)R} - \frac{P^*(D^*)}{P(D)}(1 - d^*) \tag{4}$$

The situation abroad is similar for foreign loose depositors. They deposit domestically if and only if:

$$(1 - P(D))R + P(D)dR - \varepsilon^* \leq (1 - P^*(D^*))R + P^*(D^*)d^*R \quad \text{or}$$

[14] The above analysis relies on the essential banking refinement. A plausible alternative approach might be to assume that the equilibrium is determined by a sunspot in the interval $d \in [d_p, d_b)$. The home government can avoid this uncertainty by choosing the upperbound $d = d_b$ to achieve the Domestic Banking Equilibrium or ineffective deposit insurance $d = \frac{r}{R}$ to achieve the Home Loose Leave equilibrium. Observe that the smaller is the transactions cost ε the smaller is the difference $d_b - d_p$ and the larger is the difference $d_p - \frac{r}{R}$. These differences are indicative of the opportunity costs of getting the bet wrong relative to certainty. As $\varepsilon \to 0$, the interval disappears and the lower bound $d_p \to 1$. In this limiting case, the government prefers certain outcomes and chooses deposit insurance as in the Corollary.

$$d \leq 1 + \frac{\varepsilon^*}{P(D)R} - \frac{P^*(D^*)}{P(D)}(1 - d^*) \tag{5}$$

Notice in the special case for which $d^* = 1$ equation 5 is satisfied and equation 4 simplifies to equation 2.

There are now three possible banking equilibria. As before there is the possibility of a Domestic Banking (DB) Equilibrium where $D = D^* = 1$. Substituting $P(1) = p$ and $P^*(1) = p^*$ into the above conditions implies that a DB Equilibrium exists for a particular policy pair (d^*, d) if and only if

$$d \geq 1 - \frac{\varepsilon}{pR} - \frac{p^*}{p}(1 - d^*) \equiv \underline{d}_{\text{DB}}(d^*) \quad \text{and} \tag{6}$$

$$d \leq 1 + \frac{\varepsilon^*}{pR} - \frac{p^*}{p}(1 - d^*) \equiv \overline{d}_{\text{DB}}(d^*)\ , \tag{7}$$

that is $\underline{d}_{\text{DB}}(d^*) \leq d \leq \overline{d}_{\text{DB}}(d^*)$. Observe that $\underline{d}_{\text{DB}}(d^*) < 1$, $\underline{d}_{\text{DB}}(d^*) < \overline{d}_{\text{DB}}(d^*)$ and that these terms are increasing in d^*.The DB Equilibrium exists provided that d and d^* are large enough relative to each other. In particular, d^* must be large enough that $\overline{d}_{\text{DB}}(d^*) \geq \frac{r}{R}$. Otherwise, foreign loose agents are always better off depositing in the home country and the DB Equilibrium does not exist. This possibility only arises when the ratio $\frac{p^*}{p}$ is much larger than 1. However, an increase in foreign deposit insurance d^* softens the impact of a high $\frac{p^*}{p}$ ratio, and when $d^* = 1$, depositors neglect the risk p^* because foreign deposits are fully insured.

Now consider the possibility of a Home Loose Leave (HLL) Equilibrium, where $D = B$ and $D^* = 2 - B$. It exists when inequality 4 is not satisfied, while inequality 5 is satisifed. Both conditions are satisfied if and only if

$$d < 1 - \frac{\varepsilon}{bR} - \frac{p^*}{b}(1 - d^*) \equiv \overline{d}_{\text{HLL}}(d^*) \tag{8}$$

Finally, in the general model, there is a potential new equilibrium, which we term the Foreign Loose Leave (FLL) Equilibrium. In the FLL Equilibrium both the foreign and home loose agents prefer to deposit in the home country: $D = 2 - B^*$ and $D^* = B^*$. This equilibrium exists if inequality 4 is satisfied, while 5 is not satisfied. Both conditions are satisfied if and only if

$$d > 1 + \frac{\varepsilon^*}{pR} - \frac{b^*}{p}(1 - d^*) \equiv \underline{d}_{\text{FLL}}(d^*) \tag{9}$$

The above analysis is summarized in the following generalisation of Proposition 1.

Proposition 4 *Given policies (d^*, d), Nash equilibrium deposit behaviour is as follows:*

(i) *Home Loose Leave (HLL) Equilibrium. A banking equilibrium exists in which the home loose depositors invest abroad and other depositors invest domestically, $D = B$ and $D^* = 2 - B$, if and only if $d < \overline{d}_{HLL}(d^*)$.*

(ii) *Foreign Loose Leave (FLL) Equilibrium. A banking equilibrium exists in which the foreign loose depositors invest abroad and other depositors invest domestically, $D = 2 - B^*$ and $D^* = B^*$, if and only if $d > \underline{d}_{FLL}(d^*)$.*

(iii) *Domestic Banking (DB) Equilibrium ($D = 1$ and $D^* = 1$) exists if and only if $\underline{d}_{DB}(d^*) \leq d \leq \overline{d}_{DB}(d^*)$.*

Figures 1 and 2 illustrate where the equilibria are located in the policy space (d^*, d). The origin in each figure corresponds to ineffective deposit insurance in both countries, $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$. Policies that correspond to the HLL Equilibrium lie below the (brown) $\overline{d}_{\text{HLL}}(d^*)$ line. Policies that correspond to the FLL Equilibrium lie above the (green) $\underline{d}_{\text{FLL}}(d^*)$ line. Policies that correspond to the DB Equilibrium are located on and between the (red) $\underline{d}_{\text{DB}}(d^*)$ line and the (yellow) $\overline{d}_{\text{DB}}(d^*)$ line. In general these regions overlap so that there are multiple Nash equilibria. For example, the DB Equilibrium is unique only in the region in the upper right hand corner where both d^* and d are close to 1.

In Section 3 we used an equilibrium refinement to identify a unique "essential" equilibrium for each policy d given $d^* = 1$. The refinement allowed the home loose depositors to coordinate among themselves. Extending the refinement to the general case involves also allowing the foreign loose depositors to coordinate among themselves. Now we have two groups, home loose depositors and foreign loose depositors, playing non-cooperatively. As a consequence, the refinement does not yield a unique essential equilibrium in the region of the parameter space where only the HLL and FLL equilibria coexist.

However, the essential equilibrium is unique in the region of the parameter space where a DB Equilibrium exists. The logic is similar to Corollary 1, where $\frac{b}{p} \geq \frac{1}{B}$ resulted in the home loose depositors coordinating on the DB Equilibrium (when $d \geq \widetilde{d} = d_p$ and $d^* = 1$). It turns out that the DB Equilibrium is unique in the general case when the stress ratios are in the medium or high range for both countries, namely $\frac{b}{p} \geq \frac{1}{B}$ and $\frac{b^*}{p^*} \geq \frac{1}{B^*}$. To see this suppose a HLL Equilibirum exist without the refinement. With the refinement, a HLL Equilibrium cannot be an essential equilibrium because home loose depositors as a group are better off deviating by depositing domestically for $d^* = 1$, by Corollary 1, and thefore for any $d^* \leq 1$. Conversely, with the refinement, the FLL Equilibrium cannot be an essential equilibrium because foreign loose depositors as a group are better off depositing domestically. For all policy combinations (d^*, d) for which the DB Equilibrium exists, it prevails as the essential equilibrum. The proof is straightforward and is omitted.

Proposition 5 *If a Domestic Banking Equilibrium exists for polices* (d^*, d)*, that is where* $\underline{d}_{DB}(d^*) \leq d \leq \overline{d}_{DB}(d^*)$*, then it is the essential equilibrium whenever the stress ratios are in the medium or high range,* $\frac{b}{p} \geq \frac{1}{B}$ *and* $\frac{b^*}{p^*} \geq \frac{1}{B^*}$*.*

Thus any policies (d^*, d) on or in the corridor formed by $\underline{d}_{\text{DB}}(d^*)$ and $\overline{d}_{\text{DB}}(d^*)$ yield the DB Equilibrium as the essential equilibrium. In Figure 1 this 'essential DB Equilibrium corridor' contains the origin, which corresponds to ineffective deposit insurance $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$. This situation occurs when there is relative symmtery between countries. We now turn to show that if $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ is in the essential DB Equilibrium corridor, then this policy pair is the unique policy equilibrium and it is efficient.

4.2 Policy Equilibrium and Efficiency

This section examines the policy game in which the foreign and home governments simultaneously choose their respective levels of deposit insurance, d^* and d, while anticipating the equilibria in the banking subgame described above. Each government chooses their insurance level to maximize their own country welfare taking the choice of the other government as given. A non-cooperative Nash equilibrium to the policy game may or may not exist. If it exists, it may or may not be efficient.

We focus the analysis with the following assumptions which we maintain through out this section.

Assumption 1 *(i) Depositors coordinate on essential equilibria in the banking subgame, (ii) the stress ratios are in the medium to high range* $\frac{b}{p} \geq \frac{1}{B}$ *and* $\frac{b^*}{p^*} \geq \frac{1}{B^*}$*, and (iii) the marginal deadweight loss of providing deposit insurance is positive* $c > 0$ *and* $c^* > 0$.

Recall that while the essential equilibirum refinement resulted in a unique DB Equilibrium for part of the policy space, it did not rule out multiple equilibria elsewhere. Adding the requirement that the stress ratios are high enough allows us to make progress by ranking welfare levels (independent of the existence of equilibrium). In particular, as shown below, domestic banking (weakly) welfare dominates other arrangements:

$$W_{\text{DB}}(d) \geq \max[W_{\text{HLL}}(d^*, d), W_{\text{FLL}}(d)] \text{ and } W^*_{\text{DB}}(d^*) \geq \max[W^*_{\text{HLL}}(d^*), W^*_{\text{FLL}}(d^*, d)],$$

where the subscripts indicate the banking arrangement (e.g. $W^*_{\text{FLL}}(d^*, d)$ is foreign country welfare with foreign loose agents depositing in the home country). For a given d, domestic banking gives higher home welfare than other banking arrangements independent of d^*. Similarly, for a given d^*, domestic banking gives higher foreign welfare independent of d. With the further requirement that deposit insurance is costly to provide, $c > 0$ and $c^* > 0$, there is a unique efficient outcome.

Proposition 6 *Domestic banking combined with ineffective deposit insurance,* $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$*, maximizes individual country welfare and uniquely maximizes world welfare.*

Proof. First, we prove the above welfare inequalities hold. Consider

$$W_{\mathrm{HLL}}(d^*, d) = B\{(1-b)R + br\} + (1-B)\{(1-p^*)R + p^*d^*R - \varepsilon\} - cbB(dR - r) <$$

$$B\{(1-b)R + br\} + (1-B)R - cbB(dR - r) = (1-bB)R + Bbr - cbB(dR - r) \leq$$

$$(1-p)R + pr - cp(dR - r) = W_{\mathrm{DB}}(d)$$

and similarly $W^*_{\mathrm{DB}}(d^*) > W^*_{\mathrm{FLL}}(d^*, d)$. Now consider that the failure function does not decrease with foreign deposits $P(1) = P(2 - B) = p$ but welfare declines from having to insure those deposits when $c > 0$. In summary, $W_{\mathrm{DB}}(\frac{r}{R}) = W_{\mathrm{FLL}}(\frac{r}{R})$ and $W_{\mathrm{DB}}(d) > W_{\mathrm{FLL}}(d)$ for $d > \frac{r}{R}$. Similarly, $W^*_{\mathrm{DB}}(d^*) \geq W^*_{\mathrm{HLL}}(d^*)$ for $d \geq \frac{r}{R}$.

Second, observe that $W_{\mathrm{DB}}(d)$ is declining in d independent of d^*. Thus, the lowest possible deposit insurance, ineffective deposit insurance, $d = \frac{r}{R}$, maximizes home welfare at $W_{\mathrm{DB}}(\frac{r}{R})$. Similarly, $d^* = \frac{r}{R}$, maximizes foreign welfare at $W^*_{\mathrm{DB}}(\frac{r}{R})$.

Lastly, world welfare is maximized by the sum $W_{\mathrm{DB}}(\frac{r}{R})+ W^*_{\mathrm{DB}}(\frac{r}{R})$. Whereas FLL banking can generate equally high welfare for the home country, $W_{\mathrm{FLL}}(\frac{r}{R}) = W_{\mathrm{DB}}(\frac{r}{R})$, it yields less welfare for the foreign country, $W^*_{\mathrm{FLL}}(\frac{r}{R}, \frac{r}{R}) < W^*_{\mathrm{DB}}(\frac{r}{R})$. Thus, domestic banking uniquely maximizes world welfare. ■

Ineffective deposit insurance in both the home and foreign country with domestic banking is the uniquely efficient policy for three reasons. First, there is the deadweight loss from providing deposit insurance. Second, there is a net loss from loose deposits moving abroad when the stress ratio is high enough because it leaves the domestic banking system sufficiently weakened. These two reasons are sufficient to prove Proposition 6. However, a third reason is that the transaction cost of moving abroad reduces welfare.

We now determine when a policy equilibrium exists and whether it is efficient. The following proposition shows that when the countries' banking systems are somewhat similar (as depicted in Figure 1), a policy equilibrium exists that achieves the efficient outcome. As we discuss later, this result arguably fits the European situation before the banking crisis, where a relatively low level of deposit insurance (€20,000 per deposit) was in place.

Proposition 7 *Suppose the home and foreign banking sectors face somewhat similar risk of bank failure under domestic banking,* $p^* - p \in \left[\frac{-\varepsilon}{R-r}, \frac{\varepsilon^*}{R-r}\right]$. *Then ineffective deposit insurance at home and abroad,* $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$, *is the unique policy equilibrium. It implies the Domestic Banking Equilibrium and efficiency.*

Proof. Policies $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ satisfy the condition $\underline{d}_{\mathrm{DB}}(d^*) \leq d \leq \overline{d}_{\mathrm{DB}}(d^*)$, for the existence of an essential DB Equilibrium (in Proposition 5), when $p^* - p \in \left[\frac{-\varepsilon}{R-r}, \frac{\varepsilon^*}{R-r}\right]$. This banking equilibrium is an efficient policy equilibrium because it maximizes individual country welfare by Proposition 6. To establish uniqueness, we need to show that any other policies $(d^*, d) \neq (\frac{r}{R}, \frac{r}{R})$ cannot be a policy equilibrium. Any other policies that satisfies $\underline{d}_{\mathrm{DB}}(d^*) \leq d \leq \overline{d}_{\mathrm{DB}}(d^*)$ corresponds to an essential DB Equilibrium but cannot be a policy equilibrium as at least one government could increase welfare by reducing deposit insurance slightly.

Now consider policies (d^*, d) where $d > \overline{d}_{\mathrm{DB}}(d^*)$. The home government can increase its welfare by deviating to a lower level of deposit insurance, say $\widehat{d} = \max\{\frac{r}{R}, \underline{d}_{\mathrm{DB}}(d^*)\} < d$. In Figure 1 this new point $(d^*, \widehat{d})$ lies at the bottom edge of the essential DB Equilibrium corridor. Home welfare is greater because $W_{\mathrm{DB}}(\widehat{d}) > W_{\mathrm{DB}}(d) \geq \max[W_{\mathrm{HLL}}(d^*, d), W_{\mathrm{FLL}}(d)]$.

Finally consider policies (d^*, d) where $d < \underline{d}_{\mathrm{DB}}(d^*)$.The foreign government can increase its welfare by deviating to $\widehat{d^*} < d^*$ corresponding to, say, the far left point $(\widehat{d^*}, d)$ on the edge of the essential DB Equilibrium corridor, where $\widehat{d^*}$ implicitly solves $d = \overline{d}_{\mathrm{DB}}(\widehat{d^*})$. Foreign welfare is greater because $W^*_{\mathrm{DB}}(\widehat{d^*}) > W^*_{\mathrm{DB}}(d^*) \geq \max[W^*_{\mathrm{FLL}}(d^*, d), W^*_{\mathrm{HLL}}(d^*)]$. ■

The condition $p^* - p \in \left[\frac{-\varepsilon}{R-r}, \frac{\varepsilon^*}{R-r}\right]$ is only satisfied when $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ is a DB Equilibrium. This is the case in Figure 1 where the origin $(\frac{r}{R}, \frac{r}{R})$ is in the essential DB Equilibrium corridor. The proof the of the proposition shows that any policies (d^*, d) outside the corridor would not be chosen, as one country could increase its welfare by reducing its insurance rate to locate in the corridor. In turn, policies in the corridor that involve effective insurance would not be chosen, as at least one country could increase its welfare by reducing its insurance rate while still locating in the corridor. Only when deposit insurance is ineffective for both countries will there be a policy equilibrium.

But what happens if the countries are not 'somewhat similar' in terms of the risk of banking failure? The home banking sector might be substantially riskier than the foreign sector or substantially less risky. We shall focus, without loss of generality, on the case where the home banking sector (e.g. Germany) is substantially less risky under domestic banking, i.e. $p^* - p > \frac{\varepsilon^*}{R-r}$. This case is depicited in Figure 2 where the origin $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ lies to the left of the essential DB Equilibrium corridor.

There are two subcases. First, the home banking sector is always less risky than the foreign sector, independent of the level of deposits. Second, the home banking sector is less risky if the home loose agents do not leave ($D \geq 1$) but riskier if they do leave ($D = B$). This latter case is more relevant to our policy discussion (e.g. where German's deposit in Ireland) and, therefore, is the focus of the analysis below. It also yields a stronger parameter restriction, $b - p^* \geq \frac{\varepsilon}{R-r}$.[15] Graphically, this means that the $\overline{d}_{\mathrm{HLL}}(d^*)$ intercepts the vertical axis (i.e. $\overline{d}_{\mathrm{HLL}}(\frac{r}{R}) \geq \frac{r}{R}$) as in Figure 2.

The analysis with $p^* - p > \frac{\varepsilon^*}{R-r}$ is more challenging. The ineffective deposit insurance policies $(d, d^*) = (\frac{r}{R}, \frac{r}{R})$, which welfare dominates other policies, now is in a region with two essential equilibria, the FLL Equilibrium and the HLL Equilibrium. We select an essential equilibrium in this region using a sunspot, where depositors coordinate on the HLL Equilibrium with probability q and coordinate on the FLL Equilibrium with probability $1 - q$. For simplicity the sunspot probability q is assumed to be independent of d^* and d. Two thresholds for the sunspot probability that are used to separate the domestic banking equilibrium from the loose leave equilibria are:

$$\begin{aligned} q_{DB} &\equiv 1 - \frac{[p^* - p - \frac{\varepsilon^*}{R-r}][c + (1+c)(1-B)]}{B^*(b^* - p - \frac{\varepsilon^*}{R-r}) - (p^* - p - \frac{\varepsilon^*}{R-r})} < 1 \quad \text{and} \\ q_{LL} &\equiv \frac{\frac{p}{b}[b - p^* - \frac{\varepsilon}{R-r}][c + (1+c)(1-B^*)]}{B(b - p^* - \frac{\varepsilon}{R-r}) - (p - p^* - \frac{\varepsilon}{R-r})} \geq 0 \end{aligned}$$

[15] This case is more theoretically interesting because a policy equilibrium may not exist. The other case is $(b - p^*)(R - r) < \varepsilon$.Then $\overline{d}_{\mathrm{HLL}}(\frac{r}{R}) < \frac{r}{R}$, and it can be shown that an equilibrium always exists.

where $q_{DB} < 1$ follows from the assumption $\frac{b^*}{p^*} \geq \frac{1}{B^*}$. Depending on parameters $q_{LL} < 1$ or $q_{LL} \geq 1$. If $q_{LL} < 1$, then a policy equilibrium does not exist for large q as detailed in the following proposition.

Proposition 8 *Suppose the home banking sector is substantially less risky than the foreign sector under domestic banking, $p^* - p > \frac{\varepsilon^*}{R-r}$, but is more risky when the home loose leave, $b - p^* \geq \frac{\varepsilon}{R-r}$. A policy equilibrium does not exist if the exogenous 'sunspot' probability is sufficiently large, $q > \max\{q_{DB}, q_{LL}\}$ and $q_{LL} < 1$. Otherwise, a unique policy equilibrium exists as follows:*

(i) *If $q \leq q_{DB}$, then the policy pair $(d^*, \frac{r}{R})$ where $d^* = 1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right] > \frac{r}{R}$ is the policy equilibrium. The Domestic Banking Equilibrium obtains with certainty.*

(ii) *If $q \in (q_{DB}, q_{LL}]$, then ineffective deposit insurance $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ is the policy equilibrium. The Home Loose Leave Equilibrium obtains with probability q and the Foreign Loose Leave Equilibrium with probability $1 - q$.*

Proof. The policy pair with the lowest deposit insurance rates welfare dominates other policy pairs within any banking equilibrium. First consider the policy pair $(d^*, d) = \left(1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right], \frac{r}{R}\right)$, where d^* corresponds to $\overline{d}_{\mathrm{DB}}(d^*) = \frac{r}{R}$. In Figure 2, this policy pair is located at the bottom left corner of essential DB Equilibrium corridor. Consider deviations from this policy pair. The foreign government can obtain other banking equilibria by increasing it insurance rate, $d^* > 1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]$. Between $\underline{d}_{\mathrm{DB}}$ and $\underline{d}_{\mathrm{FLL}}$ the sunspot determines either the HLL or FLL equilibrium. To the left of $\underline{d}_{\mathrm{FLL}}$ only the HLL Equilibrium exists. However, the foreign government is best off with a DB Equilibrium because $W^*_{\mathrm{DB}}\left(1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]\right) > W^*_{\mathrm{DB}}(d^*) \geq \max[W^*_{\mathrm{FLL}}(d^*, \frac{r}{R}), W^*_{\mathrm{HLL}}(d^*)]$. Similarly, the home government cannot improve its welfare by increasing from $\frac{r}{R}$ to $d > \frac{r}{R}$, as $W_{\mathrm{DB}}\left(\frac{r}{R}\right) > W^*_{\mathrm{DB}}(d) \geq \max[W_{\mathrm{FLL}}(d^*, d), W_{\mathrm{HLL}}(d)]$. Now suppose the foreign government reduces its insurance. Then it enters a region where the sunspot determines either the HLL or FLL equilibrium. In this region, foreign welfare is maxmized by setting $d^* = \frac{r}{R}$. The foreign government will choose $\left(1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right], \frac{r}{R}\right)$ over point

$(d^*, d) = \left(\frac{r}{R}, \frac{r}{R}\right)$, if and only if

$$qW^*_{\text{HLL}}(\frac{r}{R}) + (1-q)W^*_{\text{FLL}}(\frac{r}{R}, \frac{r}{R}) \leq W^*_{\text{DB}}(1 - \frac{\varepsilon^*}{p^*R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]) \tag{10}$$

or equivalently $q \leq q_{DB}$. Thus, policy pair $\left(1 - \frac{\varepsilon^*}{p^*R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right], \frac{r}{R}\right)$ is the policy equilibrium if $q \leq q_{DB}$.

If $q > q_{DB}$ the foreign country maximizes welfare at $d^* = \frac{r}{R}$ when $d = \frac{r}{R}$. Policy pair $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ is an policy equilibrium if, in turn, the home government chooses not to deviate. The relevant alternative, see Figure 2, is $\left(\overline{d}_{\text{HLL}}(\frac{r}{R}) + \epsilon, \frac{r}{R}\right)$, where $\epsilon > 0$ is an infinitesmal increment which secures the FLL Equilibrium (in the region that lies above the $\overline{d}_{\text{HLL}}(d^*)$ line). The home government prefers $(\frac{r}{R}, \frac{r}{R})$ over $\left(\overline{d}_{\text{HLL}}(\frac{r}{R}) + \epsilon, \frac{r}{R},\right)$ if

$$qW_{\text{HLL}}(\frac{r}{R}, \frac{r}{R}) + (1-q)W_{\text{FLL}}(\frac{r}{R}) \geq W_{\text{FLL}}(\overline{d}_{\text{HLL}}(\frac{r}{R})) , \tag{11}$$

or, equivalently, $q \leq q_{LL}$. Thus, if $q_{DB} \leq q \leq q_{LL}$ then $(\frac{r}{R}, \frac{r}{R})$ is the policy equilibrium.

If $q > q_{LL}$ then the home government prefers $\overline{d}_{\text{HLL}}(\frac{r}{R}) + \epsilon$ when $d^* = \frac{r}{R}$. However, this FLL Equilibrium cannot be a policy equilibrium; increasing d^* infinitesmally from $\frac{r}{R}$ increases foreign expected welfare by moving to a region with HLL and FLL equilibria. As $q > q_{LL} \geq 0$, expected welfare increases because $W^*_{\text{HLL}}(\frac{r}{R}) = (1-p^*)R + p^*r \geq W^*_{\text{FLL}}(\frac{r}{R}, 1) > W^*_{\text{FLL}}\left(\frac{r}{R}, \overline{d}_{\text{HLL}}(\frac{r}{R})\right)$. Other banking equlibria combination regions lie in the upper right hand corner of Figure 2 and include the DB Equilibrium. Since this is the essential equilibrium, policies in these areas are dominated by the

policy pair $(d^*, d) = \left(1 - \frac{\varepsilon^*}{p^*R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right], \frac{r}{R}\right)$. ■

We later use this result to examine the implication of the crisis hitting countries in the EU asymmetrically.

5 The European Situation

As part of the European Union's objective to integrate financial markets, the 1994 EU directive on deposit guarantee schemes (Directive 94/19/EC) required Member states to guarantee a minimum of €20,000 of each depositor's aggregate deposits. Demirgüç-Kunt, Kane and Laeven (2008) document that the bulk of the 27 EU countries had set their actual deposit insurance limits at or close to the €20,000 limit by the end of 2007. The two exceptions in the Eurozone were, notably, France (at €70,000) and Italy (€100,000).

Under the 1994 directive branches of credit institutions that are outside the home country are covered by the home country's deposit insurance scheme. For example, the branches of a German bank located in France are covered by the German government's deposit guarantee scheme. Thus, branches of banks provide a ready vehicle for soliciting foreign deposits and e-commerce has presumably greatly increased the scope for taking advantage of return differences between banks. EU customers can move deposits swiftly between competing regulatory regimes and deposit insurance schemes. Interestingly, the 1994 Directive explicitly mentioned the concern that competition distortions might arise from different deposit insurance coverage.[16]

In our model banks can issue just a single type of liability, namely deposits. The banking sector of the country with the highest level of deposit insurance has a competitive advantage in attracting deposits. In reality governments and regulators can shore up their domestic banking sectors using a range of instruments, including deposit insurance schemes. Laeven and Valencia (2010) assess which countries experienced a systemic banking crisis in 2007-2008 and give a comprehensive overview of the bank support measures that attempted to resolve them. Below we review the developments in the EU concerning deposits insurance and other guarantees of bank liabilities.[17]

[16] As part of the directive, however, members were also required to limit the use of advertising deposit insurance scheme related information. Although deposit insurance scheme information had to be readily available, members had to ensure that credit institutions were not advertising information that would distort competition. (Directive 94/19/EC, Article 9(3)).

[17] Depositors and other liability holders presumably react to other support measures too. However, asset guarantees were less frequently used (Panetta et al. (2009)), while in the EU liquidity support measures, asset purchases and bank nationalizations arguably leave less scope for discretion for national policy makers to create competitive

On September 30, in the midst of the credit crisis, the government of Ireland announced that they would guarantee all retail and wholesale deposits at their largest 6 banks for two years.[18] The Irish government stated that this decision to move to full deposit insurance was in response to "the impact of the recent international market turmoil on the Irish Banking system", and felt that it would "remove any uncertainty on the part of counterparties and customers of the six institutions" (Government of Ireland, 2008).

On October 3, the United Kingdom announced an increase in their deposit guarantee limit, from £35,000 to £50,000, effective October 7. Reuters (2008a) reported that the Irish guarantee caused a flood of cash from UK into the guaranteed Irish banks. According the British Bankers Association, UK banks in Northern Ireland were particularly disadvantaged by Ireland's guarantee (British Bankers Association, 2008).

On October 5, after publicly denouncing Ireland's "beggar-thy-neighbour" move earlier, the Chancellor of Germany, Angela Merkel, announced that the German government would fully guarantee the safety of the public's deposits. Previous to this move, Germany had guaranteed €20,000 of deposits. The Economist (2008) reported that Germany's move "may have been prompted by large numbers of electronic withdrawals of deposits at the weekend."

On the same day, the Austrian Minister of Finance, Wilhelm Molterer, announced that Austria would follow Germany by guaranteeing deposits. At the time no official amount was announced, but by October 8, the Austrian government approved an unlimited guarantee for private customers (European Commission, 2008). Previously Austria had insured €20,000. According to Reuters (2008b), Molterer had said that this move was to "ensure Austrian savings are not withdrawn and transferred to Germany".

On October 6, the government of Denmark announced that they would guarantee all deposits

advantages than guarantees of liabilities. Liquidity support measures are essentially in the hand of the European Central Bank, a supranational body; asset purchases and bank nationalizations have been vetted quite strongly by the European Commission in the context of the EU's State Aid Treaty Articles (see e.g. European Commission, 2011).

[18] They also guaranteed covered bonds, senior debt and subordinated debt (lower tier II). It was reported that this new scheme guaranteed an estimated E400bn of liabilities (Financial Times, 2008).

in Danish banks for two years (Government of Denmark, 2008).[19] Previous to this announcement Denmark had insured 300,000 Kroner, approximately €40,000.

On October 7, at the EcoFin Council meeting in Luxembourg, EU finance ministers agreed to raise the Union wide deposit guarantee minimum from €20,000 to €50,000 for an initial period of at least one year. In order to prevent a situation from occurring again, the Council laid the framework for Directive 2009/14/EC, that amended the 1994 Directive on deposit insurance in regards to the payout delay and the coverage level. Directive 2009/14/EC came into effect in March 2009. It specified a minimum guarantee of €50,000 until December 31, 2010 and a common level of €100,000 afterwards (European Union, 2009).

Panetta et al. (2009) review the government support measures of the financial sector in the 11 countries which "account for the bulk of these interventions" in 2008-2009. They report that the six EU countries, namely France, Germany, Italy, the Netherlands, Spain, and the United Kingdom, all announced liability guarantee programmes between 8-14 October 2008. They also explicitly mention that five of these EU countries established maximums for these guarantees, which strongly suggests that tax payers carry part of the cost of these guarantees. Bank of International Settlements (2011) reports that "By December 2010, more than 200 banks in 16 advanced economies had issued close to €1 trillion equivalent of guaranteed bonds." Levy and Zaghini (2010) show these bond guarantees were credible and resulted in a drop of the funding costs of banks. Hence, as in our model, tax payers pay at least part of the cost for these guarantees.

6 European Deposit Insurance as Determined by Regulatory Competition

The above description of the European situation confirmed that (i) prior to September 2008 most bank deposits in EU countries were uninsured, and (ii) starting in September 2008 levels of

[19] The new Danish guarantee plan is quite interesting because it takes heed of possible competitive distortions. In particular, the plan allows for branches of foreign banks located in Denmark to participate in this new plan. This allowance helps eliminate possible regional, but international, competitive distortions.

deposit insurance and other types of liability insurance increased drastically. What might account for this drastic change? Presumably, many factors contributed to the course of events.[20] In this section, we try to explain the drastic changes in European deposit insurance as following from the logic of regulatory competition in our model.

Initial low levels of deposit insurance may be desirable in our model because deposit insurance involves a deadweight loss. The model predicts low levels of deposit insurance when the banking systems are somewhat symmetric. In particular, Proposition 7 shows that there is a unique policy equilibrium involving ineffective deposit insurance when the difference in probability of banking losses with domestic banking across countries is relatively small ($p^* - p$ is relatively small). Ineffective deposit insurance in our model corresponds to low nominal insurance levels that can always be covered by bank asset returns without recourse to government funding. A meagre €20,000 per deposit of deposit insurance that prevailed in most European countries before the crisis. Arguably, it would have taken a very large drop in asset values before government funding would be needed to make good the insurance. If so, then the situation prior to September 2008 would roughly correspond to what we have termed ineffective deposit insurance.

What changed during the crisis? Proposition 7 implies that in order to move beyond the outcome of ineffective deposit insurance in both countries we need to either argue that the difference in the failure rates $p^* - p$ increased, or else modify some feature of the model. Below we consider four possible scenarios, two of which based on an increase of $p^* - p$ during the crisis. Of the four scenarios only the last scenario would qualify as a beggar-thy-neighbor policy.

6.1 Asymmetric Changes in the Risk of Bank Losses

Many banks become insolvent during the 2008 financial crisis. Here we examine the consequences of Irish banks having a higher risk of failure than German banks. In particular, suppose the crisis induced an unanticipated increase in the difference in the failure rates from $p^* - p \leq \frac{\varepsilon^*}{R-r}$, where

[20] A lack of data makes it difficult to determine what happened. At the time of the events, the key agents in our model also lacked data. It appears that in 2008 EU regulators possessed deposit flow data only for their own countries' banks at the monthly level at best (from our conversations with academics and a bank regulator from an EU nation).

Proposition 7 applies, to $p^* - p > \frac{\varepsilon^*}{R-r}$, where Proposition 8 applies. Then it is possible that the Irish government would raise deposit insurance to an effective level, $d^* = 1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right] > \frac{r}{R}$, in order to safe-guard the stability of their banking sector.

Was a move to $d^* = 1$ conceivable according to the model? Almost complete deposit insurance ($d^* \to 1$) would arise when depositors at Irish banks move abroad easily ($\varepsilon^* \to 0$) and the German banking sector is viewed as very safe ($p \to 0$). Below we argue that it is unlikely that depositors viewed deposits in Germany as perfectly safe in the midst of the crisis. Another problem for this scenario is that Proposition 8 shows that the optimal response by Germany would have been to keep deposit insurance ineffective.

In order to support this scenario consider that policy makers may be uncertain about the level of the model parameters, for example the levels of p and ε^*. Under such uncertainty rational policy makers would choose higher insurance levels than in Proposition 8. This is because a policy error of raising deposit insurance but not setting it high enough to prevent a crisis would be very costly. In addition to the high costs of more bank failures there is also the deadweight loss from using taxes to pay deposit insurance.

With uncertainty the situation may have been the following. The increase in $p^* - p$ combined with a spike in the Irish stress level b^*/p^* could have spurred Ireland to "err on the safe side" with $d^* = 1$. The the extra cost of full deposit insurance is relatively small when c is relatively small and b^*/p^* is large. Facing $d^* = 1$, the German's optimal response would be to raise deposit insurance to $d = d_p = 1 - \frac{\varepsilon}{pR}$, as shown in Proposition 3, and $d \to 1$ when the transaction cost $\varepsilon \to 0$.

According to this scenario the Irish move to full deposit insurance was not a beggar-thy-neighbour policy of Ireland who anticipated a likely reaction by other EU countries. However, Germany was justifiably upset by the Irish move to full deposit insurance as this presented the country with a high potential liability and forced a policy $volte-face$.

6.2 German Banks were also Vulnerable

In the previous scenario Ireland was hit hard during the crisis while Germany remained a safe haven. However, if Germany was a safe haven then this was arguably only true in relative terms.[21] According to Laeven and Valencia (2010), Germany and Ireland were both among the eight EU member states that experienced a full-blown systemic banking crisis in 2008 (along with Austria, Belgium, Denmark, Luxembourg, Netherlands, and the UK).

We continue to assume that the crisis impacted banks in EU countries asymmetrically. However, now suppose that both German and Ireland banking sectors were vulnerable to loosing depositors to other EU countries. In this version of the model both German and Ireland would be conflated as the Foreign country, and Germany raised deposit insurance to stem a deposit outflow to other EU countries that depositors might deem safer. Further, German authorities could justify their policy $volte-face$ by scapegoating Ireland.

Consistent with the prediction of our model, the countries with banking sectors that were deemed safer in 2008, notably Italy, Poland, and to a lesser extent France (see e.g. Laeven and Valencia, 2010) did not increase deposit insurance, and provided less support to their banking sectors than Ireland and Germany. According to the model, the move by Ireland and Germany actually benefited such safer coutries as it avoided a costly influx of deposits.

6.3 Depositors Panicked

What would happen if the financial crisis manifested as an expectations shock in which Irish loose depositors 'panicked' and failed to coordinate on the essential DB Equilibrium? Without the essential banking equilibrium refinement, low deposit insurance yields the uncertainy of multiple Nash banking equilibria. A damaging prospect for the Irish is that a Foreign Loose Leave (FLL) Equilibrium might obtain. The Irish government can avoid the prospect of the Irish loose

[21] The German banking sector was in very bad condition as well in the fall of 2008. For example, Hypo Real Estate, the country's then second largest financial institution, was severely distressed by the end of September 2008. On October 6 a €50 Bln Hypo rescue package by the German Government and German banks was adopted (Bloomberg 2008b).

depositing abroad by raising deposit insurance to a very high level to attract German depositors. It can be shown that this deviation from the €20,000 norm is optimal for the Irish when they have a very high stress ratio and probability of the FLL Equilibrium is high in the absence of action.

With the Irish moving to high deposit insurance the banking equilibrium would become the HLL equilibrium (Figures 1 and 2). However, for a high stress ratio in Germany the new situation is not a policy equilibrium. Given a high stress ratio the German authorities will follow suit and raise deposit insurance. At the very minimum Germany would raise deposit insurance to the (red) $\underline{d}_{\mathrm{DB}}(d^*)$ line. However, even in case German depositors are coordinated, this may lead to an expensive influx of panicking Irish depositors. Therefore, a best response for the German authorities would 'normally' be to raise deposit insurance to the (brown) $\overline{d}_{\mathrm{HLL}}(d^*)$ line. At this stage the policy pair is situated above the (brown) $\overline{d}_{\mathrm{HLL}}(d^*)$ line and to the right of (i.e. below) the (green) $\underline{d}_{\mathrm{FLL}}(d^*)$ line: this uniquely implies the DB Equilibrium. The scenario reveals that a depositor panick in even one constituency can trigger drastic increases in deposit insurance in both countries. Furthermore, the German authorities were justifiably upset as the Irish move inflicted a negative externality on them.

6.4 Liquidity Shocks

None of the above scenarios describe a "beggar-thy-neighbour" explanation for increasing deposit insurance. Foreign deposit insurance is increased to retain foreign loose agents domestically. That this higher deposit insurance might attract loose agents from abroad is an unfortunate side effect. Indeed, attracting the home loose increases the cost of providing insurance without changing asset returns because the failure rate does not continue to fall with deposits after $D = 1$. If we allowed instead for $P'(D) < 0$ for $D > 1$ as well, we would bring in a potential motivation for more intense competition for deposits, possibly resulting in asymmetric Nash equilibria.

Here we present a different take on a possible beggar-thy-neigbour policy. For simplicity assume $B^* = B$ and suppose that $1 - B$ loose depositors withdraw their deposits from the system for reasons that are unmodeled (for instance, to hold safe cash, or a transfer to a third country like France). Assume the remaining $1 - B$ loose depositors are distributed equally between the two countries.

In this case, for high enough foreign and home stress ratios (and low enough transaction costs), we can face a standard prisonner's dilemma setting. For both countries high deposit insurance is a dominant strategy. High deposit insurance is best given low deposit insurance abroad because it would lure in the $\frac{1}{2}(1 - B)$ depositors from abroad and lower the probability of failure to p or p^*, respectively. High deposit insurance is also best given high deposit insurance abroad because lowering deposit insurance may imply a higher probability the $\frac{1}{2}(1 - B)$ loose depositors leave the local banking sector.[22]

7 Conclusion

This paper models the provision of deposit insurance as resulting from competition between nations. In particular, we develop a two-country model in which countries compete for deposits by non-cooperatively setting deposit insurance levels. In the base model, deposit insurance is provided only to prevent capital flight which could destabilize the domestic banking system. We completely abstract from the standard normative rationales for deposit insurance, and with symmetric nations both are best off without deposit insurance. Nevertheless, the competitive equilibrium may display suboptimal outcomes. As far as we are aware, this is the first paper to develop such a positive theory where both depositors and national regulators are rational actors.

In search of maximum expected returns, depositors react to a cross-country difference in the deposit insurance rate. We start by examining the situation in which the government of a foreign country unexpectedly announces an increase from a modest level of deposit insurance to full deposit insurance. This level of deposit insurance is attractive to home footloose agents who initially only have access to a modest level of deposit insurance in the home country. The flight of the footloose stresses the home banking system in the absence of a response by the home

[22] It can also happen that there is no equilibrium in pure strategies in case of a liquidity shock.

government.

But what triggered the initial move? The model suggest a number of possible reasons why a (foreign) country would, as Ireland did, unilaterally increase its deposit insurance from a low level to full deposit insurance. One possible reason is that the Irish banking sector was hit by an adverse shock while Germany (the home country) was affected to to a lesser degree. The problem of the asymmetric shock scenario is that it can only explain Ireland's drastic move if it overestimated the soundness of the German banking system or the effect of credibility issues with its own deposit insurance scheme. Without one of these additional assumptions Ireland's move to full deposit insurance was too drastic. Another, perhaps more realistic reason that the model unveils is that Germany's banking sector was, like Ireland, in dire straights. In the presence of safer banking systems that depositors could move to at low transaction costs, *both* Ireland and Germany moved to full deposit insurance in order to retain their depositors at home. A third possibility is that during the crisis (footloose) depositors ceased to coordinate on the choice that continued to make sense to them as a group, namely to retain their deposits at home. In other words, Ireland may have increased deposit insurance to stem an inefficient outflow of its panicking depositors. In doing so it forced other EU countries to follow suit, even if depositors in these other countries continued to coordinate amongst themselves.

It is difficult to justify a move to full deposit insurance with a beggar-thy-neighbour policy. If there are enough aggregate deposits in the two countries the foreign government may increase its insurance to ensure that their citizens deposit domestically. However, the fact that the insurance is so high that it attracts foreign agents is actually a negative side effect, because it makes providing deposit insurance more expensive. If this happens it is by mistake and not optimal according to the model. Can we capture the beggar-thy-neighbour rationale by a liquidity shock in which case some depositors withdraw for an unmodeled reason and leave too few desposits in the system? It turns out that a liquidity shock can explain the events in the EU in fall 2008 through a beggar-thy-neighbour story. However, it is not entirely clear whether funds left the banking system as a whole. For example, Gatev and Strahan (2006) show that the funding position of banks improves with liquidity shocks in the commercial paper market, a phenomenon that they attribute to the tendency of governments to protect the banking sector in times of crisis. Also, while wholesale depositors did withdraw money from the interbank market the European Central Bank countered with massive liquidity injections.

References

Acharya, V. (2003). Is the International Convergence of Capital Adequacy Regulation Desirable?, Journal of Finance, 58(6), 2745-2782.

Acharya, V. (2009). A Theory of Systemic Risk and Design of Prudential Bank Regulation. Journal of Financial Stability, 5, 224-55.

Allen, F., & Gale, D. (2000). Bubbles and Crises. The Economic Journal, 110, 236-255.

Bhattacharya, S., Boot, A., & Thakor, A. (1998). The Economics of Bank Regulation. Journal of Money, Credit, and Banking, 30, 745-770.

Bloomberg (2008a) Hypo Real Estate Says Banks Withdrew Rescue Support (Update1), by Hellmuth Tromm, Bloomberg 4 October 2008. Retrieved 6 June 2011.

Bloomberg (2008b) Hypo Real Gets EU50 Billion Government-Led Bailout, by Brian Parkin and Oliver Suess, Bloomberg 6 October 2008. Retrieved 6 June 2011.

Bhattacharya, S., & Jacklin C. (1988). Distinguishing panics and information-based bank runs: Welfare and policy implications, Journal of Political

Boot, A., Dezelan, S., & Milbourn, T. (2000). Regulatory Distortions in a Competitve Financial Services Industry. Journal of Financial Serbices Research, 249-259.

British Bankers Association. (2008). BBA statement on Irish guarantee, 1 October 2008. Retrieved 15 March 2009 from the British Bankers Association: http://www.bba.org.uk

Calzolari, G. & Loranth, G. (2005). Regulation of Multinational Banks: A Theoretical Analysis. European Central Bank, Working Paper 431.

Cooper, R. & Ross, T. (1998). Bank Runs: Liquidity Costs and Investment Distortions. Journal of Monetary Economics, 41, 27-38.

Dalen, D. M., & Olsen, T. E. (2003). Regulatory Competition and Multi-National Banking. CESifo (Munich Society for the Promotion of Economic Research), Working Paper 971.

Dell'Ariccia, G., & Marquez, R. (2006). Competition among Regulators and Credit Market Integration, Journal of Financial Economics, 79, 401-430.

Demirgüç-Kunt, A., Kane, E. J., & Laeven, L. (2008). Determinants of Deposit-Insurance Adoption and Design. Journal of Financial Intermediation, 17, 407-438.

Diamond, D., & Dybvig, P. (1983). Bank runs, deposit insurance and liquidity, Journal of Political Economy , 91 (3), 401-419.

Eisenbeis, R. & Kaufman, G. (2008). Cross Border Banking and Stability in the EU. Journal of Financial Stability, 4, 168-204.

European Commission (2008). State aid: overview of national rescue measures and deposit guarantee schemes, 14 October 2008. Retrieved on 8 April 2009 from Press Release RAPID: http://europa.eu/rapid/

European Commission (2011). Legislation > state aid temporary rules established in response to the economic and financial crisis. Retrieved on 18 October 2011 from http://ec.europa.eu/competition/state_aid/legislation/temporary.html

European Union (1994). Directive 94/19/EC of the European Parliament and the Council of the European Union (on deposit-guarantee schemes). Retrieved on 26 March 2009 from EurLex: http://eur-lex.europa.eu/

European Union (2009). Directive 2009/14/EC of the European Parliament and the Council of the European Union (amending Directive 94/19/EC on deposit-guarantee schemes as regards the coverage level and the payout delay), Official Journal of the European Union, 11 March 2009.

Financial Times (2008). Ireland guarantees six banks' deposits. Financial Times 30 September 2008. London and Dublin, UK.

Garcia, G. (1999). Deposit Insurance - A Survey of Actual and Best Practice. International Monetary Fund Working Paper WP/99/54, Washington, D.C.

Gatev, E. and P. Strahan (2006) Banks' Advantage in Hedging Liquidity Risk: Theory and Evidence from the Commercial Paper Market, Journal of Finance 61(2), 867-892.

Government of Denmark (2008). Denmark guarantees that depositors and senior debt will not suffer any losses in banks and savings banks in Denmark. Ministry of Economic and Business Affairs. Copenhagen: Ministry of Finance.

Government of Ireland (2008). Government Decision to Safeguard Irish Banking System. Government of Ireland, Department of Finance.

Hardy, D., & Nieto, M. (2011). Cross-Border Coordination of Prudential Supervision and Deposit Guarantees. Journal of Financial Stability 7, 155–164.

Hoggarth, G., Jackson, P., & Nier E. (2005). Banking crises and the design of safety nets, Journal of Banking & Finance, 29 (1), 143-159.

Huizinga, H., & Nicodeme, G. (2006). Deposit insurance and international bank liabilities. Journal of Banking and Finance, 965-987.

International Association of Deposit Insurers. (2008). Deposit Insurance Systems. Retrieved March 23, 2009, from IADI: http://www.iadi.org/deposit.html

Forum on Cross-Border Financial Groups (2009). Cross-border Banking in Europe: What Regulation and Supervision? UniCredit Group, Discussion Paper March 2009: http://www.unicreditgroup.eu/ucg-static/downloads/cross_border_banking_discussion_paper.pdf

Kane, E. (2003). What Kind of Multinational Deposit-Insurance Arrangements Might Best Enhance World Welfare? Pacific Basin Financial Journal, 11, 413-428.

Laeven, L, and F. Valencia (2010). Resolution of Banking Crises: The Good, the Bad, and the Ugly, IMF working paper 10/146.

Levy, A and A Zaghini (2010): "The pricing of government-guaranteed bank bonds", Bank of Italy Working Papers, no 753.

Morrison, A.D. and L. White (2011): "Deposit Insurance and Subsidized Recapitalizations", Journal of Banking & Finance, 35, 3400-3416.

Panetta, F., T. Faeh, G. Grande, C. Ho, M. King, A. Levy, F. Signoretti, M. Taboga and A. Zaghini (2009): "An assessment of financial sector rescue programmes", BIS Papers, no 48, July.

Reuters (2008). Austria follows Germany in raising deposit guarantee, Reuters Regulatory News, 5 October 2008: http://www.reuters.com/article/2008/10/05/financial-austria-deposits-idUSL516435820081005 (retrieved on 8 April 2009).

The Economist (2008). "Lifelines," The Economist, 9 October 2008.

8 To be done or to be considered

8.1 Small issues

1. Under the subsection "Government" we write:

Note that the tax is a general revenue tax. It is not financed by a direct deposit insurance premium which would influence agents actions and allow for more control. This makes the analysis easier, yet it is more realistic to the extent that existing funded bank insurance pools are inadequate to handle banking system crises.

We should support this claim with a reference.

2. We will have to make a call how we will summarise what constituted Germany's response. At the moment we say:

"Proposition 3 helps us identify when the home government (Germany in our example) would respond with complete deposit insurance, $d = 1$. The home government only provides effective deposit insurance when it chooses the DB Equilibrium. Then it chooses $d = \widetilde{d} \geq 1 - \frac{\varepsilon}{pR}$. Observe that $d \to 1$ as $\varepsilon \to 0$. Thus, the home government would response with very high deposit insurance when the transaction cost ε is sufficiently small and the conditions for the DB Equilibrium are satisfied.". But the European case currently makes the case that the empirical counterpart of full DI is full liability insurance. In our case, Ire moved to full DI, but Germany did not respond by full DI.

8.2 Countries or sectors?

Philipp Schnabl pointed out at the presentation of the Dutch Central Bank that the model may also capture competition between sectors that are governed by two distinct regulators. The example he gave had to do with an “almost accident" in the recue attempt of money market funds in the US. If I recall well he said a rescue attempt of the money market funds was blocked by chance as the banking sector regulator pointed out that it would have a negative effect on the banking sector and compete away deposits. I forgot the details by he used the example in one of his papers and there is a study describing the event. Of course in this case regulators cooperated in the end, by practice could have been different in the spur of the moment

8.3 Depositor withdrawal data

I asked two orf three experts at the Dutch Central Bank conference on data. I asked for example whether daily withdrawal data can ever be retreived. Well... not really. The only chance of success would mean we would have to go through indl banks. Regulators (who get the best info) do not get daily deposit flow data. At best they have monthly data.

8.4 Extentions

- Govts which are maxed out (Credibility of DI & particularly the move $d^* = 1$)
- Explore link between $b-p$, and $1-B$? Specifically, presumably in reality a greater share loose agents (i.e. $1-B$ high, i.e. B low) put more pressure on the sector, so a reasonable assumption would be that

$$b - p = g(\overset{-}{B})$$

- Three different people at SFU pointed out we could/should incorporate the effect of competition for deposits. This is perhaps not too tough to model. We could assume that local banks, hence indirectly depositors, carry a share of $1 - s$ of the burden of DI. The remainder s is collected through lump-sum taxation and is hence essentially a subsidy to the local sector. The greater is the subsidy s, the greater is the net return on deposits. The introduction of s will clearly impact the decision of depositors and hence becomes a potential source of regulatory competition. Is this a relevant issue at all? I think it is. The current situation is that DI payout is harmonized to E100,000. But the EU

Commission is crafting further legislation to harmonize DI, including the funding model. I have downloaded relevant proposed legislation. However, nobody at the more specialist & active audience at the Dutch Central bank made this point.

8.5 Stackelberg versus (dynamic) Bertrand?

For me it would be more natural to cast the policy game in a Bertrand (simulataneous-move) context. And it won't take that long to do this. If we go this route, I think it may be possible to have parameters for which the policy game becomes a coordination game. Who knows it may even be possible to get parameters for which the game is a prisonners' dilemma game.

- Strategic complements/substitutes literature does not really apply. This is an equilibrium selection setting. The nicest equivalent would be one in which the govt game is a prisoner's dilemma. Neither benefits from choosing DI high, but choosing DI high is an eqm in dominant strategies. That is, responding with $d = d_p$ is a BR given either $d^* = 0$ or $d^* = d_p$. The challenge is to understand the move of Ireland, i.e. understanding why $d = d_p$ is a BR given either $d^* = 0$ (to state this in terms of the local govt.)

———-

Old material:

The joint assumptions of coordination on the essential equilibrium and “high enough" stress ratios leads to a powerful result. The first Proposition below will show that if the two banking sectors offered similar return if they were each funded with one unit of deposits, then the unique policy equilibrium is that both governments choose ineffective deposit insurance ($d = d^* = \frac{r}{R}$). Moreover, this policy equilibrium implies the efficient DB Equilibrium in which no depositors move abroad ($D = D^* = 1$). Thus, deposit insurance is kept at a minimum and the efficient outcome prevails in which depositors deposit domestically: non-cooperation between the countries achieves the cooperative outcome.

Before we turn to that proposition let us first give a brief intuitive statements about finding the policy equilibrium. First, Proposition 5 applies. This means that if d and d^* satisfy inequalities 6 and 7 then the essential equilibrium is the DB Equilibrium. However, recall that unfortunately the essential-equilibrium refinement does not yield any resolution to the multiple-equilibrium issue if these are the HLL and the FLL Equilibria.

Second, welfare levels decrease in the level of deposit insurance within equilibriums because higher insurance levels are associated with a higher deadweight loss. By implication policy equilibria (d, d^*) can potentially only lie on the lower-left boundary of areas in which we have a single banking equilibrium. For example, as indicated the DB Equilibrium prevails as the single (essential) banking equilibrium between the lines $\underline{d}_{\text{DB}}(.)$ and $\overline{d}_{\text{DB}}(.)$. So if this area contained the policy equilibrium, it would have to be its lower-left boundary, $d = d^* = \frac{r}{R} = \frac{1}{3}$.

Third, for given binding levels of (d, d^*) the welfare level associated with the DB Equilibrium is strictly higher than the welfare level associated with attracting loose depositors from abroad. This is because, by assumption, loose depositors from abroad do not further contribute to the stability of a banking system that already absorbs all available domestic deposits. Since this is true at home and abroad, we have:

$$W_{\text{DB}}(d) > W_{\text{FLL}}(d) \text{ for } d > \frac{r}{R} \text{ and } W^*_{\text{DB}}(d^*) > W^*_{\text{HLL}}(d^*) \text{ for } d^* > \frac{r}{R}$$

Here W and W^* indicate home and foreign welfare levels, respectively, and the applicable equilibrium is indicated by the subscipt.

Finally, for high enough stress ratios it is unattractive for domestic governments to see their loose depositors leave. Specifically, as the proof of the proposition below reveals, under the assumptions that $\frac{b}{p} \geq \frac{1}{B}$ and $\frac{b^*}{p^*} \geq \frac{1}{B^*}$ we have $W_{\text{DB}}(d) \geq W_{\text{HLL}}(d, d^*)$ and $W^*_{\text{DB}}(d^*) \geq W^*_{\text{FLL}}(d, d^*)$.