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

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Abstract

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. Policies are chosen to attract depositors who optimally respond to the expected return to deposits, which depends on both stability and deposit insurance levels. We identify both defensive and beggar-thy-neighbour policies. The model sheds light on the European banking crisis of 2008 in which individual nations ratcheted up their deposit insurance levels.

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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.
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> 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 rapid loss of deposits to the foreign country were it not to respond. A rapid loss of deposits would stress the home country's banking system exposing it to a much 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 country's coverage.

In our model deposit insurance involves a net cost to society because of a presumed dead-weight loss of taxes that fund possible insurance payouts. Therefore, countries would choose not to provide (effective) deposit insurance in the absence of international bank competition. We find that if countries are sufficiently similar, non-cooperation nevertheless leads to an unique, welfare-maximizing symmetric equilibrium without effective deposit insurance. We argue that this equilibrium roughly describes the initial situation in the EU where deposit guarantees were 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 presumably cover this amount.

We next try 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 various shocks that impact the home and foreign countries asymmetrically can indeed rationalize the increase. The foreign government may increase its deposit insurance coverage purely as a defensive measure to ensure that their citizens continue to deposit domestically. In this case, attracting foreign deposits may actually be a negative side effect of picking a high level of deposit insurance, because it makes providing deposit insurance more expensive. However, the model may also generate beggar-thy-neighbour policies that lead to full deposit insurance. Such policies may result from a prisoner's dilemma situation. However, if the beggar-thy-neighbour policy were only from Ireland, as suggested in the lead quote, the situation does not 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

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. In a recent study King (2012) analyzes the impact of the comprehensive banking sector rescue packages announced in October 2008. Using a sample of 78 large financial institutions in 12 OECD countries, he finds that the rescue packages affected funding costs of banks (credit default swap spreads) differentially across countries. He also finds negative correlation of bank stock returns around the announcement moments and interprets this as suggesting "...cross-border competition effects, with banks receiving favorable government support outperforming foreign rivals."

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,

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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 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) and the EU is working towards further harmonisation of deposit insurance schemes.

[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

national regulators competitively 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 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 behaviour.[4] We analyze the level of deposit insurance as the key policy variable affecting the optimal location choice of deposits and possible herding behaviour. 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 foreign full deposit insurance. Section 4 solves the general model. Section 5 documents the relevant events that occurred during the European

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.

[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.

financial crisis in 2008. Section 6 applies the model to analyze the European case and in that context develops the beggar-thy-neighbour model. Section 7 concludes.

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 realized.

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 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 and each depositor is endowed with one unit of a homogenous good. Depositors maximize their expected return by choosing to

[5] Foreign variables will be marked by an asterisk superscript. Under our assumptions it is sufficient to model just 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. An alternative asset, storage with gross return 1, is dominated in return if bank returns and deposit insurance together always yield a gross return of at least 1. If this is not the case, storage results in additional "bank run" equilibria. Though we don't model it, low levels of deposit insurance may serve the purpose of stabilizing the banking system by making storage less attractive.

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 deposits in a system that is dissimilar and remote. Note that total world deposits shall always amount to 2 units since depositors deposit either domestically or abroad.

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 so that they never move their deposits abroad. Alternatively, think of bound depositors as having no other opportunities than to deposit domestically. By contrast, 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 and has B^* bound and $1 - B^*$ loose depositors.

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".

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 banks pay out in full, and with failure depositors claim the residual r.

The European banking crisis was characterized by the banking systems of several countries

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

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 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), so we postulate an inverse relationship between the probability of failure, P, and the aggregate level of deposits, denoted D: we have $P'(D) \leq 0$.

We adopt the following short-hand notation for convenience: $g \equiv P(2-B)$, $p \equiv P(1), =$ and $b \equiv P(B)$, where g, p and b are all probabilities of banking sector failure (with varying levels of deposits) and satisfy $0 < g \leq p < b \leq 1$. When all foreign loose deposits are in the home country, we have $D = 2 - B$ and $P(2 - B) = g$. If $g < p$ home banking stability increases with an influx of foreign deposits. Further, if the difference $g - p$ is large, then it is efficient for one country's banking system to dominate the international market. In the bulk of the paper, we examine the case $g = p$ where scale economies are already in place before the crisis and deposits from abroad do not enhance stability. Throughout, we assume $g > 0$, since banks may fail due to internal causes such as mismanagement, "bad luck", etc., besides inadequate funding. Finally, 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 banking sector failure from the home loose depositing abroad.

The foreign banking system is treated symmetrically. The foreign failure function is $P^* = P^*(D^*)$, where D^* is the level of deposits held at the foreign bank. We assume $R^* = R$ and $r^* = r$, so that 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.[8] Specifically, g^* may differ from g, p^* from p, and b^* from b.

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

[8] 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*.

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 fire sale"). 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 is similar to Diamond and Dybvig (1983). Their model implicitly has no failures and a 'high' return when patient types do not withdrawal early. This is analogous to our model if $D = 1$ implied no failure, that is, $P(1) = p = 0$ and hence a high return of R. Conversely, the case when all patient depositors withdraw early in Diamond and Dybvig is like our case $D = B$ if $P(B) = b = 1$ so that $D = B$ means the return is 'low', $r = 1$. 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. Diamond and Dybvig have a two-period model, however, they assume that when agents deposit in banks in period 0 they do not consider the possibility of a bank run in period 1.[9] We do not explicitly model illiquidity or liquidity preferences as they are not essential to our results. The banking subgame is kept simple to keep the deposit insurance game tractable.

[9] 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 like in our model. When the probability of a bank run is small, the results in Diamond and Dybvig are robust.

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 $\max[r, dR]$. 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 assumption is made without loss of generality and allows us to drop the maximum operator in our equations. The construction is the same for the foreign deposit insurance rate: $\frac{r}{R} \leq d^* \leq 1$.

2.5 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 U^{B} is the utility of a bound depositor, U^{L} the utility of a loose depositor, T the tax paid by each home citizen, and $c \geq 0$ the deadweight loss from taxation expressed as a rate.[10] It is

[10] 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

the net cost of financing deposit insurance. We have:

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

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

The government budget constraint above is consistent with an actuarially fair insurance payment.[11]. It ensures that the tax revenue T matches the (expected) cost of providing deposit insurance. The tax is strictly positive only if deposit insurance is effective ($d > \frac{r}{R}$). Observe 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 also 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 behaviour 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

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.

[11] 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.

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

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

Now consider home loose depositors. Their net return from investing in the foreign country 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 $\varepsilon \geq P(D)R(1-d)$. This equation indicates that the home loose deposit at home when the cost of depositing abroad, ε, exceeds 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 also be rewritten in terms of the deposit insurance level d. 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 depositors 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 maximum:

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

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 $1-B$ 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 Equilibria 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 equilibria 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 banking equilibrium. Specifically, we assume home loose depositors coordinate on the *essential equilibrium,* the equilibrium that gives home loose depositors the greatest utility in the intermediate interval $[d_p, d_b)$. The essential equilibrium refinement yields a level of deposit insurance, $\widetilde{d}$ say, 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* $d \in [\widetilde{d}, 1]$,

where $\widetilde{d} = \max\{d_p, \min\{d^\tau, d_b\}\}$ *and* $d^\tau \equiv \frac{r}{R} + \frac{\bar{\varepsilon}-\varepsilon}{R[bB+(bB-p)c]}$ *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) $d = d_p$ *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 $T_{\mathrm{DB}} \leq T_{\mathrm{HLL}}$ 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 continuously 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 $d^* = 1$

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 $W_{\mathrm{DB}}(\widetilde{d})$ because it minimizes the deadweight loss from taxation. The government can also choose a HLL Equilibrium 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 deadweight loss of taxation) is preferable 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 $\frac{b}{p} \rightarrow \frac{1}{B}$ 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, $\frac{b}{p} \rightarrow \frac{1+c}{B}$, or when $c > 0$ is small enough. In both cases, (3) is satisfied. Conversely, for $\frac{b}{p} \rightarrow \frac{1}{B}$, $\varepsilon \rightarrow 0$ 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 $\varepsilon \rightarrow \overline{\varepsilon}$, 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 $\frac{b}{p} \rightarrow \frac{1}{B}$. The numerator is bounded below when evaluated at $\widetilde{d} \rightarrow d_p$ 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 $\frac{b}{p} \rightarrow 1$ 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, Proposition 3 implies that free riding on foreign deposit insurance may be the best policy even when $c = 0$. This happens with low stress ratios, which indicate little damage is done to the stability of the home banking system if the home loose leave.[12]

Proposition 3 helps us identify when the home country (Germany in our leading quote) would respond with a quite drastic increase in deposit insurance after the foreign country (Ireland) moves to full deposit insurance. The home government only provides effective deposit insurance when it chooses the DB Equilibrium. It then chooses $d = \widetilde{d} \geq 1 - \frac{\varepsilon}{pR}$. Since $d \rightarrow 1$ as $\varepsilon \rightarrow 0$ the home government would respond with "high" deposit insurance when the transaction cost

[12] 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, $d = r/R$ and the subsequent 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.

ε is "small" and the conditions for the DB Equilibrium are satisfied. The following corollary summarises.

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 "high" (near complete deposit insurance $d \to 1$) when the transactions cost ε is "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 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 the most conducive to a rational home government responding with very high deposit insurance to almost match $d^* = 1$.[13] Not competing by raising deposit insurance in these circumstances would result in a greater probability of banking failure, and impact homebound depositors sufficiently much so to reduce home country welfare.

4 The General Analysis

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

[13]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.

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:

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

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

Notice that 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

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

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

that is $\underline{d}_{\mathrm{DB}}(d^*) \leq d \leq \overline{d}_{\mathrm{DB}}(d^*)$. Observe that $\underline{d}_{\mathrm{DB}}(d^*) < 1$, $\underline{d}_{\mathrm{DB}}(d^*) < \overline{d}_{\mathrm{DB}}(d^*)$ 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 $\overline{d}_{\mathrm{DB}}(d^*) \geq \frac{r}{R}$. Otherwise, foreign loose agents are always better off depositing in the home country and the DB Equilibrium does not exist. It can be shown that 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 $d^* = 1$, foreign depositors neglect the risk p^* because their domestic 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 satisfied; that is, if and only if

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

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; that is, if and only if

$$d > 1 + \frac{\varepsilon^*}{gR} - \frac{b^*}{g}(1 - d^*) \equiv \underline{d}_{\mathrm{FLL}}(d^*) \tag{9}$$

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

(ii) *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 $d < \overline{d}_{HLL}(d^*)$*

(iii) *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 $d > \underline{d}_{FLL}(d^*)$.*

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 Equilibrium exists without the refinement. With the refinement, a HLL Equilibrium cannot be an essential equilibrium because home loose depositors as a group are better off depositing domestically for $d^* = 1$, by Corollary 1, and therefore 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 equilibrium. 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 symmetry 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's 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.

The analysis that follows is somewhat more technical and we have relegated the proofs of the three propositions of this subsection to an appendix in the back. Also, we focus the analysis with the following assumptions, which we maintain throughout:

Assumption 1 *(i) The marginal deadweight loss of providing deposit insurance is positive $c > 0$ and $c^* > 0$; (ii) $p = g$ and $p^* = g^*$, i.e. the home and foreign banking systems have reached economies of scale after $D = 1$ and $D^* = 1$, respectively; (iii) when possible, depositors coordinate on essential equilibria in the banking subgame; (iv) the stress ratios are in the medium to high range $\frac{b}{p} \geq \frac{1}{B}$ and $\frac{b^*}{p^*} \geq \frac{1}{B^*}$.*

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

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

where the subscripts indicate the banking arrangement (e.g. $W^*_{\mathrm{FLL}}(d^*, d)$ 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 (independently of d^*). Similarly, for a given d^*, domestic banking gives higher foreign welfare (independently 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.*

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, when the stress ratio is high enough there is a net loss from loose deposits moving abroad 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 argue later, this equilibrium describes the European situation before the 2008 banking crisis, where a relatively low level of deposit insurance (€20,000 per depositor in most countries) 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.*

If the condition $p^* - p \in \left[\frac{-\varepsilon}{R-r}, \frac{\varepsilon^*}{R-r}\right]$ is satisfied then $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ 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 of the proposition in the appendix 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 depicted 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 Germans deposit in Ireland) and, therefore, is the focus of the analysis below. Specifically assume $b - p^* \geq \frac{\varepsilon}{R-r}$.[14] 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 policy pair $(d, d^*) = (\frac{r}{R}, \frac{r}{R})$,

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

which welfare dominates other policies, is now is in a region with two essential equilibria, the FLL Equilibrium and the HLL Equilibrium (see Figure 2). For simplicity let us select one of these essential equilibra in this region using a sunspot, where depositors coordinate on the HLL Equilibrium with probability q, and the FLL Equilibrium with probability $1-q$. Let the sunspot probability q be independent of d^* and dIf we do this we find that there are two thresholds for the sunspot probability that are used to separate the domestic banking equilibrium from the loose leave equilibria are:

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

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 that 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 $q_{LL} < 1$ and the exogenous 'sunspot' probability is sufficiently large, $q > \max\{q_{DB}, q_{LL}\}$. 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 $1-q$.*

We use this result later on when we examine the possibility that the 2008 crisis affected EU countries 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 most 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 French branches of a German bank are covered by Germany'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.[15]

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.[16]

[15] 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)).

[16] 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.[17] 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 hands 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 Treaty Articles on State Aid (see e.g. European Commission, 2011).

[17] 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).[18] 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 6 EU countries (France, Germany, Italy, the Netherlands, Spain, and the United Kingdom) announced liability guarantee programmes between 8-14 October 2008. They also 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 the bulk of bank deposits in EU countries were uninsured, and (ii) starting in September 2008 levels

[18] 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.

of deposit insurance and other types of liability insurance increased drastically. In this section we try to explain the drastic changes in European deposit insurance using the logic of regulatory competition in our model.

Initial low levels of deposit insurance are desirable in our model because deposit insurance involves a deadweight loss. Proposition 7 predicts ineffective deposit insurance whenever the banking systems are somewhat symmetric. 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 of deposit insurance prevailed in most European countries before the crisis, and 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, the situation prior to September 2008 would correspond to what we have termed ineffective deposit insurance.

What changed during the crisis? Below we explore a number of potential explanations suggested by the model. The changes lead to responses that are distinguished into two groups, namely, first, responses that are best described as defensive, and, second, beggar-thy-neighbour policies.

6.1 Defensive Responses to the Financial Crisis

6.1.1 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 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, which, we saw, Germany did not.

In order to support this scenario consider that policy makers may be uncertain about the level of the model parameters, for example regarding the levels of p and ε^*.[19] Under such uncertainty rational policy makers could choose higher insurance levels than in Proposition 8. This is because a policy error of raising deposit insurance to a level which is insufficiently high to prevent a crisis, could be very costly, while, at the same time, the extra cost of full deposit insurance is relatively small when c is relatively small.

With uncertainty the situation may have been the following. The increase in $p^* - p$ combined with a possible spike in the Irish stress level b^*/p^* could have spurred Ireland to "err on the safe side" with $d^* = 1$. Facing $d^* = 1$, Germany'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 $\varepsilon \to 0$. Interestingly, in this scenario such a German response is welcomed by the Irish as it encourages German loose depositors to stay at home and hence reduces the cost of deposit insurance for Ireland.

In this scenario, the Irish move to full deposit insurance is clearly not a beggar-thy-neighbour policy (whether or not they anticipated as reaction by Germany). However, Germany was justifiably upset by the Irish move to full deposit insurance as this presented the country with a high deposit insurance potential liability and forced a policy $volte - face$.

6.1.2 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.[20]

[19] 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). This suggests that their rushed actions were made in a context with considerable uncertainty.

[20] 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

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).

Continue therefore to assume that the crisis impacted banks in EU countries asymmetrically. However, now suppose that both German and Ireland banking sectors were vulnerable to losing 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 did not increase deposit insurance, and provided less support to their banking sectors than Ireland and Germany (see e.g. Laeven and Valencia, 2010). According to the model, the move by Ireland and Germany actually benefited such safer countries as it avoided a costly influx of deposits.

6.1.3 Depositors Panicked

What would happen if the financial crisis manifested as an expectations shock? Suppose Irish depositors 'panicked' and failed to coordinate on the essential DB Equilibrium. Without the essential banking equilibrium refinement, low deposit insurance yields the uncertainty 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 depositing abroad by raising deposit insurance to a high level; i.e. to a point in Figures 1 and 2 below the (green) $\underline{d}_{\text{FLL}}(d^*)$ line where only the HLL Equilibrium obtains. Unfortunately, this response necessarily involves the extra insurance cost of attracting German depositors. Nevertheless, 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.

2008. On October 6 a €50 Bln Hypo rescue package by the German Government and German banks was adopted (Bloomberg 2008).

With the Irish moving to high deposit insurance, the new situation may not be a policy equilibrium. In particular, if Germany has a very high stress ratio, Germany would be better off responding by raising their deposit insurance level. However, this would invoke a response by Ireland and so on.

With Irish depositors panicking, a policy equilibrium could exist at very high levels of deposit insurance in the top right-hand corner in the figures; i.e. below the (green) $\underline{d}_{\mathrm{FLL}}(d^*)$ line; and above the red $\underline{d}_{\mathrm{DB}}(d^*)$ line (if German loose depositors coordinate) or the brown $\overline{d}_{\mathrm{HLL}}(d^*)$ line (if German depositor do not coordinate). The scenario reveals that depositors panicking (by not coordinating) 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.

6.2 A Beggar-thy-neighbour Model and Responses to the Financial Crisis

None of the above scenarios describe a "beggar-thy-neighbour" motive for increasing deposit insurance. Insurance is increased to retain domestic deposits. Attracting deposits from abroad is a costly side effect because it involves providing insurance to nonresidents. Under Assumption 2, where $g = p$ and $g^* = p^*$, there are no stability benefits to increasing the scale of the banking system beyond servicing domestic depositors.

6.2.1 A Beggar-thy-neighbour Model

We can model a beggar-thy-neighbour situation by examining the case $g < p$ and $g^* < p^*$. Now increasing the scale of the home banking system by attracting foreign deposits improves its stability. The benefit to the home country is $(p - g)(R - r)$, which is the expected gain to all home depositors from the lower failure risk. This is a beggar-thy-neighbour benefit because it can be achieved only at the expense of making the foreign banking system less stable.

When the beggar-thy-neighbour benefits for both countries are sufficiently small relative to the associated costs (of moving deposits and raising deposit insurance), the equilibria are unchanged from Propositions 7 and 8. However, if the benefit is sufficiently great, then the countries may face a prisoner's dilemma with full deposit insurance as the outcome.

For a simple analysis, let us make assumptions which give the most intense competition in the banking subgame (stage 1). Assume transaction costs are very small ($\varepsilon \to 0$) and that loose depositors coordinate by depositing in the country with the highest posted deposit insurance rate; if both countries post the same rate, all depositors deposit domestically. These assumptions are consistent with depositors maximizing their rate of return net of the transactions cost in equilibrium. They also result in depositors switching countries to pursue marginally higher deposit rates and governments choosing marginally higher deposit rates in a race to full insurance.

In the Nash game between countries (stage 2), each country's choices boil down to one of three effective choices. The home country will either choose to: set an ineffective rate ($d > \frac{r}{R}$), match the foreign deposit insurance rate ($d = d^*$), or just beat it ($d = d^* + \Delta$, where $\Delta > 0$ is very small). Just beating the foreign rate attracts foreign deposits and earns the beggar-thy-neighbour benefit $(p - g)(R - r) > 0$. Consider the total cost of this policy for the home country. In the event of a banking failure, the home country incurs the deadweight loss from insuring domestic depositors, $c(dR - r)$, plus the costs of insuring the $(1 - B)$ depositors from abroad, $(1 - B)(1 + c)(dR - r)$. Thus, the expected cost is $g[c + (1 - B)(1 + c)](dR - r)$. With full deposit insurance, the beggar-thy-neighbour benefit exceeds the total cost when $g < p/(1 + c)(2 - B)$. With a similar condition for the foreign country, both countries have an incentive to just beat the other's posted rate in a race to full deposit insurance.[21]

But even if no such similar condition holds in the home country deposit insurance level can ratchet up. Facing foreign full deposit insurance, the home country's best response is to match

[21] This sketch omits some important technical issues. For finite small values of ε, home loose deposit abroad if and only if $d^* \geq d + \Delta(\varepsilon)$, where $\Delta(\varepsilon) > 0$ is the corresponding small minimum increment in insurance needed to compensate them for incurring the transactions cost. Thus when faced with $d^* = 1$, the best response is to set $d = 1 - \Delta(\varepsilon) - \epsilon < 1$,where $\epsilon > 0$ is infinitesimally small. Assume countries have the same parameter values. Then, the foreign government, taking d as given, would (wanting to save on deposit insurance costs) undercut their rate to $d^* = 1 - 2\Delta(\varepsilon) - 2\epsilon$. From this point the home government would raise deposit insurance to $d = 1 - \Delta(\varepsilon) - \epsilon$.This cycling near full deposit insurance can be stopped by imposing a refinement, cost or other impediment. For example, suppose rates can only be set discretely at set fractions L, so that only 1, $1 - L$, $1 - 2L$... are feasible. Then when $L \geq \Delta(\varepsilon)$, the Nash equilibrium is $d^* = d = 1$.

it whenever the conditions in Corollary 2 (e.g. high stress ratio) are satisfied. Either way the beggar-thy-neighbour policy is ultimately self defeating in this scenario because the quantities deposited in each country in equilibrium are the same as they would be with ineffective insurance levels.

6.2.2 Changes in the Risk of Bank Losses

Initial ineffective deposit insurance is generated by the model when the beggar-thy-neighbour benefit is so small that it does not to matter. If the benefit mattered in the crisis, then the difference $p^* - g^*$ must have increased. Even without a similar change in parameters for Germany, there would still be a race to full deposit insurance. In this race, Germany wants to match the Irish rate rather than beat it.

In this asymmetric scenario, Germany is the victim of an Irish beggar-thy-neighbour policy. The policy is unambiguously aggressive if the change in p^* was still within the bounds described in Proposition 7. Those bounds describe the range of $p^* - p$ where it is not necessary for Ireland to change from ineffective deposit insurance to protect itself from capital flight. On the other hand, if the change in p^* was large enough to lie outside the bounds (e.g. as described in Proposition 8), then Ireland had to raise its deposit insurance rate, at least somewhat, to prevent capital flight. If it mistakenly set the rate too high as described in Section 6.1, then there is an alternative motive for the Irish action in the model. In either scenario, the Irish move to raise deposit insurance was self defeating and myopic as Germany responded. Of course, if Germany was also shocked with an increase in $p - g$, then the situation is a prisoner's dilemma as described in the previous subsection. In a prisoner's dilemma setting neither country is myopic but both suffer from being uncooperative.

The above analysis assumes that countries can instantly benefit from a sudden large net inflow of deposits. An inflow of deposits might help assuage expectations in the very short run. However, it puts banks in the difficult situation of finding ways to invest extra funds in a crisis. For this reason we provide a second beggar-thy-neighbour scenario.

6.2.3 Liquidity Shocks

A beggar-thy-neighbour situation may be triggered by a liquidity shock which removes some existing deposits from the banking system. Then there is a scarcity of overall deposits and, as we show with an example, attracting deposits from abroad has a benefit.

For simplicity, assume that parameters are symmetric across countries. Suppose that $\frac{1}{2}(1-B)$ loose depositors from each country receive a liquidity shock and withdraw their deposits from the banking system for reasons that are unmodeled (for instance, they have preferential access to a safe asset or investment in a third country).[22] Now let the probability of failure when both countries retain their domestic loose depositors be $P(B + \frac{1}{2}(1 - B)) = l$, where $p < l < b$.

In this setting, countries may face a prisoner's dilemma where full deposit insurance is the outcome.[23] Choosing higher deposit insurance, when feasible, is a best response as it lures in the $\frac{1}{2}(1 - B)$ depositors from abroad and achieves the lowest the probability of failure, p. If there is already full deposit insurance abroad, the best response is to match it in order to retain domestic loose deposits. This gives a probability of failure l, whereas not matching a higher probability of failure b. The equilibrium has full deposit insurance in both countries. This a prisoner's dilemma as both countries are better off with ineffective deposit insurance.

7 Conclusion

In this paper deposit insurance is determined by competition between nations. In our two-country model deposit insurance levels are chosen non-cooperatively. Deposit insurance levels affect international deposit flows. Countries play a balancing act between minimizing the net

[22] In a financial crisis, one contender for a liquidity shock could be wholesale depositors who in 2008 withdrew money from the interbank market. We have also learnt from the episode of the global financial crisis that other possible contenders could be collapses of other segments of the wholesale funding market, such as, for example, the commercial paper market (Kacperczyk and Schnabel, 2010). On the other hand, the European Central Bank countered with massive liquidity injections. Interestingly, Gatev and Strahan (2006) find 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.

[23] As analysed above, a prisoner's dilemma arises when the parmeters related to the beggar-thy-neighbour benefit and stress ratio (here $b - l$ and $l - p$) are large enough and costs (low c and ε) are low enough. To ensure an equilibrium in pure strategies, we need to use a refinement, cost or impediment as described above.

costs of deposit insurance provision and preventing a possible capital flight which could destabilize the domestic banking system. Our model completely abstracts from the standard normative rationales for deposit insurance; if countries are symmetric both are best off without deposit insurance. Nevertheless, the 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 the model, depositors each maximize expected returns of their deposits and hence react to a cross-country difference in the deposit insurance rate. But the relationship between deposit insurance and the actions of depositors involves multiple equilibria because the joint actions of depositors determines the funding position of banks and hence the returns to banking. 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 home deposit insurance. The flight of the footloose stresses the home banking system in the absence of a response by the home government. We characterize when the home government rationally responds with full insurance.

A more difficult task is to understand the dramatic initial changes in deposit insurance policy. A key event in our analysis of the European banking crisis was Ireland's sudden unilateral adoption of full deposit insurance. Our review the history of the crisis suggests a number of triggers in our model that rationalize a response of with higher deposit insurance. We categorize the responses into defensive responses, that unintentionally affected other nations, and beggar-thy-neighbour responses. Depending on the triggers and uncertainty, the motive for behaviour may or may not be identified in the model. Examining the strengths and weaknesses of the various scenarios uncovers some of the complexity of the political economy.

Overall, the analysis demonstrates the value in modeling deposit insurance as a positive phenomenon. By highlighting the non-trivial interaction between local regulators, our basic model addresses some fundamental features underlying international banking in a world with ever more integrated financial markets.

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A Proofs Propositions of Section 4.2

A.1 Proof of Proposition 6

First, prove the above welfare inequalities hold. Consider

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

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

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

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

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

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

A.2 Proof of Proposition 7

When $p^* - p \in \left[\frac{-\varepsilon}{R-r}, \frac{\varepsilon^*}{R-r}\right]$ policies $(d^*, d) = (\frac{r}{R}, \frac{r}{R})$ satisfy the condition $\underline{d}_{\text{DB}}(d^*) \leq d \leq \overline{d}_{\text{DB}}(d^*)$, for the existence of an essential DB Equilibrium (in Proposition 5). 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 $\underline{d}_{\text{DB}}(d^*) \leq d \leq \overline{d}_{\text{DB}}(d^*)$ 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 $d > \overline{d}_{\text{DB}}(d^*)$. The home government can increase its welfare by deviating to a lower level of deposit insurance, say $\widehat{d} = \max\{\frac{r}{R}, \underline{d}_{\text{DB}}(d^*)\} < d$. 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 $W_{\text{DB}}(\widehat{d}) > W_{\text{DB}}(d) \geq \max[W_{\text{HLL}}(d^*, d), W_{\text{FLL}}(d)]$ under Assumption 1.

Finally consider policies (d^*, d) where $d < \underline{d}_{\text{DB}}(d^*)$.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 $d = \overline{d}_{\text{DB}}(\widehat{d}^*)$. Foreign welfare is greater because $W^*_{\text{DB}}(\widehat{d}^*) > W^*_{\text{DB}}(d^*) \geq \max[W^*_{\text{FLL}}(d^*, d), W^*_{\text{HLL}}(d^*)]$ under Assumption 1.

A.3 Proof of Proposition 8

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 $\overline{d}_{\text{DB}}(d^*) = \frac{r}{R}$. 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 its insurance rate, $d^* > 1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]$. Between $\underline{d}_{\text{DB}}$ and $\underline{d}_{\text{FLL}}$ the sunspot determines either the HLL or FLL equilibrium. To the right of $\underline{d}_{\text{FLL}}$ only the HLL Equilibrium exists. However, the foreign government is best off with a DB Equilibrium because $W^*_{\text{DB}}\left(1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]\right) > W^*_{\text{DB}}(d^*) \geq \max[W^*_{\text{FLL}}(d^*, \frac{r}{R}), W^*_{\text{HLL}}(d^*)]$. Similarly, the home government cannot improve its welfare by increasing from $\frac{r}{R}$ to $d > \frac{r}{R}$, as $d^* > 1 - \frac{\varepsilon^*}{p^* R} - \frac{p}{p^*}\left[1 - \frac{r}{R}\right]$ and Assumption 1 show $W_{\text{DB}}\left(\frac{r}{R}\right) > W^*_{\text{DB}}(d) \geq \max[W_{\text{FLL}}(d^*, d), W_{\text{HLL}}(d)]$. 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 maximized 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

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

or equivalently $q \leq q_{DB}$. Thus, the 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 $d = \frac{r}{R}$. The 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 infinitesimal 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

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

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

Figure 1. Symmetry between the Home and Foreign banking sectors.

R=1.5; r=0.5; p=p*=5%; b=b*=30%; eps=eps*=0.01

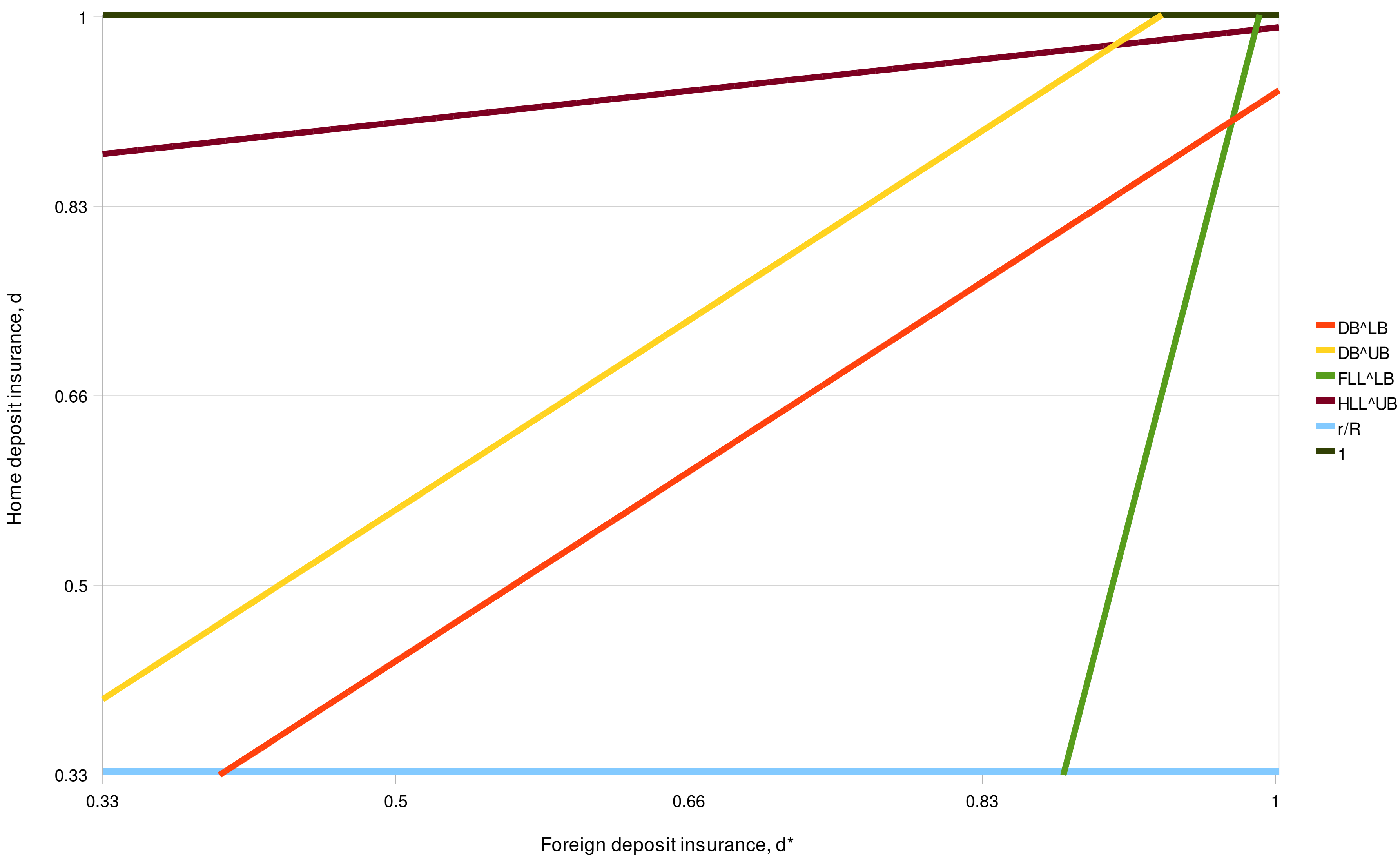

Figure 2. Foreign banking sector is riskier than the Home banking sector.