# International Liquidity Sharing: Evidence from Financial Crises

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November 30, 2010

**Abstract**

This paper explores the role of multinational banking in shock propagation. International spillovers arise from bank linkages that transmit shocks across markets. I model and then test the bank's liquidity sharing mechanism using a new measure for bilateral bank holdings constructed from over 90,000 holding company level linkages. I consider funding shocks originating from financial crises and analyze the resulting dynamics in lending at affiliate branches. Estimates suggest that a one standard deviation increase in crisis exposure results in a 1.5% contraction in lending at branches outside of the crisis country. I find that greater liquidity constraints arise if banks also raise deposits in the crisis country which induces additional contractions in lending. However banks with non-depository assets in the crisis country face capital shocks that can distort lending incentives. Then using the model's prediction that greater deposit stability can amplify capital constraints while dampening liquidity constraints, I construct a triple differences identification strategy to show that credit contractions follow the geography of banking at both the micro bank and macro aggregate level.

This is the main chapter in my dissertation and I would like to thank the members of my committee Zhiguo He, Anil Kashyap, Sam Kortum, and Raghuram Rajan for thoughtful comments. The paper also benefited from discussions with Roni Kisin, Alexi Savov, and Louis Serranito. All errors are of course my own.

## 1 Introduction

Does financial intermediation alter the dynamics of risk sharing across regions or countries? We have seen in the last financial crisis that the banking sector can play a key role in the transmission of shocks. However, while we have seen from Peek and Rosengreen (1997, 2000), Schnabl (2010), and Cetorelli and Goldberg (2008) that multinational banks propagate liquidity shocks, our understanding of the importance of this mechanism and its consequences for regional risk sharing is still limited. The focus of this paper is to investigate how funding shocks originating from exposure to financial crises impact a bank's lending at its affiliate branches. In particular, I show that the same mechanism that generates gains to diversification also leads to comovements in the supply of loanable funds across countries. This in turn suggests that one consequence of financial globalization is that bilateral bank linkages can result in synchronized cross-country lending and investment.

I model and then test this mechanism using a new measure for bilateral bank linkages constructed from data on over 90,000 holding company level cross-country linkages encompassing banks from 100 countries. Basic tests at the aggregate level reveal one main stylized fact, presented in Table 1, that countries with greater bank linkages exhibit increased comovement in aggregate investment and output. However the main focus of this paper is on shock dynamics following adverse liquidity shocks. To provide a formal framework to analyze this channel, I extend the model from Liu (2010) to a two region setting and investigate the impact of aggregate productivity shocks on the supply of loanable funds. The setup consists of a standard overlapping generations neoclassical growth framework and incorporates a depository financial intermediary. The model plays off the potential mismatch between liquidity needs in different countries and cross country lending following adverse productivity shocks. The bank's ability to share liquidity across borders allows it to avoid prematurely liquidating some loans and raises the equilibrium rate of return to depositors. While this allows for diversification gains, it also results in positive comovements in lending and investment.

The purpose of this paper is to identify how funding shocks originating from financial crises create spillovers which are transmitted to affiliate bank branches. Suppose for instance that Barclays has branches in the US and UK. I investigate how a financial crisis in the US impacts Barclays' lending in the UK and whether this has a real effect on output and investment. According to the model's prediction, an adverse shock reduces the bank's overall supply of liquidity so that it decreases lending not just in the US but in the UK as well. I indeed find that lending contractions at affiliate branches are increasing in crisis exposure and a one standard deviation increase in exposure results in a 1.5% contraction in lending at affiliate branches. Furthermore, the potential magnitude of this mechanism is large since bank assets comprise a significant component of cross-country debt. This suggests that international banking can synchronize credit contractions and expansions at both the holding company and aggregate level. The bank's liquidity sharing may thus leave economies exposed to international developments in credit markets.

While this banking mechanism suggests that we should expect to see greater comovements in lending and even macro aggregates, distinguishing this channel from other linkages that can result in similar outcomes is empirically challenging. Moreover, most studies in this literature such as Peek and Rosengreen (2008) and Schnabl (2010) focus on banks from one country. Limited data availability and endogeneity issues make it challenging to identify this effect on a broad scale. To address these issues, I construct a dataset that allows me to identify funding shocks to banks from over 100 countries. I then differentiate between liquidity and capital constrained banks and consider how the stability of a region's deposits can amplify or dampen these constraints. This generates unique shock propagation dynamics that I use to identify lending contractions emanating from credit supply shocks.

To separate between shocks to bank capital and shocks to liquidity, I first distinguish between two types of exposures: non-depository asset exposure versus depository institution exposure. Banks that raise deposits in the crisis country will face a reduction in both the value of their banking assets as well as declines in deposit funding. In contrast, the crisis will result in an adverse shock to the value of the non-depository assets but not holding company deposits and short term funding. Therefore, non-depository asset exposure in a crisis country is likely to be a source of shocks to capital, while depository institution exposure will result in shocks to both capital and liquidity. If deposits decline in the crisis country, this may cause the balance sheet to shrink so that the shortfall in regulatory capital may be quite minimal, while the transmitted liquidity shock is much greater. Banks with greater non-depository asset exposure are hence more likely to become capital constrained whereas those with greater depository institution exposure experience greater liquidity constraints.

I then consider how the stability of a bank's depositor base (its deposit elasticity) impacts these two constraints. Consider a bank holding company's affiliate branches in countries with more stable (less elastic) deposits so that there are smaller declines in inflows following the shock. If the bank holding company is primarily liquidity constrained due to its crisis-country depository institution holdings, then the stable deposits would offset its funding constraints so that it can increase lending. However, if the bank holding company is capital constrained due to greater non-depository assets, then it responds to additional deposit inflows by shifting its portfolio towards liquid assets. By investing in zero risk-weighted assets, it can concurrently maintain a larger balance sheet as well as lower capital level requirements. It will therefore contract lending and increase its securities holdings in stable-deposit countries. I will test this prediction in the empirical section and use the implication that while less elastic deposits can ameliorate liquidity constraints, they can also exacerbate capital constraints.

Continuing the example from before, now suppose that Santander also has branches in the United States as well as Spain. However Barclays raises deposits in the US whereas Santander only owns non-depository assets. Following the crisis, Barclays experiences loan losses as well as declines in deposits which leads to a large funding shock. Since both its capital and liabilities decline, Barclays faces a greater liquidity constraint but not significant capital impairment. Santander sees a decline in its asset values but not its funding in Spain and therefore experiences a large capital shock. As a result, Barclays becomes primarily liquidity constrained whereas Santander becomes capital constrained. However, both cut back lending in the US, UK, and Spain due to the decline in holding company liquidity.

As a result of this decline in lending and hence economic activity, we see that deposit elasticities in both the UK and Spain as well as the United States can amplify feedback effects through additional deposit inflow declines. If Barclays sees smaller declines in deposit inflows in the UK, it exhibits a smaller lending contraction since additional funding can lessen its liquidity shortfall. In contrast, if Spain also has a stable depositor base, then these additional inflows can exacerbate Santander's capital constraint. In order for Santander to accommodate greater liabilities, it must tilt its portfolio toward liquid securities. A capital constrained bank often cannot lend these additional funds since this will cause its assets to increase at a much faster rate than its capital and therefore decrease its capital ratio. As a result, Santander, which is capital constrained due to its non-depository asset exposure, may see greater lending contractions if it is based in countries with stable deposits. However if Barclays, which raises deposits in the US and therefore faces greater liquidity constraints, has branches in areas with stable deposits, it will experience a smaller lending contraction.

This distortion therefore generates a unique prediction that I use to identify the banking channel at both the aggregate country and micro bank level. This strategy allows for a broad analysis of international shock transmission to show that this liquidity sharing is a pervasive consequence of multinational banking. The empirical analysis employs four features of cross-country pairs that the model predicts should influence the strength of spillovers. First, I isolate financial crises that occurred from 1990 through 2007 as plausibly exogenous shocks to aggregate output and bank conditions. Second, I exploit the cross-border patterns that connect some country pairs and not others. Third, I account for cross-country linkages that involve both deposit and lending operations as well as those that are limited to non-depository assets. Fourth, I draw on demographic variation that impacts deposit elasticities and can therefore mediate the impact of liquidity effects.

Using a differences in differences methodology, I first test the implication that banks with deposit exposure face greater liquidity constraints and therefore exhibit larger contractions in lending. However, banks with non-depository asset exposure are more likely to become capital constrained in which case they will cut lending as well. In the bank level analysis, I first form a control and treatment group by exploiting variation in holding company level asset and deposit exposure. I then identify changes in post crisis lending behaviors at affiliate branches in non-crisis countries. The results provide robust evidence that banks with crisis exposure decrease lending and that depository institution exposure results in greater liquidity shocks. On average, a one standard deviation increase in asset exposure leads to a 1% decline in lending while an analogous increase in deposit exposure leads to a 2% decline following the crisis. I then test these implications at the aggregate country level and find that countries with greater bilateral bank holdings experience greater declines in aggregate investment and output following a crisis. The estimates imply that moving from the 25th to 75th percentile in country level depository institution exposure can lead to a 0.7% decline in aggregate investment following a crisis.

The analysis then uses the deposit elasticity predictions to construct a triple difference methodology to identify the bank lending channel. In addition to the basic differences in differences framework, I use heterogeneity in non-crisis country deposit stability to examine how these feedback effects interact with crisis exposure. As a measure for deposit elasticities, I use country and regional demographics data. The rationale behind this measure is as follows: since countries offer a social security or pension network so that senior citizens are guaranteed a constant income stream, the impact of a shock should be smaller in areas with a higher concentration of seniors. This third layer therefore compares across banks with depository and non-depository institution exposure in areas with different underlying demographics to test these implications.

I first employ this triple differences strategy at the bank branch level. Perhaps the most compelling evidence is that non-depository asset exposure results in significant capital ratio reductions and these effects are amplified in areas with low deposit elasticities. As a result, capital constrained banks exhibit greater lending contractions and increase their securities holding. Moreover, I split the sample based on the holding company capital ratio and find that this effect is concentrated among banks within poorly capitalized holding companies. This strongly supports the hypothesis that greater deposit stability can amplify capital constraints and distort lending incentives which then delivers these shock dynamics. Also, banks with depository institution exposure lend more in areas with lower elasticities since for liquidity constrained banks, a greater concentration of seniors can lessen funding constraints. I find the same distortion in the aggregate country and regional level analysis which suggests that these linkages can distort cross-country risk sharing.

This paper contributes to the existing literature by deriving a model that incorporates deposit contracting into a standard growth model and then using its implications to identify the bank liquidity sharing channel. I use its prediction that greater deposit stability can dampen liquidity shocks while amplifying capital shocks to motivate the empirical strategy and identify a unique shock propagation distortion. I then test these implications on a broad cross-country dataset for 30 financial crises which overcomes the limitations of other empirical studies in that it shows that liquidity sharing is a pervasive mechanism. The paper provides evidence that greater comovements in country level bank lending are a ubiquitous effect of financial globalization. Furthermore, these banking channel spillovers have the potential to distort and alter risk sharing dynamics.

The paper proceeds as follows: Section 2 reviews the related literature and Section 3 introduces the model setup. Section 4 solves for the equilibrium. Section 5 then discusses the data and Section 6 provides the methodology and the main empirical results. Section 7 conducts robustness checks and Section 8 concludes.

## 2 Literature Review

The model mostly combines insights from the financial intermediation literature with those from the international business cycle literature. One building block is Allen and Gale (1997) who explore the role of financial intermediation in the diversification of aggregate risk across time. Their work addresses the intermediary's ability to accumulate reserves and provide individuals with a constant payoff or deposit rate. Liu (2010) uses this same principle by studying a similar OLG production economy and shows that demandable deposits amplify investment volatility and generate a real liquidity financial accelerator. It also incorporates elements of Diamond and Rajan (2009). They look at how the supply of liquidity fluctuates with depositor needs for liquidity. In their model, an increase in depositor withdrawals results in a liquidity shortage and banks must call in their long term projects. The same mechanism operates in my model.

The analysis uses this banking mechanism to identify the role of financial intermediation in international risk sharing. We see that the bank's liquidity sharing mechanism generates positive comovements in investment and hence output. This contrasts with the standard international business cycle model of Backus and Kehoe (1992) which cannot match the empirical positive comovement in investment and output. Recent papers have also begun to explore the impact of credit frictions under perfect capital mobility. One example is Perri and Quadrini (2010) who explore a Kiyotaki and Moore (1997) type collateral shock in an international economy. In these papers, a shock to firms' ability to borrow uniformly increases the global cost of credit and as a result, consumption, output, and investment are perfectly correlated. However, output shocks still generate the same predictions as the standard model and the friction arises from a shock to firms' ability to pledge collateral.

On the empirical side, Peek and Rosengren (1997) is the first paper to show that country specific shocks can be transmitted to bank branches in other countries. They show that negative shocks to Japanese banks' domestic portfolios resulted in contractions in subsidiary lending in the US. Morgan et al (2004) show that US banking deregulation resulted in decreased volatility in state business cycles. They argue that this is evidence that increased financial integration leads to greater comovements in macro aggregates. These analyses though are isolated to banks in one country so the results may not be general. Cetorelli and Goldberg (2008) show that following the 2007 financial crisis, there was a significant decline in aggregate bank flows to developing countries. However their data only includes aggregate country level bank holdings. Most papers in the financial integration literature look at general financial linkages (the extensive margin) and since there are many potential linkages that may propagate these shocks, causality is hard to prove.

I also consider the role of deposit funding shocks on bank lending. Kashyap and Stein (2000) show that the monetary policy transmission mechanism matters more for banks that rely more heavily on deposits for funding. Since then other papers have explored the importance of funding shocks on bank lending. Kwaja and Mian (2008) exploit random nuclear tests in Pakistan as liquidity shocks and then trace their impact on lending at other branches. Various studies have also considered how capital requirements impact bank portfolios. Peek and Rosengren (1995) is the most similar in that they find that capital constrained banks shrink deposits in order to meet their capital requirements.

## 3 Model Assumptions

The model extends the economy from Liu (2010) to a two region framework. The setup uses a standard OLG neoclassical growth framework and incorporates deposit contracting. Agents in the economy face ex-ante unknown liquidity preference shocks as in Diamond Dybvig (1983) so the bank can offer improved risk sharing through deposit contracting. Individuals therefore invest with an infinitely lived financial intermediary that accumulates capital during good times and pays out of this reserve when it experiences negative shocks. Each generation of agents invest their labor income with the bank which must first meet withdrawals from past generations before allocating funds for investment. Premature loan liquidation occurs if returns and new inflows are insufficient to meet withdrawals. Therefore the bank's optimal portfolio includes liquid assets to hedge this loan liquidation risk. In a two region setting, the bank's ability to avoid liquidation by transferring funds allows for gains to diversification and generates positive comovements in lending.

This framework formalizes the mechanism through which multinational banking can result in synchronized credit contractions and expansions. It is intended to model the relationship between deposit inflows and withdrawals, investment returns, and aggregate uncertainty as they pertain to the bank balance sheet. The model thus allows for an analysis of the financial intermediary's optimal investment allocations following a shock. I then consider the role of deposits in liquidity sharing and their impact on liquidity and capital constraints. Finally, the model also delivers predictions regarding how deposit elasticities can amplify or dampen these constraints.

*Economy.* I assume that there are two identical regions. Let asterisks $*$ denote foreign country quantities. All trading occurs at time 0.

*Agents.* There are overlapping generations of three-period lived agents (and an initial "old" generation in period zero). There are a fraction $\alpha$ of "early" consumers that only derive utility from consuming in the first period and a fraction $(1-\alpha)$ of "late" consumers that derive utility from consuming in the second period. Agent liquidity preferences are ex-ante unknown as in Diamond Dybvig (1983). Agents work in period zero and supply labor inelastically for some wage rate $w_t$ and $w_t^*$ determined by the production technology. They then invest this money with the financial intermediary which guarantees them a rate of return $r_{1t}$, $r_{1t}^*$ if they withdraw in one period and $r_{2t}$, $r_{2t}^*$ if they wait two periods to withdraw. Individuals in both regions have identical preferences for consumption and liquidity and labor is immobile.

*Financial Intermediaries.*

There is one representative financial intermediary in each country with a depository liability structure that offers rates of return $r_{1t}$ and $r_{2t}$ to depositors. It invests in a portfolio of the safe and risky assets, $\{S_t,\ I_t^h,\ I_t^{h*}\}$, respectively and let $I_t = I_t^h + I_t^{h*}$ denote total investment. Capital is perfectly mobile across countries so that banks can both invest in capital and set up depository branches abroad. A fraction $-1 \leq \gamma_t \leq 1$ of the home county's funds can flow to the foreign country. Let $\{\lambda,\ \lambda^*\}$ denote the bank's deposit market share in each country and $\{\rho_t, \rho_t^*\}$ are the fraction of assets liquidated in each country in period $t$. If investment must be liquidated at an intermediate date, it earns a liquidation value of $0 < V < 1$. I assume that the intermediary operates in a perfectly competitive industry so that its maximization problem is equivalent to agent utility maximization given as:

$$max_{\{r_{1t},r_{2t},r_{1t}^*,r_{2t}^*\}} \quad \sum_{t=0}^{\infty} \beta^t \left[\lambda\left(\alpha U(r_{1t}w_tL) + (1-\alpha)U(r_{2t}w_tL)\right) + \lambda^*\left(\alpha U(r_{1t}^*w_t^*L) + (1-\alpha)U(r_{2t}^*w_t^*L)\right)\right]$$

$$subject\,to$$

$$\pi_t + S_t + (I_t^h + I_t^{h*}) \leq \lambda w_t L + R_t I_{t-2}^h$$
$$+\lambda^* w_t^* L + R_t^* I_{t-2}^{h*} + S_{t-1} + \rho_t V_{t-1} + \rho_t^* V_{t-1}^*$$

Where $\pi_t = \lambda(\alpha r_1 w_{t-1}L + (1-\alpha)r_2 w_{t-2}L) + \lambda^*(\alpha r_1 w_{t-1}^* L + (1-\alpha) r_2 w_{t-2}^* L)$ is the amount of deposit withdrawals in period $t$. The left hand side of the intertemporal constraint is equal to the amount of withdrawals plus portfolio investments in each period. The right hand side is the value of production in that period plus any proceeds from liquidation and investment in the liquid asset from the previous period. The foreign bank faces the same maximization problem except that its market share of deposits are $(1-\lambda)$ and $(1-\lambda^*)$.

*Goods.* There are two goods: a capital good and a consumption/output good. Output produced in period t can be consumed in period t or invested in either the safe or risky asset. The safe asset $S_t$ is essentially a storage technology that translates into one unit of output in the next period. The risky assets $I_t$, $I_t^*$ produce a unit of capital in two periods and it is assumed that the expected price of capital is worth more than one unit of the consumption good. Capital cannot be consumed but it can be used in the production of output. For simplicity, I assume that capital fully depreciates in two periods.

*Production Technologies.* There is one production technology for output, a CES production function which uses capital and labor. I assume that production occurs in a perfectly competitive industry. $A_t \sim U(0, x)$, $A_t^* \sim U(0, x)$ are random iid aggregate productivity shocks. For simplicity, I assume that the goods are perfect substitutes so that $y_t = A_t r I_{t-2} + A_t L$ and analogously, $y_t^* = A_t^* r I_{t-2}^* + A_t^* L$ for some $r > 1$ although I generalize the equilibrium in the appendix.

## 4 Equilibrium

The following section presents the equilibrium allocations and main propositions that will form the basis of the empirical tests. All proofs and derivations are contained in the appendix.

***Definition 1.*** *An equilibrium is defined as a policy function for investment, liquidation, and banking structure* $\{I_t,\, I_t^*,\, S_t,\, S_t^*,\, \rho_t,\, \rho_t^*, \gamma_t,\, \gamma_t^*, \lambda, \lambda^*\}$ *and rates of return* $\{r_{1t},\, r_{2t},\, r_{1t}^*,\, r_{2t}^*\}$ *such that the representative agent's problem is maximized, the bank's portfolio maximizes expected rates of return, and markets clear. A steady state equilibrium is a time invariant policy function which holds for all t.*

***Proposition 1.*** *The equilibrium values of* $r_1$ *and* $r_2$ *are budget feasible iff*

$$(\alpha r_1 \bar{w} L + (1-\alpha) r_2 \bar{w} L) + (\alpha r_1 \bar{w}^* L^* + (1-\alpha) r_2 \bar{w}^* L^*) \leq$$
$$(1-\bar{\rho})\bar{R}(\bar{w}L - \bar{S}') + (1-\bar{\rho}^*)\bar{R}^*(\bar{w}^* L^* - \bar{S}^*) + \bar{S} + \bar{\rho}\bar{V} + \bar{\rho}^*\bar{V}^*$$

*Where* $\bar{\rho}\bar{V} = E(\rho_t V_t)$ , $\bar{\rho}^*\bar{V}^* = E(\rho_t^* V_t^*)$, $\bar{S} = E(S_t)$, $E(w_t L) = \bar{w}L$ $E(w_t^* L^*) = \bar{w}^* L^*$,$\bar{R} = E(R_t)$, *and* $\bar{R}^* = E(R_t^*)$ *are the expected values for liquidation, liquid assets, labor income, and risky asset returns and* $\bar{S}' + \bar{S}^* = \bar{S}$ . *Banks offer the same deposit rates in both countries*

The intuition here is that the deposit rates cannot be more than the expected payoff from the optimal investment policy. The left hand side is the expected value of withdrawals by early and late consumers in each period. The first two terms in the right hand side are equal to the expected return to capital since expected investment in each period is equal to labor income net of the amount invested in the short asset. The other two terms consist of the average liquid asset holding $\bar{S}$ plus the expected liquidation payoff $\bar{\rho}\bar{V} + \bar{\rho}^*\bar{V}^*$.

***Proposition 2.*** *If there is no uncertainty in the economy such that* $A_t r = A_t^* r = \bar{\mu}$ *for all t, we have that there is no liquidation risk so that* $S_t = 0$*, and the optimal policy is to invest new inflows entirely in the risky asset such that*

$$I_t = \bar{\mu}\left(\lambda f(I_{t-2},\, L) + \lambda^* f(I^*_{t-2},\, L^*)\right) - \pi_t = \lambda \bar{w} L + \lambda^* \bar{w}^* L^*$$

*and* $I_t^h = I_t^{h*}$*. Deposit rates, are set so that* $r_1 = \frac{\sqrt{\alpha^2+4(1-\alpha)\bar{\mu}}-\alpha}{2(1-\alpha)}$ *and* $r_2 = r_1^2$*. Banking structure is irrelevant.*

***Proposition 3.***

*Following an unanticipated shock at t and continued uncertainty at time t + 1, the policy function for investment in the liquid asset is:*

$$S_t = \begin{cases} \pi - (\lambda+\lambda^*)\eta\left(f(I^*_{t-1}, L) + f(I_{t-1}, L)\right) & if\ \rho_t = 0 \\ 0 & if\ \rho_t > 0 \end{cases}$$

*where* $\eta = (\frac{\bar{R}}{2} + \frac{(\beta\bar{R}-1)x^*V}{2(\beta\bar{R}-V)})$ *and* $\pi_{t+1}$ *is equal to deposit withdrawals at t+1, and* $\bar{R} = E(A_t)$

*Then the steady state equilibrium policy function for investment* $I_t = I_t^h + I_t^{h*}$ *is:*

$$I_t = \begin{cases} \lambda A_t f(I_{t-2}, L) + \lambda^* A_t^* f(I^*_{t-2}, L) + S_{t-1} - S_t - \pi_t & if\ \rho_t = 0 \\ 0 & if\ \rho > 0 \end{cases}$$

*Moreover, we have that* $I_t^h = I_t^{h*}$*so that* $\gamma_t$ *is set to equate investment in both countries.*

*The optimal intertemporal state dependent liquidation decision can be given as follows*

$$\rho_t = \rho_t^* = \begin{cases} 0 & if\ \ \lambda A_t f(I_{t-2}, L) + \lambda^* A_t^* f(I^*_{t-2}, L) + S_{t-1} > \pi_t \\ \frac{\pi_t - \lambda A_t f(I_{t-2},L) - \lambda^* A_t^* f(I^*_{t-2},L) - S_{t-1}}{2V} & if\ \ \lambda A_t f(I_{t-2}, L) + \lambda^* A_t^* f(I^*_{t-2}, L) + S_{t-1} < \pi_t \end{cases}$$

*The optimal banking structure is any* $0 \leq \lambda = \lambda^* \leq 1$

## 4.1 Predictions

***Prediction 1.*** *Diversification implies equal lending in both countries. Therefore a negative shock in one country induces lending contractions at both branches. The bank can also transfer liquidity from its other branch to avoid liquidating loans. Moreover, due to the bank's precautionary liquidation hedging motive, the optimal liquid asset holding* $S_t$ *is countercyclical.*

This follows directly from propositions 1 and 3. There are two main deviations from the standard international business cycle model that arise in this setup. The first is that the liquidity sharing mechanism results in positive comovements in lending and investment due to the cost of liquidation. The intuition behind this banking mechanism is as follows: if the bank invests or raises a fraction of its deposits abroad, then a shock in one country can be spread across it branches in both countries. From proposition 1, we see that the bank's ability to transfer liquidity across branches with uncorrelated returns allows for it to avoid liquidation and thus generates lower holdings of the liquid asset $S_t$ and hence greater lending. Gains to diversification therefore arise from the intermediary's ability to avoid costly liquidation by transferring liquidity from its other branch and this mechanism also leads to synchronized lending. Moreover, the bank lends equally in both countries due to labor immobility.

The second implication comes from the amplification mechanism generated by demandable deposit contracting. The optimal liquid asset holding is increasing in expected withdrawals and decreasing in maturing loans $I_{t-1}$ and similarly $I^*_{t-1}$. Therefore, an increase in the optimal liquid asset holding following a negative shock exacerbates the liquidity shortage. Since there is lower anticipated production when the investment matures but constant deposit withdrawals in each period, there is a greater probability of liquidation and as a result, a greater marginal return to hedging this risk. Therefore liquidity hoarding will further reduce the supply of credit as the bank increases investment in the liquid asset to hedge against the anticipated decline in output in future periods.

**Ex 1.** Suppose that Santander has branches in Spain and the United States. It raises 200 of deposits in Spain in each period and assume that its investment at time $t-2$ and $t-1$ was 100 in each country and it holds 20 in securities. The deposit rate is 10%, the expected rate of return to loans is 20%, $\alpha = .5$ so that half of depositors withdraw in one period and the rest in two periods, and the discount rate is equal to one. Let $V$ be set so $\eta = .5$ and the optimal liquid asset holding equals $S_t = \pi_{t+1} - I_{t-1} - I^*_{t-1}$. [1] Now suppose that at time t, there is a shock to loan returns in the United States so that the bank receives a -20% return. Total funds available for investment are

$$\underbrace{1.2*100+.8*100}_{loan\,returns}+\underbrace{20}_{S^s_{t-1}}+\underbrace{(200)}_{inflows}-\underbrace{1.1*200}_{withdrawals}= \quad 200$$

Therefore, the bank can only lend 90 in each country since its optimal liquid asset holding remains unchanged since $S^s_t = 1.1*(200) - 200 = 20$. The countercyclical optimal liquid asset holding occurs at time $t+1$, and $S^s_{t+1} = 1.1*200 - 180 = 40$ since expected withdrawals remain unchanged but there is a significant decline in expected maturing loans.

***Prediction 2.*** *Banks that raise deposits in the shock hit region have correlated deposit inflows and therefore exhibit greater contractions in lending.*

This result is immediate since a bank with both investment and deposits abroad will receive a shock to both its capital returns and deposit inflows. It experiences a greater reduction in its total supply of liquidity induced by declines in deposit inflows which generates a greater contraction in lending following a negative shock.[2]

[1] For simplicity, I assume that expected deposit inflows equal $(1-.5r)(I_{t-1}+I^*_{t-1})$. Furthermore, $\eta$ captures the liquidation return tradeoff and is a function of expected returns to maturing loans and the liquidation value. The liquid asset holding is decreasing in the liquidation value $V$ and the loan return $\bar{\mu}$.

[2] The majority of the crisis countries in my sample did not instate deposit insurance until after the crisis as documented by Demirgu-Kunt et al (2008). Therefore, there was no flight to safety so this is a plausible prediction.

**Ex 2.** Suppose that Barclays has branches in the UK and United States. It raises 100 of deposits in the US and 100 of deposits in the UK in each period and otherwise holds the same portfolio as Santander. Now assume that the same shock hits the United States and causes its loan returns to decline to -20% and moreover, wages in the US decline as well so that new deposit inflows are 80. Total funds available for investment are

$$\underbrace{1.2*100+.8*100}_{loan\,returns}+\underbrace{20}_{S^b_{t-1}}+\underbrace{180}_{inflows}-\underbrace{1.1*200}_{withdrawals}= \quad 180$$

Therefore, the bank can only lend 85.5 in each country since $S^b_t = 1.1*(90+100)-200 = 9$. Once again, the countercyclical optimal liquid asset holding occurs at time $t+1$ and $S^b_{t+1} = 1.1*(90+100)-171 = 38$.

***Prediction 3.*** *However, Banks that do not raise deposits in the shock hit region may experience greater declines in their capital ratios.*

By definition, capital to equal the expected (market) value of the bank's assets net of its liabilities to depositors. Since the Basel capital ratio is defined as capital divided by risk weighted assets, I give the liquid asset a 0% risk weighting and the risky asset has a 100% weighting. So we get that

$$\tau \quad = \quad \frac{\kappa}{\nu - S_t}$$

Where $\kappa$ is the capital level and $\upsilon$ are total assets. It is immediate that a negative shock to asset returns generally decreases this ratio since capital and assets decrease by the same amount. However, the opposite can be true for a shock to labor income since the ratio is decreasing in deposit inflows if the loan-deposit spread is less than the current capital ratio times $\bar{\mu}$, i.e. $(\bar{\mu} - \alpha r_1 - (1-\alpha)r_2) < \bar{\mu}\tau$. [3]

To give intuition for why this occurs, consider when the bank experiences a one dollar decline in deposit inflows which it invests entirely in the risky asset. Capital is reduced by $(\bar{\mu} - \alpha r_1 - (1-\alpha)r_2)$ but assets decline by $\bar{\mu}$ and shrink by a faster rate than capital. This is because the capital level only decreases by the surplus but its assets go down by the full inflow amount. When the interest rate spread is less than $\bar{\mu}\tau$, we see that the ratio actually increases. So a decline in deposit inflows can create a natural deleveraging effect if the bank also raises deposits in the shock hit region. Therefore, if the bank only has asset exposure, then a negative shock can cause a greater reduction in the capital ratio.

[3] The values for capital and total assets are given formally in the appendix along with prediction derivations

***Prediction 4.*** *Although there is regional segmentation in labor income and hence consumption, the general equilibrium effect implies that the greater the elasticity of deposit inflows to investment levels, the greater the magnitude of the contraction in lending for liquidity constrained banks.*

Since individuals do not hold equity directly, the channel through which a shock in one country is transmitted to the other must be through a decline in investment which subsequently impacts deposit inflows if the wage rate is dependent on the level of investment in the economy. Although shocks are iid, wages are still linked through the decline in investment. The greater the decline in wages, the more elastic deposit inflows are to investment levels. The bank decreases lending in both countries so that when this investment matures, if deposits are elastic, then inflows decline in both regions. This then results in greater shock propagation in both countries.

**Ex 2. cont.** Now assume that at time $t+1$ Barclays, which is not capital constrained, receives 110 in loan returns in each country and deposit inflows are unchanged. Total available funds are then:

$$\underbrace{110+110}_{loan\,returns}+\underbrace{9}_{S_t^b}+\underbrace{200}_{inflows}-\underbrace{1.1*190}_{withdrawals}=\quad 230$$

So Barclays lends 96 in each country since we know that $S_{t+1}^b = 38$. Now at time $t+2$, suppose that deposit inflows are elastic and decline by $\triangle$ and recall that investment at time $t$ was 171 and returns are 20%. Then Barclays' total funds are:

$$\underbrace{1.2*171}_{loan\,returns}+\underbrace{38}_{S_{t+1}^b}+\underbrace{(200-\triangle)}_{inflows}-\underbrace{1.1*190}_{withdrawals}=\quad 234.2-\triangle$$

So total lending is equal to $206.2-.45\triangle$ since $S_{t+2}^b = 1.1*(100+100-.5*\triangle)-192 = 28-.55\triangle$. Therefore, the greater the decline in deposit inflows $\triangle$, the greater the shortfall in lending.

***Prediction 5.*** *For poorly capitalized banks, a low deposit elasticity can amplify the capital shock so that we see greater declines in lending.*

Recall that prediction 3 states that banks with only asset exposure experience greater declines in their capital ratios. Similarly, areas with greater deposit elasticities (and thus greater declines in deposit inflows) also experience a natural deleveraging effect and can actually face smaller declines in their capital ratios following the shock. Banks with asset exposure in areas with low deposit elasticities should therefore expect to see the greatest capital ratio declines.

Poorly capitalized banks also have an incentive to increase their liquid asset holding since this may cause a smaller decline in the capital ratio. This is because riskless securities receive a zero risk weighting so increased holdings do not increase risk weighted assets. As seen from Prediction 3, lending can potentially increase assets by a much faster rate than they increase capital thus causing additional declines in the capital ratio. Therefore capital constrained banks that desire to buffer their capital ratio may instead increase their securities holding. Banks with greater asset exposure in areas with low elasticities are also predicted to experience the largest capital ratio declines so these banks are the most likely to shift their portfolios towards securities holdings.

**Ex 1. cont** Assuming that loan returns are 220 and deposit inflows remain unchanged at time t+1, we see that the total supply of loanable funds for Santander becomes:

$$\underbrace{220}_{loan\,returns} + \underbrace{20}_{S_t^s} + \underbrace{200}_{inflows} - \underbrace{1.1*200}_{withdrawals} = \quad 220$$

Therefore investment is 90 in each country since from before we have that $S_{t+1}^s = 40$. Now consider what happens when Santander sees a decline in deposit inflows of $\triangle$ at time $t+2$ in Spain. Total liquidity is equal to:

$$\underbrace{1.2*180}_{loan\,returns} + \underbrace{40}_{S_{t+1}^s} + \underbrace{200}_{inflows} - \underbrace{1.1*200}_{withdrawals} = \quad 216$$

At time $t+2$, we get that $S_{t+2}^s = 1.1*(200-.5\triangle) - 180 = 40 - \triangle * 0.55$. Total investment is therefore $176 - \triangle * .45$. So risk weighted assets are equal to

$$RA = \quad \underbrace{1.2*180}_{\substack{expected\,returns \\ to\ t+1\,loans}} \quad \underbrace{+1.2*(176-\triangle*.45)}_{\substack{expected\,return \\ to\ t+2\,loans}}$$

Capital is equal to risk weighted assets plus securities holdings net of total liabilities:

$$RA \quad \underbrace{+40-\triangle*0.55}_{liquid\,asset\,holdings} \quad \underbrace{-1.1*(400-\triangle)}_{\substack{expected\,deposit \\ withdrawals}}$$

Therefore the capital ratio is $\tau = \frac{27.2+0.01\triangle}{427.2-.54\triangle}$. So consider when $\triangle = 40$ so that $\tau = \frac{27.6}{405.6} = 7\%$ and this is the bank's target capital ratio. Since this ratio is increasing in $\triangle$, when $\triangle = 39$, the bank cannot lend out this additional dollar because it will cause its ratio to decline.

Moreover, there is another mechanism that may reinforce this prediction. Assume that the bank sets a target capital ratio and that this constraint is binding. If the average deposit rate is greater than the rate of return to riskless securities, i.e. $\alpha r_1 + (1-\alpha) r_2 > r_s$, then an increase in deposit inflows can actually crowd out lending. When this condition holds, even if the bank allocates all of the additional deposit inflows towards investment in the liquid asset, there is still a decrease in the capital ratio. To see this, suppose that the bank receives an additional dollar in deposit inflows. If the bank invests all of the additional inflows in the liquid asset, the capital ratio becomes $\frac{\kappa-(\alpha r_1+(1-\alpha)r_2-r_s)}{v-S_t} < \frac{\kappa}{v-S_t}$. To get back to its target ratio, the bank must increase its liquid asset holding by more than the deposit inflows which crowds out lending. Therefore, this effects implies that the lending contraction can be decreasing in the deposit elasticity for capital constrained banks. In the example above, if we increase deposit inflows by some amount $\delta$ (from the benchmark inflow of 160), the bank must invest this amount entirely in securities since additional lending will cause additional ratio declines. We see that the ratio then becomes $\frac{27.6-(\alpha r_1+(1-\alpha)r_2-r_s)\delta}{405.6} < \frac{27.6}{405.6} = 0.07$ so the bank actually must allocate an amount greater than $\delta$ toward the liquid asset maintain its capital ratio.

In the next section, I will test these implications in the data. The main test will use two sets of predictions. First, the model shows that exposure types matters as banks which raise deposits in the crisis country face greater liquidity constraints whereas banks that only have asset exposure face greater capital constraints. Second, lower deposit elasticities should dampen liquidity constraints but amplify capital constraints and induce greater contractions in lending. The empirical analysis tests these implications by using a bank's depository institutions and non-depository assets in crisis countries as measures for exposure types. Furthermore, I use demographics data, specifically the percentage of seniors in the economy, as a measure for deposit elasticities. I then construct a differences in differences and triple differences methodology to test these predictions.

## 5 Data and Measurement

**Bank Linkages Data** Once challenge to empirically analyzing shock transmission is in constructing a measure for multinational bank linkages since there is limited data on cross country bank holdings. To form a linkage measure for a large subset of countries and bank holding companies, I obtain data from the Bankscope ownership database which provides bank holding company level data on the locations of all its institutions. This dataset reveals over 90,000 cross border bank level linkages and includes detailed data on the ownership amount, industry categorization, and size of both depository and non-depository institutions. This permits the construction of a new measure for international bank linkages at both the country and bank holding company level that covers a much broader set of countries than any previous study.

Furthermore, I can classify the bank's properties by whether they are deposit taking institutions or non-depository institutions and aggregate the different exposures into $DEXP_{ij}$

and $AEXP_{ij}$ respectively. $DEXP_{ij}$ is therefore the measure for depository institution exposure and is equal to the sum of all of bank i's commercial bank branch assets in country j. [4] I use it as a proxy for the bank's assets that are susceptible to both capital price and labor income risk. The model predicts that banks with both deposit and asset exposure are less likely to face a binding capital ratio following a shock. Therefore, $DEXP_{ij}$ is intended to measure the exposure that is concentrated among institutions that also take deposits and hence are subject to declines in deposit inflows. Analogously, $AEXP_{ij}$ is the measure for exposures that are only subject to asset price risk and is the sum of bank i's non-depository assets in country j.[5]

Banks are matched to their holding company exposure so that $aexpos_{it}$ and $dexpos_{it}$ are the fraction of holding company i's non-depository and depository institution assets in crisis countries at time t. Let $C_t$ be the set of countries undergoing a financial crisis at time t. Therefore $aexpos_{it} = \frac{1}{assets_i} \sum_{j \epsilon C_t} AEXP_{ij}$ and $dexpos_{it} = \frac{1}{assets_i} \sum_{j \epsilon C_t} DEXP_{ij}$ are the bank exposure measures. Here $assets_i$ are holding company i's total assets and $texpos_{it} = aexpos_{it} + dexpos_{it}$ equals total exposure.

[6]

Table II contains summary statistics for the banks in the sample split by whether they are solely domestic banks or if they belong to a multinational holding company. All units are in millions of US dollars. We see that while balance sheet characteristics are fairly uniform, the main difference is in size as multinational banks are on average more than seven times larger than their purely domestic counterparts. Table III lists the cross-border exposure statistics sorted by country wealth. To normalize the exposure measures, I define $DEXPOS_{ij}$ and $AEXPOS_{ij}$ to equal Country i's total depository and non-depository assets held in Country j divided by Country i's GDP. Let $I$ be the set of all banks in country i so thats $AEXPOS_{it} = \frac{1}{GDP_i} \sum_{k \epsilon I} \sum_{j \epsilon C_t} AEXP_{kj}$ and $DEXPOS_{it} = \frac{1}{GDP_i} \sum_{k \epsilon I} \sum_{j \epsilon C_t} DEXP_{kj}$ are equal to exposure to crisis countries at time t. These are the country linkage measures that I use in the subsequent analysis. [7]

Bankscope also provides annual balance sheet data for banks in more than 100 countries. The outcome variables I use in the bank level analysis are growth in loans, securities, and deposits. These are measured using $\triangle Loans = \frac{Loans_t - Loans_{t-1}}{Assets_{t-1}}$, $\triangle Securities =$

[4]The main limitation is that this database only contains current linkages. So to form a consistent time series, I obtain M&A data from Zephyr tocorrect for changes in asset holdings. I construct the bank ownership time series by workinb backwards and adjusting the ownership data following every completed deal. To limit the noise that may have resulted from this process, the measure uses the average linkage since the study covers a relatively short time period.

[5]The BIS also publishes an alternative source for aggregate bilateral holdings. However, these only include loan making offices (the components of $DEXP_{ij}$)and covers a significantly small set of countries. Comaprisons with BIS verify that the aggregated bilateral flows are consistent with their estimates for $DEXP_{ij}$. The main bias that studies have found with Bankscope balance sheet data is that although it has very good coverage of large international banks, it is more limited in its coverage of small banks. Since the focus of this paper is on international linkages etween large multinational banks, the main downside is that the control group is not complete.

[6]These measures are normalized by total holding company assets. Therefore they are the pecent of total assets in the crisis country.

[7]The data is also windsorized at the 1% level to eliminate outliers such as the Cayman Islands and Chad

$\frac{Securities_t - Securities_{t-1}}{Assets_{t-1}}$ and $\triangle Deposits = \frac{Deposits_t - Deposits_{t-1}}{Assets_{t-1}}$. Since the regressions include a holding company fixed effect, the regression identifies deviations from the average holding company loan, securities, and deposit growth rate.[8]

**Country and Regional Data** To control for other linkages, bilateral trade data is obtained from the IMF and NBER. The aggregate capital account positions data is available from the Milesi-Ferretti (2007) database. To measure aggregate growth and investment, I use country level growth in purchasing price power adjusted GDP and investment provided by the Heston et al Penn World Tables (2007). Additional country controls are obtained from the World Bank and UN world development database. The dependent variable in the country level regressions is $\triangle y_{it} = \frac{INV_t - INV_{t-1}}{INV_{t-1}}$ and the analogous quantities for output and consumption.

I also use regional level data on output and innovation for wealthy OECD countries to exploit within country variation. The OECD publishes demographics as well as account data for provinces and states within the OECD. The measures used for this section will include regional output and capital intensive industry investment which is available for most OECD regions and also research and development expenditure data which is available for a smaller subset of the OECD regions. I use the same growth rate measure as the country level analysis. Summary statistics for these variables are provided in Table II of the appendix. The variable $DEMO_i$ is the average percentage of senior citizens in country or region i which are defined to be individuals 60 and older and is used as a proxy for an area's deposit elasticity.[9] The assumption is that areas with higher concentrations of senior citizens have smaller declines in deposit inflows following a shock. I provide evidence in support of this assumption in the empirical section.

The financial crises data is obtained from the IMF database by Laeven and Valencia (2005).[10] I use the data to pinpoint the year in which these 30 crises occurred and the sample is limited by Bankscope coverage. $Crisis_t$ is a dummy that equals 1 at time t and t+1 if there is a financial crisis at time t. Table IV presents the bank exposure statistics for the 30 financial crises used in this study. The exposures are aggregated at the holding company level and the banks and holding companies included in this table are not located in the crisis country. The regression analysis also excludes banks that belong to a holding company which is located in a crisis country during the crisis period. We see that the mean exposure for each holding company is 8.58% and on average, 215 holding companies and 928

[8] I use this variable since it measures the cyclical component of growth and therefore controls for holding company level effects. The exception is the capital ratio, which we do not expect to change so in that case, I measure the deviation from the average ratio

[9] This measure is robust to other cutoffs such as 55 and 65.

[10] Studies by Dell'Ariccia et al (1997) and Kroszner et al (2007) have also used it as their source for the timeframe and categorization of these financial crises.

branch level banks have exposure to each crisis. Cross border financial institution exposure is also on average twice as large as asset exposure.

# 6 Empirical Methodology and Results

I now proceed to analyze the impact of bank and country level financial crisis exposure on lending and investment. This analysis of funding shock propagation consists of two main parts. I first consider the impact of depository institution exposure since the contraction in lending should be greater for banks that raise deposits in crisis countries. These institutions face greater liquidity constraints due to correlated deposit inflows so there should be a larger decline in lending at affiliate branches. However, banks with inadequate capital buffers may become capital constrained due to non-depository asset exposure. This in turn can also lead to lending contractions. I use a differences in differences methodology to test this hypothesis and analyze the impact of different exposure types on lending dynamics following the crisis.

I then investigate the implication that low deposit elasticities can amplify capital constraints and dampen liquidity constraints. Since the model predicts that banks with greater non-depository asset exposure in areas with less elastic deposit inflows face the greatest capital constraints, we should expect to see larger contractions in lending. However those that raise deposits in shock hit regions are primarily liquidity constrained and lend out additional deposit inflows. A triple differences methodology is used to test this prediction. Liquidity and capital constraints thus create predictions that are unique to shock propagation through bank lending. I explore these implications at the balance sheet level to test if banks decrease lending at affiliate branches due to funding shocks. I then use country level linkages to identify these distortions at the aggregate level.

Finally, recall that I use the percentage of seniors in the country as a measure for deposit elasticity. The rationale here is that seniors rely heavily on social security and pension benefits so their income is not as reliant on economic activity. I explore this in more detail in a later section and present evidence supporting this assumption. I also conduct robustness checks using the elasticity in the crisis country in place of the bank branch country. Finally, I estimate these regressions for the recent 2007 crisis.

## 6.1 Differences in Differences Methodology

My first hypothesis is that countries or banks with crisis country exposure experience greater declines in lending and investment due to liquidity sharing in the wake of a shock. This is a direct implication of Prediction 1 which states that banks spread shocks across branches in different regions. Furthermore, I test Prediction 2 which shows that banks with deposit exposure should exhibit larger contractions in lending due to correlated deposit inflows. This in turn should show up in aggregate output and investment. To estimate this, I construct a differences in differences estimator using the measures for deposit and asset linkages. I first run the regression at the micro bank level and then explore its implications for aggregate linkages.[11] Let $X_{it}$ consist of country, year, and bank control variables. I include year and holding company fixed effects in the regression so that the estimated regression becomes: [12]

$$\triangle y_{it} = \alpha + \gamma_1^a aexpos_{it} * crisis_t + \gamma_1^d dexpos_{it} * crisis_t + \beta X_{it} + \epsilon_{it}$$

The variables $aexpos_{it}$ and $dexpos_{it}$ are bank i's holding company level exposure to a crisis at time t and $\triangle y_{it}$ is the change in net lending. The financial crisis is used as an exogenous shock to returns and deposit inflows to measure the impact of shock exposure on affiliate lending. This identification strategy exploits three sources of variation. The financial crises provide for a time-series variation of funding shocks and I compare across pre and post-crisis lending and investment. The depository and non-depository institution exposure provide for two sources of cross sectional variation using holding company level ownership in crisis countries. Therefore, I exploit differences in funding shocks across banks and compare them against the sample of banks with no exposure. Furthermore, I control for bank characteristics as well as country-year controls to match banks based on institutional and country characteristics.

What this regression captures is the impact of different exposure types on lending at affiliate branches when compared against a control group of similar banks with no exposure. Suppose that Barclays has depository institution exposure and Santander has non-depository asset exposure to the US. However, Banco Popular (which is similar to Santander) and Lloyds (which is comparable to Barclays in terms of lending opportunities and funding) have no exposure to the US. The coefficient for $\gamma_1^a$ captures the difference in lending between Banco Popular and Santander following a crisis which impairs Santander's loan returns in the US. Similarly $\gamma_1^d$ captures the how the shock to Barclays' US loan returns and deposit inflows impacts its lending relative to Lloyds.

If a crisis in one country is spread to others through banking ties, then $\gamma_1^a$ and $\gamma_1^d$ should be negative. A shock to holding company assets reduces the overall supply of liquidity and therefore results in declines in lending at non-crisis affiliate branches. Also, banks that raise deposits in the crisis country face greater liquidity constraints. However, those with non-depository exposures experience larger capital ratio shocks and are more likely to become capital constrained. When the liquidity constraint dominates the capital constraint, we

[11] So Citibank's German branch would be one observation while its branch in Frace would be another observation in the sample. Furthermore, for many banks, this data is more detailed as different branches may report their data separately even if they are based within the same company

[12] The $crisis_t$ dummy is absorbed by the year fixed effects.

should expect for $\gamma_1^d > \gamma_1^a$ which implies that banks that raise deposits in crisis countries lend less due to greater funding shocks.

For our estimates of $\gamma_t$ and $\gamma_t^*$ to be unbiased, the shock should be exogenous and there should be a sufficient number of banks and countries to form control and treatment groups. As can be seen in table IV, there is substantial heterogeneity in exposures as well as a large number of banks in the sample so the latter requirement is satisfied. This regression also relies on the exogeneity of the financial crisis. In other words, there should not be an omitted variable that is correlated with crisis exposure that also impacts bank lending or investment. I formalize this argument in the appendix where I present regressions showing that the decision to invest in the crisis country does not appear to be impacted by pre-crisis lending and other attributes of the average bank in my sample.

**Bank Level Results** I first test these implications using bank balance sheet data. The observations are at the country-branch level and exposures are grouped by holding company. Therefore, I identify the average contraction in lending resulting from the crisis. The regressions will follow the same estimation approach as all the bank level regressions in this analysis. The vector of control variables $X_{it}$ contains both year and holding company fixed effects as well as country level time varying controls. The regressions also contain bank control variables for contemporaneous size, size within the holding company, loans over assets, deposits over assets, and loan losses over assets. I also control for bilateral trade with crisis countries in every regression. Standard errors are corrected to allow for clustering of the error terms at the holding company level.

The first variable I consider is the change in net lending. Moreover, recall that the model has predictions for the bank's optimal securities holding. Prediction 1 implies that banks will hedge this increase in future liquidation risk by increasing their liquid asset holding due to the decline in expected maturing loans. I also look at the impact of the shock on the capital ratio since the model's prediction that capital constrained banks face different investment incentives is crucial for the identification. The primary goal of the differences in differences analysis is to provide direct evidence of this liquidity sharing mechanism and show that deposit exposure results in greater contractions in lending.

Table V presents the results from the regressions for loan and securities growth. Column (2) of panel A reveals that a one standard deviation increase in asset exposure results in an additional 1% contraction in lending while the same increase in deposit exposure will result in a 2% contraction. Although they seem large, these numbers are actually reasonable because they result from an increase in exposure of almost 10% of total holding company assets. This finding confirms the hypothesis that funding shocks result in decreased lending at affiliate branches. The contraction is also larger for banks with deposit exposures and we see from column (4) that these banks also increase their securities holdings.

To give intuition for what this regression captures, consider Erste Bank, an Austrian bank with over 300 billion in assets and 7% of its commercial lending operations in the UK. Following the 2007 crisis, Erste's short term funding declined by 1.2 billion and it increased its securities holding by 1% and decreased lending by 0.5%. Since its holding company capital ratio also increased from 10 to 12 percent during the same period, the contraction in lending was induced by a liquidity constraints rather than a large capital shock. This decline in lending is captured by the negative estimate for $\gamma_1^d$ in our regression which predicts that Erste would decrease its lending by 0.8% and increased its securities holdings increased by 1.2%. Therefore, these estimates are plausible and hold for more moderate exposure numbers.

However, banks that have greater non-depository institution asset may become capital constrained and exhibit different lending patterns. To investigate this capital constraint, I split the sample based on the holding company capital ratio to see if capital constrained banks exhibit different lending patterns. I categorize a bank as well capitalized if its holding company capital ratio is greater than 15%. If its holding company ratio is less than 15%, I define it to be less capitalized. I then run the regression on subsamples split based on this cutoff which essentially halves the sample. The results from the subsample regressions are presented in panel B and C of Table V.

I find striking evidence that asset exposure can also generate lending contractions for poorly capitalized banks. Column (12) shows that a one standard deviation increase in asset exposure for capital constrained banks leads to a 4.2% decline in our capital ratio. We can then infer from column (7) of panel B that this shock results in greater contractions in lending for poorly capitalized banks. Moving from the 25th to 75th percentile in asset exposure results in a 0.9% contraction in lending. These estimates imply that banks with lower capital levels are more susceptible to asset exposure. To put this into perspective, consider Banco Desio, an Italian bank which had substantial asset exposure in Japan. Following the Japanese crisis, Banco Desio decreased its portfolio lending by 3.3% although its short term funding increased by 410 million dollars. Furthermore, in the course of two years, its capital ratio declined from 18% to 14%. Therefore Banco Desio faced a large capital shock rather than a decline in funding. This effect is therefore captured by the negative coefficient for $\gamma_1^a$ and we see that large capital shocks can also induce lending contractions as well.

From columns (8), (10), (14), and (16) of panel C, we see that for both subsamples, depository institution exposure actually leads to a greater contraction in lending and an increase in securities holdings. However, the coefficient for our interaction term $aexpos_{it} * crisis_t$ is not significant in the regressions for well capitalized banks. Once example of this from the recent crisis is KBC Bank, a bank holding company in Belgium with 450 billion in assets and 4.4% of non-depository asset exposure to the UK. Following the crisis, its capital ratio did not experience a significant shock and it actually increased lending in 2008 by 14 billion dollars. Therefore, asset exposure does not seem to cause declines in affiliate bank lending for institutions with adequate capital levels. Liquidity constraints do still matter for shock propagation though as we see contractions at affiliate branches for institutions with large capital buffers.

**Regional and Country Level Evidence** I then run these regressions at the country and regional level using aggregate country level linkages. The country and regional level tests are intended to capture whether these banking linkages appear to impact aggregate risk sharing patterns. If a country's banks have a large portion of their portfolios invested in a foreign country, then a shock in the other country can potentially cause a decrease in lending in the home country. If this effect is large enough, countries or regions with greater bilateral bank linkages will experience comovements in investment and output as a result of lending synchronization. All regressions include country-time varying controls, bilateral trade linkages with crisis countries, and year fixed effects. The country level regressions also contain country fixed effects and standard errors are clustered by country. The regional level analysis uses regional fixed effects and corrects for clustering by region.

Table VI presents the results from the regional level regressions and we see that the evidence generally matches the micro-level results. Columns (2) and (4) of panel A show that a one standard deviation increase in depository institution exposure leads to a 1% decrease in aggregate output and a 3% decline in capital intensive investment. Analogously, a shift from the 25th percentile to the 75th percentile of asset exposures leads to a 1.5% decrease in regional GDP and a 3.5% decline in total R&D expenditures. The country level estimates are presented in panel B and we see that greater bank asset linkages also lead to decreases in investment and output.

What this evidence really indicates is that if we take two countries, for instance France and the UK, that have large bilateral bank linkages, a shock to funding in the UK can lead to declines in lending in France. France owns over 112 billion of assets in UK which is 5.6% of its GDP. If we break this down further, 62.58 billion of this is through non-depository asset exposure whereas 49.86 billion of its exposure consists of depository institutions. In contrast, countries that have smaller linkages, such as the UK and Turkey should expect to see less shock propagation through the banking channel. Turkey's exposure to the UK is less than 0.1% of its GDP. So suppose that a financial crisis occurs in the UK. The regression estimates imply that France should expect to see a 0.7% decrease in aggregate investment whereas in Turkey, the predicted decline is 0.002%. Therefore, France, through its bank exposure to the UK, sees a much larger decline in aggregate investment as a result of this banking channel. Overall, the results suggest that greater bank linkages may lead to synchronized cross country investment and output as described here.

### 6.2 Triple Differences Methodology

I now consider the distortionary impact of regulatory capital requirements on shock propagation. This section of the analysis explores in more detail how capital and liquidity constraints interact with regional deposit elasticities to alter shock dynamics. Recall that prediction 4 of the model hypothesizes that a low deposit elasticity will lead to less shock amplification for liquidity constrained banks (those with greater depository institution exposure). Banks in areas with low deposit elasticities lend out additional funds since greater deposit stability can lessen liquidity constraints. However, prediction 3 suggests that banks that do not raise deposits in the shock hit country should see greater capital ratio declines. Additionally, prediction 5 shows that these capital constraints are amplified in areas with low deposit elasticities. Banks with non-depository asset exposure in areas with low elasticities may actually see a greater reduction in lending and shift their portfolios toward securities holdings.

I use a triple differences identification strategy that exploits heterogeneity in asset and deposit exposure and interacts this with the demographical differences across regions to test these implications. The predictions generate a unique implication particular to the bank lending channel so they allow for me to identify an effect unlikely to be driven by other factors. Moreover, I test to see whether these distortions arise in the regional and country level analysis as well which would suggest that bank linkages have the potential to distort aggregate risk sharing dynamics. Once again I include year and country fixed effects so that the triple differences equation that I estimate is:[13]

$$\begin{aligned}\triangle y_{it} &= \alpha + \beta_1^a aexpos_{it} * crisis_t * demo_i + \beta_1^d dexpos_{it} * crisis_t * demo_i \\ &\quad + \beta_2^a aexpos_{it} * crisis_t + \beta_2^d dexpos_{it} * crisis_t \\ &\quad + \beta_3 demo_i * crisis_t + \beta X_{it} + \epsilon_{it}\end{aligned}$$

The additional layer of variation compares across banks with similar exposures in areas with different deposit elasticities $demo_i$ (the percentage of seniors in the bank branch country). Therefore, this regression uses variation in depositor bases to test the model's predictions regarding deposit elasticities and exposures. To give intuition for what this regression captures, suppose that two similar banks, Santander and Barclays, both have the same depository institution exposure in the US. Santander also has branches in Spain which

[13] A formal derivation and explanation for the regression specification is given in the appendix.

has fewer seniors than the UK and hence more elastic deposits. Following the crisis, both banks face the same return and deposit inflow shock at their US branch and then reduce lending at their affiliate branches. However, due to depressed economic activity and elastic deposit inflows in Spain, Santander sees a larger decrease in non-crisis country deposit inflows than Barclays. As a result, Santander contracts lending more in Spain due to a greater liquidity constraint. The estimate for $\beta_1^d$ captures this effect since it measures the differential impact of less elastic deposit inflows on lending when comparing across banks with similar depository institution exposure. Analogously, for two banks with similar non-depository asset exposure, $\beta_1^a$ estimates the impact of greater deposit stability for capital constrained banks.

Our coefficients $\beta_2^a$ and $\beta_2^d$ for $aexpos_{it} * crisis_t$ and $dexpos_{it} * crisis_t$, respectively, can therefore be viewed as constants, or the expected decrease in lending for a given exposure if there are no seniors in the economy. The triple interaction terms $\beta_1^a$ and $\beta_1^d$ can be treated as the slope coefficients which estimate whether the contraction is increasing or decreasing in the fraction of seniors conditional on the holding company exposure. Therefore, banks in areas with low deposit elasticities should load on this coefficient. The model predicts the value of $\beta_1^d$ to be positive since liquidity constraints are dampened by low deposit elasticities. However, the value of $\beta_1^a$ will be negative if greater deposit inflows amplify capital constraints. So while a higher concentration of individuals with constant income streams generally provides a cushion against the depository institution exposure, it may cause banks with asset exposure to decrease lending to buffer their capital ratio.

**Bank Level Results** The triple differences estimation essentially controls for two effects. First, it adjusts for country level outcomes by exploiting variation in bank level exposures within the same country. Second, by including a holding company fixed effect, I compare across holding companies in countries with different underlying demographics and hence deposit elasticities.[14] Therefore, the triple differences identification strategy controls for both the institution and country effect and allows for identification of the impact of holding company level exposures and deposit bases on lending and bank portfolio allocations. I use the same outcome variables and controls as the differences in differences regressions.

I first employ the triple differences specification to examine the impact of crisis exposure on bank portfolio allocations and the capital ratio. Table VII presents the results from the regressions for loan and securities growth and the capital ratio. The full sample results are given in Panel A. Once again I split the sample based on the holding company capital ratio and the results for less capitalized and well capitalized banks are presented in Panels B and C, respectively.

[14]The results are robust to including firm fixed effects.

Perhaps the most compelling evidence in favor of the hypotheses are presented in Panel B for less capitalized banks. From column (12), we see that the coefficient for the triple interaction term $\beta_1^a$ is negative and statistically significant. Therefore, banks facing asset exposure shocks experience the greatest capital ratio decline and this effect is amplified in areas with low deposit elasticities. For banks with average non-depository asset exposure, a two standard deviation increase in the percentage of seniors corresponds to a 1.5% decrease in this ratio.

The estimates in column (7) then show that these capital constrained banks indeed lend less, particularly in areas with more seniors. To interpret these results, note that $\beta_2^a$, the coefficient for $aexpos_{it} * crisis_t$ can be viewed as an intercept which gives the effect of asset exposure when there are no seniors in the country. As we increase the fraction of seniors in the area, since our coefficient for $aexpos_{it} * crisis_t * demo_i$ is negative, we get greater declines in lending. Moving from the 5th to 95th percentile of deposit elasticities generates an additional 1.2% contraction in lending. However, for well capitalized banks, asset exposure appears to have no impact on affiliate lending.

Next, I consider the impact of these shocks on liquid securities holdings. In columns (9) and (15), our estimates for $\beta_1^a$ are positive which provides evidence that capital constrained banks shift their funds toward greater securities holdings. Moreover, this effect occurs despite smaller funding declines in areas with more seniors. Even though well capitalized banks do not decrease lending, they still invest new deposit inflows in liquid securities rather than lending this amount out as can be inferred from Panel C. This is direct evidence which corroborates the model's prediction that capital shocks cause banks to shift investment towards zero risk-weighted securities. This is an important finding since it shows that capital constrained banks do not pursue lending opportunities as a result of regulatory capital requirements.

To give a real example of this mechanism from the last crisis, consider two banks with substantial non-depository asset exposure: Dexia Credit[15] which had 8.8% asset exposure to the US crisis and is based in France where seniors comprise 15% of the total population and Dresdner Bank with 5% exposure that is located in Germany where seniors comprise 20% of the total population. Dexia saw its equity over total loans decline from 4.9% to just 1.1% so it experienced a significant capital shock. It decreased its lending by 4.7% as a result and increased its liquid securities holdings by 0.3%. Dresdner, which saw smaller declines in deposit inflows, experienced a 6.5% decline in lending while increasing its liquid asset holdings by 6.8% in the year following the crisis. Therefore, we see that although Dresdner is located in a stable deposit country, it used these additional deposit inflows to increase its liquid assets holdings. This reinforces what I find in the regressions since low deposit

[15]Dexia has a two large locations, once in Belgium and the other in France. Here I look only at French assets. The calculated changes are in terms of portfolio percentages.

elasticities appear to amplify capital constraints as banks with additional deposit inflows contract lending more and increase their securities holdings.

However, I find that banks with depository institution exposure increase lending in areas with less elastic deposits since the estimate for $dexpos_{it} * crisis_t * demo_i$ is positive. Going from the 25th to 75th percentile of deposit elasticities leads to a 0.9% increase in lending. So for liquidity constrained banks, a greater concentration of seniors actually provides a buffer resulting in smaller lending contractions. We see from Panel C that deposit exposure results in greater lending contractions regardless of a bank's capitalization. The results also show that liquidity constrained banks in areas with greater funding actually shift their portfolios away from liquid securities holdings. The negative coefficient for $\beta_1^d$ suggests that these banks lend out additional deposit inflows rather than increasing their liquid asset holdings.

Now consider two banks with significant depository institution exposure. Kabushiki, a bank with over 92 billion of assets and 14% depository institution exposure to the UK crisis, is based in Japan where seniors constitute over 21% of the total population. Following the crisis, Kabushiki experienced a 5% deposit inflow decline. However its capital ratio remained around 12% following the crisis. Contrast this with LaSer Cofinoga, a French bank with 11% exposure to the UK and over 16 billion of assets. In France, seniors comprise 17% of the total population so deposits are more elastic. LaSer Cofinoga's capital ratio remained between 12 and 13% during the crisis neither bank was capital constrained. The estimates predict that greater deposit declines in France would cause LaSer Cofinoga to contract its lending by an additional 3%. We also see that Kabushiki bank increased its liquid asset holdings by 1% in the year following the crisis but LaSer Cofinoga increased its holdings by 4.6%. This illustrates the point that liquidity constrained banks benefit from greater deposit stability and exhibit smaller declines in lending while decreasing their securities holding.

**Regional and Country Level Evidence** The next section identifies these distortions at the aggregate level. The regional level analysis uses regional demographics data to utilize within country variation. The analysis therefore allows for a comparison of regions within the same country with different underlying demographics. However, at the same time, it uses heterogeneity in exposures across countries to identify the impact of bilateral bank linkages on aggregate outcomes. Additionally, it considers regions within OECD countries and this means that the results are unlikely to be driven by developing-industrialized country wealth effects.

The regional and country level analysis is central for two reasons. First, if the general equilibrium feedback loop has an impact on deposit inflows, then aggregate linkages are crucial towards identifying shock dynamics. Since we expect for greater country level bilateral holdings to amplify these spillovers effects, the aggregate analysis allows us to identify these distortions. At the micro-bank level, it is hard to determine the extent to which these shocks impact a region's deposit inflows. For instance, a small bank with heavy crisis exposure may have a negligible impact on regional investment. However, if we aggregate these linkages, then the banking sector's total exposure to these crises can have a plausible influence on a country's investment. This then impacts future deposit inflows and can generate distortions at the aggregate level.

Table VIII presents the results from the regional and country level triple differences regression which are consistent with the predictions for $\beta_1^a$ and $\beta_1^d$. From columns (1), (4), and (7), we see that following the shock, regions with greater depository institution exposure and higher concentrations of senior citizens experience a smaller decline in investment. However, for regions with non-depository asset exposure, the coefficient on $\beta_1^a$ is statistically significant and negative, so the opposite is true. Regions with more seniors actually experience greater declines in investment and output.[16]

To give intuition for what the regional level analysis identifies, consider two regions in Italy: Lombardy, where 18% of the population are over the age of 65, and Tuscany, where seniors comprise 24% of the population. Furthermore, Italy has 2.6% (recall that exposure is given as a percentage of total GDP) of depository institution exposure and 0.1% of asset exposure to Ireland. Suppose that a financial crisis in Ireland results in capital and funding shocks. According to the regression estimates, Lombardy should see a 1.7% greater decline in capital intensive investment relative to Tuscany. For Italian banks, a senior citizen buffer will lessen funding constraints.

Now contrast this with two regions in France: Lorraine where 15% the population are seniors and Provence, where seniors constitute 19% of the population. France has 1.1% of asset exposure and 0.2% of depository institution exposure. Following the shock in Ireland, the regional estimates suggest that Provence will actually see an additional 0.6% decline in capital intensive investment relative to Lorraine due to its lower deposit elasticity. The estimates predict that greater deposit inflows in Provence actually exacerbate lending contractions. Since French banks are mainly capital constrained whereas Italian banks are primarily liquidity constrained, greater deposit stability in France exacerbates the shock whereas in Italy, it dampens the decline in investment.

In summary, the empirical analysis presents evidence in favor of a liquidity sharing story in which funding shocks are transmitted to a bank's other branches. We see that banks with crisis exposure decrease lending at affiliate branches located outside the crisis country. Depository institution exposure results in greater funding shocks and therefore greater

[16] Additional estimates from the regression are included in Table VIII(a) of the appendix. This includes estimates for crisic country banks with holdings in the home country.

lending contractions. Banks with non-depository asset exposure however suffer from capital shocks and also decrease lending. Countries and regions with greater aggregate exposure experience decreases in investment and output following the crisis. Furthermore, the triple differences regression corroborates the model's predictions that stable deposits can amplify capital constraints while dampening liquidity constraints. This creates a unique shock dynamics distortion and these results provide strong support for bank shock propagation that is unlikely to be explained by other channels.

### 6.3 Deposit Elasticities

The primary objective of this section is to provide evidence to support the assumption that a greater concentration of seniors citizens results in lower regional deposit elasticities. I examine whether areas with more seniors experience smaller declines in deposit inflows following the shock. Furthermore, I conduct robustness checks to see if using the crisis country demographics measure in place of the bank branch country demographics variable generates results consistent with the model's predictions. We expect for banks with deposit exposure to countries with greater deposit elasticities to exhibit amplified contractions following the crisis. However, since banks with asset exposure are not exposed to crisis country deposit inflows, we expect for the elasticity to have no impact on these exposures.

**Seniors and Deposit Elasticities** Becker (2006) considers the impact of seniors on metropolitan deposit funding and argues that senior citizens provide a greater depositor base for banks to generate lending and thus identifies a demographics level effect. He finds that deposit supply has a positive effect on local outcomes, such as the number of firms and lending. However, I am interested in a growth effect and the impact that seniors have on deposit elasticities following adverse shocks. I now test the assumption that there is a low deposit elasticity in regions with greater fractions of percentages using the bank level data.

I estimate a differences in differences regression and the triple differences regression to assess the validity of this assumption. Seniors receive social security benefits and pensions or retirement benefits. Therefore areas with greater concentrations of seniors should experience smaller declines in deposit inflows following the shock. The interaction term $demo_i * crisis_t$ for the differences in differences regression should then be positive since it identifies whether there is a positive correlation between deposit inflows and the percentage of seniors in an area following the crisis. Similarly, $\beta_1^d$ and $\beta_1^a$, our triple interaction terms, should also be positive since this implies that following the shock, banks with exposures in areas with more seniors see greater deposit inflows.

Table IX presents the regression results for different deposits categories. I first consider the impact of seniors on savings and demand deposits and this evidence is presented in columns (3), (4), (9), (10), (15), and (16).[17] The triple difference regressions corroborate this assumption and banks in areas with more seniors receive greater savings and demand deposit inflows following the shock regardless of exposure type. We see that the double as well as triple interaction terms are significantly positive. The estimates imply that a one standard deviation increase in the percentage of seniors in the region seniors leads to a 1.2% increase in savings and demand deposit inflows. This effect is present as well as the subsamples.

However, poorly capitalized banks with greater asset exposure in areas with higher percentages of seniors see smaller inflows of commercial and total deposits. From the regressions for total and commercial deposits in Panel B, one can infer that there is a shrinkage effect such as that found by Peek and Rosengren (1995b) in which poorly capitalized banks actually decrease their deposit inflows to comply with capital requirements. The reason, they argue, for the decrease in commercial and large CD accounts is that in order to lower its liabilities, the bank no longer targets large volume accounts although it exhibits less control over new inflows from smaller customers. This explains why areas with more seniors see greater savings and demand deposits but poorly capitalized banks shrink other deposit accounts. In prediction 5, we see that banks must increase their liquid asset holding to offset the capital ratio decline. However, another option would be for them to shrink their liabilities which would achieve a similar outcome.

**Crisis Country Deposit Elasticities** I now use deposit elasticities from the crisis country to test whether the results are robust and consistent with the model's predictions. If we substitute the crisis country demographics variable $demo_j$ in place of the bank-branch country variable $demo_i$, we should expect for the coefficient on the triple interaction term $dexpos_{it} * crisis_t * demo_j$ to be positive. This follows directly from Prediction 4 since low elasticities imply a smaller decline in crisis country deposit inflows. However, since $aexpos$ is our measure for non-depository institution exposure, the coefficient for $aexpos_{it} * crisis_t * demo_j$ should not be statistically significant. This is because the deposit elasticity in the crisis country should not have an impact on the bank's deposit inflows if it raises its deposits elsewhere.

The results from the subsample regressions are presented in Table X. We find that the coefficient for $dexpos_{it} * crisis_t * demo_j$ is statistically significant and positive for lending. So depository institution holdings in areas with less elastic deposits experience smaller funding shocks. The coefficient for $aexpos_{it} * crisis_t * demo_j$ is not statistically significant in either regression.[18] To put into perspective what these regressions show us, consider again

[17] I choose to analyze demand and savings deposits since individual accounts typically fall into these categories.

[18] For further robustness, I also use changes in deposits for the bank in place of $demo_i$. The results are consistent with the main triple difference regression.

Banco Desio, which has 10% asset exposure to Japan and Erste Bank, with 10% depository institution exposure to the UK. Although Japan has more seniors and therefore less elastic deposit inflows, Banco Desio is not exposed to Japanese deposit funding shocks. However Erste bank has significant depository institution exposure in the UK. Therefore, following a crisis, the greater the percentage of seniors in the UK, the smaller the funding shock and contraction in lending.

Also, consistent with Prediction 3, this coefficient for $dexpos_{it} * crisis_t * demo_j$ is negative for the capital ratio regressions. This implies that banks in areas with low elasticities actually see greater reductions in their capital ratio. Recall that declines in deposit inflows can actually create a shrinkage effect which explains this pattern. This is direct evidence that declines in deposit inflows can actually lead to smaller reductions in the capital ratio.

### 6.4 The 2007 Financial Crisis

An interesting case study that arises from this analysis is the impact of the 2007 US and UK financial crisis.[19] Table XI gives a summary of bank exposures in other countries. In total, countries had assets of almost 7 trillion invested in the US and UK combined. To put this into perspective, consider a country whose banking system had a large exposure to US and UK assets: Japan which has over 450 billion of asset holdings in the US and UK combined. Japanese banks had exposures averaging 3.8% in the US and 1.8% in the UK. The estimates suggest that following the crisis, these banks decreased lending by an additional 3.2% relative to banks with no exposure.

Table XII presents these results using just 2007 crisis exposures and focusing on bank balance sheet data from 2003-2009. We see that for the full sample regressions presented in Panel A, the results generally match the findings from the broader sample of exposures and financial crises. On average, foreign banks with assets in the US or UK experience 1.8% declines in lending. A one standard deviation increase in exposure lead to an additional 3.4% decrease in lending and 3.3% decline in the capital ratio.

The notable difference from the general results comes from the regression for the sub-sample of less capitalized banks. The coefficients for the triple interaction terms $dexpos_{it} * crisis_t * demo_i$ and $aexpos_{it} * crisis_t * demo_i$ are both negative for lending and the capital ratio. This suggests that there was an unusually large capital shock for banks with both US and UK exposure during the recent crisis. Recall that while the model predicts that asset exposure generally results in larger capital ratio declines, if the shock is sufficiently large, deposit exposure can also cause large reductions in the capital ratio. In this case, we would expect for the coefficient for $dexpos_{it} * crisis_t * demo_i$ to be negative as well. These poorly capitalized banks also have an incentive to shift their holdings toward securities.

[19] The results are robust to excluding the 2007 crisis

# 7 Robustness

## 7.1 Alternative Channels and Explanations

We observe that $\beta_1^*$, the triple interaction term for $AEXPOS_{it} * CRISIS_t * DEMO_i$ is significantly negative and this result rules out many other channels. This is because both the trade and equity channel would predict that having a higher concentration of seniors should buffer against a negative shock so we would expect both for $\beta_1$ and $\beta_1^*$ to be positive. The standard trade linkage story would be that a shock to one country decreases its demand for exports from its trading partners. This in turn results in a decline in investment in the other country as well. However, countries with greater fractions of seniors should experience lower declines regardless of bank exposures since wages are less dependent on investment. The same is true for equity holdings since seniors are shown to have less equity investments.

I also control for size and run the regressions on the subsample of banks with over 1 billion in assets and find that the results are robust to restricting the sample. The concern here would be that smaller banks with greater asset exposure are also concentrated in areas with more seniors but have relatively small impacts on regional lending and hence wages. However, the results are robust to restricting the analysis to larger banks so this alleviates that concern. Controlling for size effectively controls for developing countries since they essentially drop out of the regression. Also, most of the banks that fall into this category are located in countries that comply with the Basel accord.

Another potential issue involves a composition effect in which countries with greater asset exposure and seniors contain some omitted variable that drives these results. However, the micro-bank level evidence should allay these concerns because we see that banks in the same countries with different exposure types exhibit different patterns in lending. However, some might argue that there is an underlying difference between banks with deposit and asset exposures. In response to this critique, first, we see substantial declines in capital ratios consistent with the story. Second, banks that have deposit exposure usually have asset exposures in the same country as well so the heterogeneity is driven by relative differences in both exposure types.

Additionally, a negative correlation between deposit elasticities and wealth is not sufficient to bias the results since I look at the interaction between different exposure types and these elasticities. Therefore, any variable would need to be correlated with deposit elasticities but also exhibit a different correlation structure with asset and depository institution exposure. I do not find a bias between bank exposure types and country wealth in the data since there is substantial heterogeneity in my sample. Furthermore, restricting the sample to developed countries still yields estimates consistent with the predictions.

There is also concern regarding whether the differences in asset and depository institution exposure shock dynamics are driven by differences in branch and subsidiary effects. Since subsidiaries are separate legal entities, they face separate capital constraints. The results suggest that depository institution exposure results in contractions in lending and if the subsidiary structure mattered for shock propagation, then this would not occur. Furthermore, banks might still curtail lending to provide interbank loans to their subsidiaries since only in the most extreme case would they desire to give up ownership of that entity.

### 7.2 Crisis Country Banks

Thus far, I have restricted the analysis to banks whose holding companies are not based in the crisis hit country to limit demand side effects. However, we might expect for banks based in crisis hit countries to cut back lending in other countries as well. In addition to our estimates from the triple differences regression, I define $PAEXPOS_{it}$ and $PDEXPOS_{it}$ to be the measures for crisis country asset and depository institution ownership in country i at time t and include the variables in the triple differences regression. Table VIII (a) of the appendix presents estimates for the effect of crisis country bank holdings on investment and output in other countries. We see that these results are consistent with the effects for home country exposure for consumption and output but not investment. At the regional level, areas with crisis country bank branches experience a decline in output and consumption which corresponds directly to the result from Peek and Rosengren (1997).

### 7.3 Recessions and Sample Bias

This analysis examines a subset of very large events which facilitates identification but leaves questions regarding the generality of these results. To address this, I estimate the analysis for recessions at the country level and find that the main results still hold for investment. They are much weaker though for consumption and output. The measure that I use for recessions is $DEV_{it}$, the deviation from the Hodrick Prescott trend divided by the total standard deviation of the detrended time series. Tables XIII(a) presents the country level recession regressions and we see that both the differences in differences approach and triple differences results are consistent with results from the financial crisis. $\beta_1^{rd}$, the coefficient for $AEXPOS_{it} * DEV_{it} * DEMO_i$, is statistically significant and positive (recall that $DEV_{it}$ is negative for contractions). Also, for these slow moving moments, banks from the recession hit country propagate the effect to their branches in other countries. We see that both home exposure abroad and a foreign bank presence increase shock transmission to foreign countries.

## 8 Conclusion

This paper explores the role of multinational banking in shock transmission. I model and test the depository financial intermediary's liquidity sharing mechanism which generates gains to diversification but also leads to positive comovements in investment and output. The empirical analysis then considers funding shocks originating from 30 financial crises and proceeds to test these predictions. The micro level evidence shows that bank holding company exposure results in contractions in lending at affiliate branches outside of the crisis country. I also find that banks with greater depository institution exposure experience larger declines in lending due to greater liquidity constraints. Greater non-depository asset exposure results in capital shocks that can cause poorly capitalized banks to decrease lending at affiliate branches as well. The aggregate results suggest that countries and regions with greater bank linkages also experience greater declines in investment and output.

I then consider how greater deposit stability can amplify capital constraints and dampen liquidity constraints. Additional deposit inflows can actually exacerbate capital ratio shocks therefore inducing greater lending contractions. The most convincing evidence that capital requirements distort shock dynamics is the substantial capital ratio decline for banks with non-depository asset exposure in areas with low deposit elasticities. I then find that these capital constrained banks also lend less and shift their portfolios toward liquid securities holdings following the shock. However, for banks with greater depository institution exposure, low deposit elasticities ameliorate funding shocks. These liquidity constrained banks lend out additional funds. This evidence shows that liquidity constrained and capital constrained banks exhibit very different lending behaviors in the wake of the shock. Furthermore, the triple differences estimation is corroborated at the country and regional level and I find the same distortionary patterns.

This paper highlights how financial intermediation can result in not just the transmission of shocks across countries, but can also create distortions in risk sharing patterns. While many papers have looked at the effects of globalization on international comovements, this is the first to provide broad evidence that international banking is a pervasive force that links investment and output across countries. Furthermore, I use unique predictions generated from the interaction between deposit elasticities and capital and liquidity constraints to rule out other channels and identify the banking channel at the micro and macro level. The empirical evidence suggests that there is much work that remains to be done to investigate the role of different capital assets and flows in explaining global risk sharing patterns. Furthermore, due to these linkages, economies are susceptible to international credit market events as these shocks can be spread through the banking channel.

Table I

Cross Country Correlation Regressions

Dependent variable is the correlation between country1 and country2 Hodrick Prescott detrended investment (1)+(2), consumption (3)+(4) and output (5)+(6). I index the countries by their per capita income so that country1 is always the wealthier country and this eliminates recurrences of the same correlation. Each cell displays the point estimate and standard error for the OLS coefficient. Regressions include country1 and country2 fixed effects. Standard errors are clustered by country1 and country2. DEXPOS is equal to the value of country1's total depository institutions in country2 divided by country1 GDP. AEXPOS is equal to the the value of country 1's non-depository assets in country2 divided by country1 GDP. DEXPOS2 and AEXPOS2 are the equivalent variables for country2's assets in country1 divided by country2 GDP.

| | Investment Correlation | | Consumption Correlation | | Output Correlation | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DEXPOS | 0.588** | 0.464* | 0.399 | 0.310 | 0.589** | 0.475* |
| | (0.243) | (0.243) | (0.262) | (0.263) | (0.272) | (0.273) |
| DEXPOS2 | 0.488*** | 0.453*** | 0.586*** | 0.557*** | 0.539*** | 0.504*** |
| | (0.146) | (0.146) | (0.158) | (0.158) | (0.164) | (0.164) |
| AEXPOS | 1.761* | 1.254 | 4.174*** | 3.838*** | 3.942*** | 3.494*** |
| | (0.985) | (0.987) | (1.063) | (1.065) | (1.105) | (1.107) |
| AEXPOS2 | 1.289*** | 1.152*** | 1.284*** | 1.17*** | 1.107** | 0.967** |
| | (0.393) | (0.394) | (0.429) | (0.429) | (0.445) | (0.446) |
| IMPORT | | 5.196*** | | 3.565*** | | 4.664*** |
| | | (0.830) | | (0.906) | | (0.941) |
| IMPORT2 | | 0.037 | | 0.059 | | 0.055 |
| | | (0.035) | | (0.037) | | (0.039) |
| Constant | 0.06*** | 0.057*** | 0.119*** | 0.117*** | 0.11*** | 0.107*** |
| | (0.007) | (0.007) | (0.010) | (0.011) | (0.010) | (0.011) |
| R2 | 0.13 | 0.13 | 0.24 | 0.25 | 0.22 | 0.22 |
| N | 10,714 | 10,714 | 10,714 | 10,714 | 10,714 | 10,714 |

Table II

Bank Summary statistics

All values are in millions US. Banks included in the top panel only have domestic assets

Domestic Bank Summary Statistics

| | Average | Median | Minimum | Maximum | Std Dev |
|---|---|---|---|---|---|
| Total Assets | 3170 | 225 | 3.13 | 801969 | 22941 |
| Total Loans | 1796 | 137 | 0.90 | 593318 | 13432 |
| Total Deposits | 0.79 | 0.84 | 0 | 1 | 0.15 |
| Demand + Savings Deposits | 0.62 | 0.65 | 0 | 0.94 | 0.25 |
| Total Securities | 0.24 | 0.22 | 0 | 0.86 | 0.14 |
| Investment Securities | 0.20 | 0.19 | 0 | 0.83 | 0.14 |
| Gov Securities | 0.07 | 0.05 | 0 | 1.02 | 0.08 |
| Total Capital Ratio | 16.38 | 14.15 | 0 | 476.95 | 12.63 |
| Tier 1 Capital Ratio | 14.78 | 12.81 | 0 | 450.73 | 12.78 |
| DEMO | 13.84 | 15 | 3 | 27.35 | 3.19 |
| CRISIS | 0.048 | 0 | 0 | 1.00 | 0.21 |
| Country CRISIS | 0.030 | 0 | 0 | 1.00 | 0.17 |
| Holding CRISIS | 0.028 | 0 | 0 | 1.00 | 0.17 |
| N | 14833 | | | | |

Multinational Bank Summary Statistics

Banks included in the lower panel also have foreign assets

| | Average | Median | Minimum | Maximum | Std Dev |
|---|---|---|---|---|---|
| Total Assets | 23307 | 1338 | 1.93 | 1610670 | 96349 |
| Total Loans | 11379 | 711 | 0.91 | 792122 | 45161 |
| Total Deposits | 0.69 | 0.75 | 0 | 0.99 | 0.20 |
| Demand + Savings Deposits | 0.56 | 0.51 | 0 | 0.93 | 0.24 |
| Total Securities | 0.19 | 0.17 | 0 | 0.83 | 0.13 |
| Investment Securities | 0.15 | 0.13 | 0 | 0.79 | 0.13 |
| Gov Securities | 0.09 | 0.06 | 0 | 0.70 | 0.09 |
| Total Capital Ratio | 14.42 | 11.46 | 0 | 100 | 6.72 |
| Tier 1 Capital Ratio | 13.81 | 11.19 | 0 | 81.76 | 5.90 |
| DEMO | 12.2 | 12.42 | 2.99 | 27.35 | 3.28 |
| CRISIS | 0.36 | 0 | 0 | 1.00 | 0.48 |
| Country CRISIS | 0.07 | 0 | 0 | 1.00 | 0.25 |
| Holding CRISIS | 0.06 | 0 | 0 | 1.00 | 0.25 |
| Branches | 11.8 | 4.00 | 1 | 60.00 | 15.25 |
| N | 3134 | | | | |

Table III
Cross Border Bank Asset Statistics

Country i is the country that owns assets in Country j. All values are in US millions. The 1st quartile denotes the 0-25th percentiles and the 4th denotes the 75th - 100th percentile of wealth. Country i GDP is normalized by US GDP

| Country i Quartile | Country j Quartile | N | Total Assets | Avg Assets | Country i GDP |
|---|---|---|---|---|---|
| 1st | 1st | 314 | 159,197 | 507 | 4.70 |
| 1st | 2nd | 194 | 9,026 | 47 | |
| 1st | 3rd | 732 | 80,152 | 109 | |
| 1st | 4th | 9401 | 4,735,828 | 504 | |
| 2nd | 1st | 36 | 5,261 | 146 | 11.11 |
| 2nd | 2nd | 15 | 1,561 | 104 | |
| 2nd | 3rd | 24 | 10,824 | 451 | |
| 2nd | 4th | 90 | 26,760 | 297 | |
| 3rd | 1st | 118 | 64,847 | 550 | 25.56 |
| 3rd | 2nd | 78 | 24,857 | 319 | |
| 3rd | 3rd | 173 | 47,579 | 275 | |
| 3rd | 4th | 397 | 155,080 | 391 | |
| 4th | 1st | 3569 | 1,892,702 | 530 | 82.47 |
| 4th | 2nd | 2914 | 268,944 | 92 | |
| 4th | 3rd | 7282 | 1,398,413 | 192 | |
| 4th | 4th | 64775 | 21,674,667 | 335 | |
| | Total | 90,112 | 30,555,700 | | |

Table IV

Crisis Bank Level Exposure Summary Statistics

All values are in thousands US. dexpos is the total depository institution assets in the crisis country over total holding company assets. aexpos is total non-depository institution assets over total holding company assets. AEXP is total holding company industrial assets in the crisiscountry. DEXP is total holding company depository inst assets in the crisis country. Banks in this sample are not located in the crisis country and do not belong to holding companies based in the crisis country

| crisis | Year | Holding | Banks | Mean AEXP | Median AEXP | Mean DEXP | Median DEXP | Percent aexpos | Percent dexpos |
|---|---|---|---|---|---|---|---|---|---|
| Sweden | 1991 | 272 | 1129 | 96,085 | 1,578 | 216,377 | 741 | 3.27 | 1.76 |
| Slovenia | 1992 | 106 | 397 | 96,026 | 1,651 | 216,417 | 757 | 1.38 | 0.23 |
| Poland | 1992 | 248 | 1031 | 78,695 | 4,883 | 197,804 | 2,747 | 5.30 | 6.56 |
| India | 1993 | 215 | 852 | 114,248 | 5,009 | 264,430 | 2,875 | 1.42 | 0.42 |
| Venezuela | 1993 | 22 | 77 | 170,503 | 1,724 | 339,225 | 742 | 1.98 | 6.96 |
| Brazil | 1994 | 240 | 1069 | 90,248 | 5,127 | 209,762 | 2,483 | 1.06 | 0.67 |
| Costa Rica | 1994 | 16 | 39 | 28,537 | 1,275 | 43,284 | 521 | 1.99 | 15.02 |
| Mexico | 1994 | 141 | 597 | 128,558 | 3,081 | 290,154 | 1,521 | 0.28 | 5.84 |
| Uruguay | 1994 | 86 | 409 | 114,689 | 2,563 | 242,733 | 1,007 | 0.00006 | 1.79 |
| Belarus | 1995 | 46 | 128 | 38,893 | 2,336 | 77,336 | 855 | 0 | 4.01 |
| Paraguay | 1995 | 1 | 2 | 758 | 1,040 | 1,049 | 603 | 0 | 20.34 |
| Bulgeria | 1996 | 171 | 747 | 70,619 | 2,042 | 170,982 | 735 | 0.00519 | 0.52 |
| Jamaica | 1996 | 5 | 13 | 1,215 | 1,715 | 2,022 | 376 | 0.59 | 60.15 |
| Japan | 1997 | 304 | 1294 | 98,185 | 2,655 | 222,272 | 1,149 | 1.95 | 0.62 |
| Philippines | 1997 | 146 | 560 | 100,115 | 1,520 | 221,422 | 736 | 2.44 | 1.78 |
| Thailand | 1997 | 194 | 899 | 121,530 | 1,409 | 270,243 | 748 | 3.99 | 2.97 |
| Malaisia | 1997 | 158 | 679 | 102,706 | 2,798 | 223,759 | 1,266 | 1.71 | 1.30 |
| Vietnam | 1997 | 63 | 242 | 88,245 | 173 | 186,399 | 72 | 0 | 0.60 |
| Korea | 1997 | 209 | 844 | 97,749 | 558 | 242,115 | 251 | 2.91 | 0.63 |
| Indonesia | 1997 | 164 | 698 | 90,441 | 509 | 200,679 | 229 | 1.44 | 0.15 |
| China | 1998 | 238 | 1069 | 123,009 | 1,380 | 282,430 | 534 | 0.81 | 0.32 |
| Colombia | 1998 | 67 | 282 | 148,338 | 244 | 341,698 | 97 | 0.05 | 12.15 |
| Slovakia | 1998 | 116 | 424 | 84,188 | 1,575 | 206,870 | 855 | 0.001 | 3.11 |
| Ukraine | 1998 | 176 | 754 | 69,141 | 3,609 | 160,800 | 1,983 | 1.76 | 17.05 |
| Turkey | 2000 | 230 | 994 | 75,357 | 1,618 | 176,519 | 531 | 2.92 | 1.93 |
| Argentina | 2001 | 136 | 538 | 90,462 | 685 | 206,431 | 95 | 2.69 | 9.52 |
| USA | 2007 | 388 | 1852 | 105,916 | 59 | 236,404 | 39 | 5.27 | 7.77 |
| UK | 2007 | 643 | 2792 | 64,455 | 167 | 144,403 | 104 | 7.48 | 7.76 |
| Average | | 215 | 928 | 95,098 | 2,589 | 215,623 | 1,237 | 2.93 | 5.65 |

Table V

Differences in Differences Bank Level Portfolio Regressions

Dependent Variable is growth in loans over total assets, securities over total assets, and the capital ratio. dexpos is equal to average total depository institution assets divided by total holding company assets. aexpos is equal to average total non-depository assets divided by total holding company assets. TEXPOS is equal to the sum of aexpos and dexpos. DEMO is the average percentage of senior citizens in the home country. All regressions include holding company and year fixed effects as well as country controls. Standard errors are clustered by holding company.

Panel A: Full Sample

| | Loans | | Securities | | Capital Ratio | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{TEXPOS}_{it} * CRISIS_t$ | -0.106*** | | 0.016 | | -0.063* | |
| | (0.028) | | (0.019) | | (0.034) | |
| $\text{AEXPOS}_{it} * CRISIS_t$ | | -0.080*** | | -0.054* | | -0.011 |
| | | (0.026) | | (0.029) | | (0.235) |
| $\text{DEXPOS}_{it} * CRISIS_t$ | | -0.226** | | 0.204** | | -0.053 |
| | | (0.095) | | ( 0.088) | | (0.039) |
| N | 122,441 | 122,673 | 104729 | 104661 | 74,664 | 74,639 |
| R2 | 0.13 | 0.15 | 0.12 | 0.12 | 0.10 | 0.11 |

Panel B: Less Capitalized Banks

| | Loans | | Securities | | Capital Ratio | |
|---|---|---|---|---|---|---|
| | (7) | (8) | (9) | (10) | (11) | (12) |
| $\text{AEXPOS}_{it} * CRISIS_t$ | | -0.109*** | | -0.064 | | -0.601*** |
| | | (0.036) | | (0.263) | | (0.101) |
| $\text{DEXPOS}_{it} * CRISIS_t$ | | -0.118** | | 0.176** | | -0.070 |
| | | (0.056) | | (0.073) | | (0.112) |
| $\text{TEXPOS}_{it} * CRISIS_t$ | -0.101*** | | 0.148 | | 0.220 | |
| | ( 0.031) | | (0.194) | | (0.300) | |
| N | 65,471 | 65,471 | 55,623 | 55,623 | 40,603 | 40,603 |
| R2 | 0.14 | 0.14 | 0.12 | 0.12 | 0.18 | 0.20 |

Panel C: Well Capitalized Banks

| | Loans | | Securities | | Capital Ratio | |
|---|---|---|---|---|---|---|
| | (13) | (14) | (15) | (16) | (17) | (18) |
| $\text{AEXPOS}_{it} * CRISIS_t$ | | 0.001 | | -1.946*** | | 0.383** |
| | | (0.046) | | (0.297) | | (0.166) |
| $\text{DEXPOS}_{it} * CRISIS_t$ | | -0.168** | | 2.358*** | | -0.036** |
| | | (0.063) | | (0.270) | | (0.015) |
| $\text{TEXPOS}_{it} * CRISIS_t$ | -0.102** | | 0.952 | | -0.111** | |
| | (0.039) | | (0.828) | | (0.045) | |
| N | 56,970 | 56,970 | 49,106 | 49,038 | 34,036 | 34,036 |
| R2 | 0.16 | 0.16 | 0.13 | 0.13 | 0.15 | 0.15 |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Holding Company Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |

Table VI

Regional and Country level Differences in Differences Regression (full sample)

Dependent variable is growth in per capita gdp (1)+(2)+(11)+(12), capital intensive investment (3)+(4), and R+D expenses (5)+(6), investment (7)+(8), and consumption (9)+(10). Each cell displays the point estimate and standard error for the OLS coefficient. All regressions include region and year fixed effects Standard errors are clustered by country. DEXPOS is equal to average total depository institution asset exposure divided by GDP. AEXPOS is equal to total non-depository asset exposure divided by GDP. TEXPOS is equal to the sum of aexpos and dexpos. DEMO is the average percentage of seniors in the country.

| Regional Level Differences in Differences Regression | | | | | | |
|---|---|---|---|---|---|---|
| | Output Growth | | Capital Intensive Investment | | R+D Growth | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{DEXPOS}_{it} * CRISIS_t$ | -0.102*** | | -0.259 | | 0.692** | |
| | (0.032) | | (0.374) | | (0.311) | |
| $\text{AEXPOS}_{it} * CRISIS_t$ | -0.614*** | | -2.695*** | | -1.426*** | |
| | (0.093) | | (0.376) | | (0.302) | |
| $\text{TEXPOS}_{it} * CRISIS_t$ | | -0.427*** | | -0.420** | | -0.306** |
| | | (0.109) | | -0.175) | | (0.104) |
| R2 | 0.15 | 0.13 | 0.04 | 0.03 | 0.08 | 0.04 |
| N | 2,558 | 2,558 | 1,480 | 1,480 | 970 | 970 |
| Regions | 205 | 205 | 133 | 133 | 109 | 109 |
| **Country Level Triple Difference Regression** | | | | | | |
| | Investment Growth | | Consumption Growth | | Output Growth | |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| $\text{DEXPOS}_{it} * CRISIS_t$ | -0.055 | | 0.076 | | 0.018 | |
| | (0.077) | | (0.085) | | (0.034) | |
| $\text{AEXPOS}_{it} * CRISIS_t$ | -1.063* | | -0.779** | | -0.876*** | |
| | (0.566) | | (0.362) | | (0.330) | |
| $\text{TEXPOS}_{it} * CRISIS_t$ | | -0.129* | | -0.174** | | -0.053* |
| | | (0.066) | | (0.079) | | (0.030) |
| R2 | 0.08 | 0.08 | 0.14 | 0.10 | 0.14 | 0.13 |
| N | 2,880 | 2,880 | 2,880 | 2,880 | 2,880 | 2,880 |
| Countries | 130 | 130 | 130 | 130 | 130 | 130 |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Holding Company Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |

Table VII

Bank Level Portfolio Triple Differences Regressions

Dependent variable is growth in loans over total assets (1)+(2)+(7)+(8)+(13)+(14), securities over total assets (3)+(4) +(9)+(10)+(15)+(16), and the capital ratio (5)+(6)+(11)+(12)+(17)+(18). The sample is split by capital ratio. Panel A consists of the full sample. Panel B presents the regressions for banks with a capital ratio under 15 percent. Panel C consists of banks with a capital ratio greater than 15 percent. dexpos is equal to average total depository institution assets divided by total holding company assets aexpos is equal to average total non-depository assets divided by total holding company assets. DEMO is the average percentage of senior citizens in the home country. Regressions include holding company and year fixed effects and country controls. Standard errors are clustered by holding company

Panel A: Full Sample

| | Loans | | Securities | | Capital Ratio | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.0934** | | -0.485* | | 0.062** | |
| | (0.045) | | (0.259) | | (0.028) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.036*** | | 0.090* | | -0.085 | |
| | (0.013) | | (0.049) | | (0.112) | |
| DEXPOS$_{it} * CRISIS_t$ | -1.117* | | 6.408* | | -0.682** | |
| | (0.613) | | (3.359) | | (0.282) | |
| AEXPOS$_{it} * CRISIS_t$ | 0.3814** | | -1.189* | | 0.980 | |
| | (0.173) | | (0.632) | | (1.379) | |
| DEMO$_i * CRISIS_t$ | 0.0008*** | 0.00057* | -0.00009 | -0.00031 | 0.00100* | 0.00112* |
| | (0.0001) | (0.0001) | (0.00033) | (0.00032) | (0.00080) | (0.00061) |
| N | 122,284 | 122,284 | 122,284 | 122,284 | 74,639 | 74,639 |
| R2 | 0.131 | 0.128 | 0.152 | 0.124 | 0.205 | 0.194 |

Panel B: Less Capitalized Banks

| | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.126*** | | -0.136*** | | 0.472*** | |
| | (0.043) | | (0.045) | | (0.100) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.044*** | | 1.262*** | | -0.055** | |
| | (0.014) | | (0.401) | | (0.021) | |
| DEXPOS$_{it} * CRISIS_t$ | -1.625** | | 1.497*** | | -5.352*** | |
| | (0.697) | | (0.505) | | (1.136) | |
| AEXPOS$_{it} * CRISIS_t$ | 0.471** | | -14.60*** | | 0.567* | |
| | (0.196) | | (4.765) | | (0.274) | |
| DEMO$_i * CRISIS_t$ | 0.00056*** | 0.00037 | -0.00003** | -0.00001 | 0.00100 | 0.00050* |
| | (0.00015) | (0.00039) | (0.00001) | (0.00039) | (0.00070) | (0.00028) |
| N | 65,408 | 65,408 | 55,599 | 55,599 | 40,593 | 40,593 |
| R2 | 0.136 | 0.132 | 0.118 | 0.116 | 0.299 | 0.243 |

Panel C: Well Capitalized Banks

| | (13) | (14) | (15) | (16) | (17) | (18) |
|---|---|---|---|---|---|---|
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.508* | | -0.844*** | | 0.489** | |
| | (0.311) | | (0.122) | | (0.189) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.013 | | 0.445*** | | -0.403 | |
| | (0.233) | | (0.075) | | (1.937) | |
| DEXPOS$_{it} * CRISIS_t$ | -6.047* | | 10.79*** | | -3.486** | |
| | (3.107) | | (1.247) | | (1.485) | |
| AEXPOS$_{it} * CRISIS_t$ | 1.782 | | -7.025*** | | -1.447 | |
| | (2.427) | | (0.763) | | (15.45) | |
| DEMO*CRISIS | 0.00074*** | 0.00094* | -0.00036 | -0.00097* | 0.00100* | 0.00100 |
| | (0.00013) | (0.00049) | (0.00026) | (0.00060) | (0.00060) | (0.00080) |
| N | 56,876 | 56,876 | 49,038 | 49,038 | 34,036 | 34,036 |
| R2 | 0.160 | 0.155 | 0.127 | 0.106 | 0.246 | 0.215 |

Table VIII

Regional and Country Level Triple Differences Regression

Dependent variable is growth in per capita gdp (1)+(2)+(11)+(12), capital intensive inv (3)+(4) R+D expenses (5)+(6), Investment (7)+(8), and consumption (9)+(10). Each cell displays the point estimate and standard error for the OLS coefficient. All regressions include region and year fixed effects. Standard errors are clustered by country. DEXPOS is equal to average total depository institution asset exposure divided by GDP. AEXPOS is equal to total non-depository asset exposure dividedby GDP. DEMO is the average percentage of seniors in the country.

Regional Level Regressions

| | GDP Growth | | Capital Investment | | R+D Expenditures | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DEXPOS*CRISIS*DEMO | 0.046** | | 0.119* | | 0.255** | |
| | (0.019) | | (0.065) | | (0.102) | |
| AEXPOS*CRISIS*DEMO | -0.048*** | | -0.132** | | -0.305*** | |
| | (0.016) | | (0.053) | | (0.064) | |
| DEXPOS*CRISIS | -0.497*** | | -4.515* | | -3.485** | |
| | (0.198) | | (2.237) | | (1.463) | |
| AEXPOS*CRISIS | 0.218*** | | 0.209 | | 4.806*** | |
| | (0.071) | | (1.032) | | (2.235) | |
| CRISIS*DEMO | 0.005 | 0.0009** | 0.006 | 0.005** | 0.006 | -0.0003 |
| | (0.003) | (0.00054) | (0.007) | (0.002) | (0.012) | (0.0010) |
| R2 | 0.22 | 0.15 | 0.05 | 0.04 | 0.18 | 0.10 |
| N | 2,558 | 2,558 | 1,480 | 1,480 | 970 | 970 |
| Regions | 205 | 205 | 133 | 133 | 109 | 109 |

Country Level Regressions

| | Investment Growth | | Consumption Growth | | Output Growth | |
|---|---|---|---|---|---|---|
| | (7) | (8) | (9) | (10) | (11) | (12) |
| DEXPOS*CRISIS*DEMO | 0.253** | | 0.136** | | 0.14** | |
| | (0.118) | | (0.064) | | (0.060) | |
| AEXPOS*CRISIS*DEMO | -1.743** | | -1.171** | | -1.197** | |
| | (0.806) | | (0.456) | | (0.527) | |
| DEXPOS*CRISIS | -0.102 | | -0.041 | | -0.004 | |
| | (0.065) | | (0.025) | | (0.025) | |
| AEXPOS*CRISIS | -0.337 | | -0.320 | | -0.197 | |
| | (0.677) | | (0.265) | | (0.144) | |
| CRISIS*DEMO | 0.018* | 0.036** | -0.005 | 0.020** | -0.008 | 0.025*** |
| | (0.009) | (0.018) | (0.007) | (0.011) | (0.007) | (0.007) |
| R2 | 0.11 | 0.08 | 0.06 | 0.04 | 0.17 | 0.11 |
| N | 2,880 | 2,880 | 2,880 | 2,880 | 2,880 | 2,880 |
| Countries | 130 | 130 | 130 | 130 | 130 | 130 |

Table IX

Bank Level Triple Differences Deposit Regressions

Dependent variable is growth in total deposits (1)+(2)+(7)+(8)+(13)+(14), savings + demand deposits (3)+(4)+(9) +(10)+(15) +(16), and commercial deposits (5)+(6)+(11)+(12)+(17)+(18) The sample is split by capital ratio. Panel A consists of the full sample. Panel B presents the regressions for banks with a capital ratio under 15 percent. Panel C consists of banks with a capital ratio greater than 15 percent. dexpos is equal to average total depository institution assets divided by total holding company assets aexpos is equal to average total non-depository assets divided by total holding company assets. DEMO is the average percentage of senior citizens in the home country. Regressions include holding company and year fe's and country controls. Standard errors are clustered by holding company

| Panel A (Less Capitalized Banks) | | | | | | |
|---|---|---|---|---|---|---|
| | Total Deposits | | Savings + Demand | | Commercial | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.164** | | 0.043*** | | 0.083* | |
| | (0.078) | | (0.010) | | (0.046) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.076*** | | 0.251* | | -0.077*** | |
| | (0.021) | | (0.142) | | (0.027) | |
| DEXPOS$_{it} * CRISIS_t$ | -1.746** | | -0.441* | | -0.721* | |
| | (0.747) | | (0.217) | | (0.383) | |
| AEXPOS$_{it} * CRISIS_t$ | 0.785*** | | -3.234* | | 0.767*** | |
| | (0.223) | | (1.821) | | (0.268) | |
| DEMO$_i * CRISIS_t$ | 0.00022 | 0.00072*** | 0.00014 | 0.00013** | 0.00008 | 0.00005 |
| | (0.00016) | (0.00014) | (0.00009) | (0.00006 | (0.00011) | (0.00044) |
| N | 117,131 | 117,131 | 112,271 | 112,271 | 53,758 | 53,758 |
| R2 | 0.142 | 0.124 | 0.108 | 0.097 | 0.114 | 0.104 |
| **Panel B (Less Capitalized Banks)** | | | | | | |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.503*** | | 0.068*** | | 0.320*** | |
| | (0.108) | | (0.009) | | (0.071) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.124*** | | 0.540** | | -0.103*** | |
| | (0.023) | | (0.223) | | (0.015) | |
| DEXPOS$_{it} * CRISIS_t$ | -5.839*** | | -0.797*** | | -3.614*** | |
| | (1.303) | | (0.132) | | (0.863) | |
| AEXPOS$_{it} * CRISIS_t$ | 1.409*** | | -6.894** | | 1.106*** | |
| | (0.272) | | (2.837) | | (0.181) | |
| DEMO$_i * CRISIS_t$ | -0.00035** | 0.00005 | -0.00010 | 0.00006* | -0.00009 | -0.00006 |
| | (0.00015) | 0.00013) | (0.00007) | 0.00003) | (0.00011) | 0.00011) |
| N | 62,349 | 65,408 | 60,275 | 60,275 | 28,163 | 28,163 |
| R2 | 0.126 | 0.103 | 0.115 | 0.081 | 0.116 | 0.105 |
| **Panel C (Well Capitalized Banks)** | | | | | | |
| | (13) | (14) | (15) | (16) | (17) | (18) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.745* | | 0.279* | | 0.351 | |
| | (0.419) | | (0.167) | | (0.420) | |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.279 | | 1.707* | | -0.274 | |
| | (0.404) | | (0.946) | | (0.538) | |
| DEXPOS$_{it} * CRISIS_t$ | -7.068 | | -0.936 | | -5.424 | |
| | (4.701) | | (1.671) | | (5.010) | |
| AEXPOS$_{it} * CRISIS_t$ | 3.422 | | -20.65* | | 5.045 | |
| | (5.209) | | (12.83) | | (6.286) | |
| DEMO$_i * CRISIS_t$ | -0.00062 | 0.00009 | 0.00008 | 0.00070*** | -0.00038 | -0.00037 |
| | (0.00066) | (0.00028) | (0.00026) | (0.00026) | (0.00060) | (0.00057) |
| N | 54,782 | 54,782 | 51,996 | 51,996 | 24,995 | 24,995 |
| R2 | 0.143 | 0.126 | 0.110 | 0.086 | 0.122 | 0.105 |

Table X
Bank Level Triple Differences Portfolio Regressions
(split sample, crisis country demographics)

Dependent variable is growth in loans over total assets (1)+(2)+(7)+(8), securities over total assets (3)+(4)+(9)+(10), and the capital ratio (5)+(6)+(11)+(12). The sample is split by the holding company capital ratio. The top panel consists of banks with a capital ratio under 15 percent. The lower panel constists of well capitalized banks with more than 15 percent in capital holdings. dexpos is equal to average total depository institution assets dividedby total holding company assets aexpos is equal to average total non-depository assets divided by total holding company assets. texpos is the sum of dexpos and aexpos. DEMO is the percentage percentage of senior citizens in the crisis country. All Regressions include holding company and year fixed effects as well as country-year controls. Standard errors are clustered by holding company

| Panel A (Less Capitalized Banks) | | | | | | |
|---|---|---|---|---|---|---|
| | Loans | | Securities | | Capital Ratio | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{DEXPOS}_{it} * CRISIS_t * DEMO_j$ | 0.293** | | -0.633** | | -0.557*** | |
| | (0.139) | | (0.295) | | (0.207) | |
| $\text{AEXPOS}_{it} * CRISIS_t * DEMO_j$ | -0.025 | | 0.055 | | 0.060 | |
| | (0.017) | | (0.029) | | 0.302) | |
| $\text{DEXPOS}_{it} * CRISIS_t$ | -3.683* | | 5.946** | | 7.292*** | |
| | (1.978) | | (2.689) | | (2.697) | |
| $\text{AEXPOS}_{it} * CRISIS_t$ | 0.305 | | -0.532 | | -1.942 | |
| | (0.309) | | (0.280) | | (3.513) | |
| $\text{DEMO}_j * CRISIS_t$ | 0.00011 | -0.00006 | -0.00099 | -0.00099 | 0.001 | 0.001 |
| | (0.0005) | (0.00053) | (0.00110) | (0.00110) | (0.001) | (0.001) |
| N | 65,408 | 65,408 | 55,590 | 55,590 | 40,543 | 40,543 |
| R2 | 0.149 | 0.109 | 0.133 | 0.113 | 0.110 | 0.081 |

| Panel A (Well Capitalized Banks) | | | | | | |
|---|---|---|---|---|---|---|
| | Loans | | Securities | | Capital Ratio | |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| $\text{DEXPOS}_{it} * CRISIS_t * DEMO_j$ | 0.629** | | -0.668*** | | -1.840* | |
| | (0.247) | | (0.229) | | (0.900) | |
| $\text{AEXPOS}_{it} * CRISIS_t * DEMO_j$ | 0.003 | | -0.052 | | 0.048 | |
| | (0.086) | | (0.045) | | (0.095) | |
| $\text{DEXPOS}_{it} * CRISIS_t$ | -6.395*** | | 5.627*** | | 1.851* | |
| | (1.962) | | (1.834) | | (0.889) | |
| $\text{AEXPOS}_{it} * CRISIS_t$ | 0.980 | | 0.493 | | -4.531* | |
| | (2.600) | | (0.447) | | (2.297) | |
| $\text{DEMO}_j * CRISIS_t$ | -0.00012 | 0.00022 | -0.00101 | -0.00129 | 0.001 | 0.001 |
| | (0.00092) | (0.00071) | (0.00165) | (0.00114) | (0.001) | (0.002) |
| N | 56,876 | 56,876 | 49,083 | 49,083 | 34,036 | 34,036 |
| R2 | 0.145 | 0.115 | 0.144 | 0.107 | 0.282 | 0.221 |

Table XI

Summary Statistics for the 2007 Financial Crisis

All values are in millions US. N is the number of bank holding companies with exposure.

| Parent Country | N | Average Exposure | Total Exposure | Parent Country | N | Average Exposure | Total Exposure |
|---|---|---|---|---|---|---|---|
| ALGERIA | 1 | 598 | 598 | KOREA REP. OF | 4 | 352 | 1,409 |
| ANDORRA | 1 | 73 | 73 | KUWAIT | 4 | 895 | 3,582 |
| ANTIGUA AND BARBUDA | 1 | 270 | 270 | LIBYAN ARAB JAMAHIRIYA | 1 | 598 | 598 |
| AUSTRALIA | 7 | 3,063 | 21,440 | LIECHTENSTEIN | 2 | 0.57 | 1.14 |
| AUSTRIA | 9 | 1,338 | 12,046 | LUXEMBOURG | 12 | 30,922 | 371,069 |
| BAHRAIN | 8 | 2,225 | 17,797 | MALAYSIA | 6 | 13 | 80 |
| BELGIUM | 9 | 26,130 | 235,166 | MAURITIUS | 1 | 11 | 11 |
| BERMUDA | 5 | 13,375 | 66,877 | MEXICO | 3 | 3,091 | 9,273 |
| CANADA | 12 | 23,637 | 283,647 | MOROCCO | 2 | 457 | 914 |
| CHINA-PEOPLE'S REP. | 2 | 694 | 1,388 | NAMIBIA | 1 | 12 | 12 |
| COLOMBIA | 2 | 173 | 347 | NETHERLANDS | 15 | 13,751 | 206,263 |
| CYPRUS | 1 | 110 | 110 | NETHERLANDS ANTILLES | 1 | 1.37 | 1.37 |
| CZECH REPUBLIC | 1 | 1.40 | 1.40 | NEW ZEALAND | 1 | 27 | 27 |
| DENMARK | 7 | 2,443 | 17,099 | NIGERIA | 1 | 1.81 | 1.81 |
| DOMINICAN REPUBLIC | 1 | 551 | 551 | NORWAY | 6 | 1,342 | 8,052 |
| EGYPT | 1 | 598 | 598 | PAKISTAN | 2 | 235 | 471 |
| FINLAND | 3 | 30 | 91 | PHILIPPINES | 1 | 1.00 | 1.00 |
| FRANCE | 28 | 26,114 | 731,205 | POLAND | 1 | 1.00 | 1.00 |
| GEORGIA REP. OF | 1 | 0.41 | 0.41 | PORTUGAL | 5 | 598 | 2,989 |
| GERMANY | 29 | 30,380 | 881,017 | QATAR | 2 | 44 | 89 |
| GREECE | 5 | 5,942 | 29,710 | ROMANIA | 1 | 161 | 161 |
| HONG KONG | 4 | 466 | 1,864 | RUSSIAN FEDERATION | 1 | 68 | 68 |
| ICELAND | 5 | 109 | 543 | SAUDI ARABIA | 2 | 3.67 | 7.34 |
| INDIA | 2 | 1,756 | 3,512 | SINGAPORE | 4 | 42 | 170 |
| INDONESIA | 1 | 178 | 178 | SLOVENIA | 1 | 12 | 12 |
| IRAN | 2 | 520 | 1,040 | SOUTH AFRICA | 4 | 8,606 | 34,425 |
| IRELAND | 10 | 10,975 | 109,750 | SPAIN | 9 | 40,520 | 364,676 |
| ISRAEL | 3 | 9,012 | 27,035 | SWEDEN | 6 | 7,068 | 42,410 |
| ITALY | 24 | 3,216 | 77,195 | TAIWAN | 3 | 829 | 2,486 |
| JAMAICA | 1 | 1.00 | 1.00 | UNITED ARAB EMIRATES | 1 | 0.43 | 0.43 |
| JAPAN | 16 | 28,671 | 458,729 | UNITED KINGDOM | 22 | 84,224 | 1,852,932 |
| JORDAN | 6 | 38 | 229 | USA | 54 | 19,744 | 1,066,170 |
| | | | | Total | 387 | | 6,948,468 |

Table XII
2007 Financial Crisis Regressions

Dependent variable is change in loans over assets (1) and securities over assets (2), the capital ratio (3), the change in savings+demand deposits over assets (4), commercial deposits over assets (5), and total eposits over assets (6). d dexpos is equal to average total depository institution assets divided by total holding company assets. aexpos is equal to average total non-depository assets divided by total holding company assets DEMO is the average percentage of senior citizens in the country. All Regressions include holding company and year fixed effects as well as country-year controls. Standard errors are clustered by holding company.The sample covers the time period 2003-2009

| | Net Loans | Total Securities | Capital Ratio | Savings+ Demand | Commercial Deposits | Total Deposits |
|---|---|---|---|---|---|---|
| Panel A: Full Sample | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | 0.528* | 0.060 | 8.974*** | 1.253*** | -1.044*** | -0.329* |
| | (0.191) | (0.068) | (2.926) | (0.186) | (0.397) | (0.121) |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.600** | 0.26*** | 18.043*** | 0.322* | 1.034*** | 0.849*** |
| | (0.171) | (0.050) | (5.647) | (0.123) | (0.387) | (0.107) |
| DEXPOS$_{it} * CRISIS_t$ | -7.074* | -0.783 | -72.274*** | -15.857*** | 14.079*** | 5.151** |
| | (2.562) | (0.861) | (24.945) | (2.245) | (4.202) | (1.569) |
| AEXPOS$_{it} * CRISIS_t$ | 7.893** | -2.217** | -292.681*** | -3.977 | -14.184*** | -10.67*** |
| | (2.376) | (0.712) | (91.522) | (1.978) | (4.050) | (1.380) |
| CRISIS$_t * DEMO_i$ | 0.001*** | 0.001 | 0.003* | 0.008*** | 0.001 | 0.008*** |
| | (0.0003) | (0.002) | (0.002) | (0.001) | (0.001) | (0.002) |
| Observations | 47,593 | 47,593 | 47,593 | 47,593 | 17,136 | 47,593 |
| R-squared | 0.151 | 0.128 | 0.186 | 0.14 | 0.128 | 0.15 |
| Panel B Less Capitalized Banks | | | | | | |
| | (7) | (8) | (12) | (9) | (19) | (11) |
| DEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.505*** | -0.549 | -3.252** | 1.367*** | -0.392* | -0.104 |
| | (0.167) | (0.346) | (1.020) | (0.159) | (0.118) | (0.623) |
| AEXPOS$_{it} * CRISIS_t * DEMO_i$ | -0.898** | 0.880* | -6.078** | 0.449** | -2.080* | -0.206* |
| | (0.385) | (0.483) | (1.937) | (0.128) | (0.939) | (0.118) |
| DEXPOS$_{it} * CRISIS_t$ | 1.483** | -8.124* | 98.541** | -6.020** | 33.755* | 3.345* |
| | (0.604) | (4.197) | (31.403) | (2.121) | (15.228) | (1.905) |
| AEXPOS$_{it} * CRISIS_t$ | 0.417*** | 4.600 | 27.466** | -17.497*** | 0.001 | 0.844 |
| | (0.138) | (2.908) | (8.551) | (1.874) | (0.002) | (0.523) |
| CRISIS$_t * DEMO_i$ | 0.001 | 0.001 | 0.002*** | 0.008*** | 0.003** | 0.012*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Observations | 20114 | 20114 | 20114 | 20114 | 8,216 | 20114 |
| R-squared | 0.156 | 0.108 | 0.186 | 0.148 | 0.155 | 0.162 |

$i$

# 9 Appendix

## 9.1 Model Derivation

To solve for the equilibrium allocations in each country, I first derive the optimal contracting and a bound for deposit contract payoffs.I then show that a per capita treatment of banking flows is equivalent to any other potential equilibrium. This will simplify the later analysis since it reduces the set of potential equilibria which have isomorphic aggregate outcomes. Then I prove an irrelevance theorm for a steady state equilibrium with no possibility of liquidation so that all banking structures are equivalent. I go on to solve for the equilibrium when there is a positive probability of liquidation in each country and a constant expected price of capital. This consists of calculating the optimal liquid asset holding that maximizes the return-liquidation payoff. I also generalize the results to the cobb douglas case with diminishing returns and hence time varying expected price of capital and a positive complementarity between labor and capital.

**9.1.1** *Proposition 1. Assume that the bank has already accumulated excess reserves as in Allen and Gale (1997) so as to rule out insolvency. If optimal contracts are determined at time 0 and state contingent contracting is not allowed, then the optimal contract offers constant rates of return $r_1^*$, $r_2^*$ to agents in the economy .*

Essentially, the bank can insure agents against some degree of generation specific risk. This depends though on the availability of state contingent contracting. If the contracts are not allowed to be state contingent, then the optimal deposit contract will offer a constant rate of return and individuals will be directly exposed to labor income shocks. The bank offers protection against idiosyncratic illiquidity shocks and capital price risk but individuals are exposed to some degree of aggregate uncertainty themselves.

*proof*

If deposit contracts are non-state contingent, we get that the deposit rate is independent of the wage rate in that period. Define any alternative non-state contingent deposit contracting scheme with deposit rate distributions $f(r_{1t})$ and $f(r_{2t})$ and note that $E(r_{1t}|w_t) = E(r_{1t}) = r_1$ and $E(r_{2t}|w_t) = E(r_{2t}) = r_2$. Assume that $r_1$, $r_2$ are the maximum feasible constant deposit rate that the bank can offer to individual in the economy. Now by concavity of the utility function.

$$E(U(\alpha(r_{1t}w_tL) + (1-\alpha)(r_{2t}w_tL))|w_t) \leq U(E(\alpha r_{1t}w_tL + (1-\alpha)(r_{2t}w_tL)|w_t))$$

Now taking the unconditional expectation, we get that

$$\begin{aligned} E\left[E(U(\alpha(r_{1t}w_tL) + (1-\alpha)(r_{2t}w_tL))|w_t)\right] &= E(U(\alpha(r_{1t}w_tL) + (1-\alpha)(r_{2t}w_tL))) \\ &\leq E\left[U(E(\alpha r_{1t}w_tL + (1-\alpha)(r_{2t}w_tL)|w_t))\right] \\ &= E\left[U(\alpha E(r_{1t}|w_t)w_tL + (1-\alpha)E(r_{2t}|w_t)w_tL)\right] \\ &= E\left[U(\alpha r_1w_tL + (1-\alpha)r_2w_tL\right] \end{aligned}$$

So a constant deposit rate is optimal non-state contingent deposit contract under time 0 trading.

### 9.1.2 Proof of Proposition 1

Below I show that the bounds for this equilibrium must hold. The proof of this involves forming the iterative sequential constraints for the expected value of $I_t^{'}$ and taking the limit as $t \to \infty$. I rewrite the sequential budget as intertemporal restrictions on $E(I_t^{'})$ and recursively substitute the bounds on $E(I_{t-2}^{'})$ . Let $S^{t'}$denote the history of safe asset investments until $time\, t$ : $\{S_{-1}^{'}, ..., S_t^{'}\}$. A more detailed description of the general proof is given in the 8.4 of the appendix in Liu (2010).

Define $(1-\bar{\rho}^{'})R_t^{'} = \frac{1}{\lambda I_t + \lambda^* I_t^*}\left(\lambda(1-\bar{\rho}_t)\bar{R}_tI_t + \lambda^*(1-\bar{\rho}_t{}^*)\bar{R}_t{}^*I_t^*\right)$ and $w_t^{'}L^{'} = \lambda w_tL + \lambda^* w_t^* L^*$. Also, let $\bar{\rho}^{'}\bar{V}^{'} = \bar{\rho}\bar{V} + \bar{\rho}^*\bar{V}^*$ and define $I_t^{'} = \lambda I_t + \lambda^* I_t^*$, $r_1^{'} = \frac{1}{\lambda w_tL + \lambda^* w_t^* L^*}\left(\lambda r_1 w_t L + \lambda^* r_1^* w_t^* L^*\right)$ and $r_2^{'} = \frac{1}{\lambda w_tL + \lambda^* w_t^* L^*}\left(\lambda r_2 w_t L + \lambda^* r_2^* w_t^* L^*\right)$ . So by substituting in recursively, we get that:

$$
\begin{aligned}
E(I^{'}_{2k}|S^{2k}) &\leq (1-\bar{\rho}^{'})E(R^{'}_{2k})E(I^{'}_{2k-2}) \\
&+E\left[S_{2k-1}+\rho^{'}_{2k}V^{'}_{2k}+w^{'}_{2k}L-\alpha r^{'}_1\bar{w}^{'}L-(1-\alpha)r^{'}_2\bar{w}^{'}L-S_{2k}+\rho^{'}_0\right] \\
&\leq w^{'}_{2k}L^{'}+\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}\left((1-\bar{\rho}^{'})\bar{R}^{'}\bar{w}^{'}L^{'}-\alpha r^{'}_1\bar{w}^{'}L^{'}-(1-\alpha)r^{'}_2\bar{w}^{'}L^{'}+S_{2i}+\bar{\rho}^{'}\bar{V}^{'}-S_{2i+1}\right)
\end{aligned}
$$

$$
\begin{aligned}
E(I^{'}_{2k+1}|S^{2k+1}) &\leq (1-\bar{\rho}^{'})E(R^{'}_{2k+1})E(I^{'}_{2k-1}) \\
&+E\left[S_{2k}+\rho^{'}_{2k+1}\bar{V}^{'}_{2k+1}+w^{'}_{2k+1}L^{'}-\alpha r^{'}_1\bar{w}^{'}L^{'}-(1-\alpha)r^{'}_2\bar{w}^{'}L^{'}-S_{2k}\right] \\
&\leq \bar{w}^{'}L^{'}+\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}\left((1-\rho^{'}_{2i})\bar{R}^{'}\bar{w}^{'}L^{'}-\alpha r^{'}_1\bar{w}^{'}L^{'}-(1-\alpha)r^{'}_2\bar{w}^{'}L^{'}+S_{2i}+\bar{\rho}^{'}\bar{V}^{'}-S_{2i+1}\right)
\end{aligned}
$$

So

$$
\begin{aligned}
I^{'}_{2k}+I^{'}_{2k+1} &\leq 2\bar{w}^{'}L^{'}+lim\frac{2\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k+1}}{(1-\bar{\rho}^{'})\bar{R}^{'}-1} \\
&x\left((1-\bar{\rho}^{'})\bar{R}^{'}\bar{w}^{'}L^{'}-\left((1-\bar{\rho}^{'})\bar{R}^{'}-1\right)\bar{S}+\bar{\rho}^{'}\bar{V}^{'}-\alpha r^{'}_1\bar{w}^{'}L^{'}-(1-\alpha)r^{'}_2\bar{w}^{'}L^{'}\right)
\end{aligned}
$$

So if $\alpha r^{'}_1+(1-\alpha)r^{'}_2 \geq (1-\bar{\rho}^{'})\bar{R}^{'}\bar{w}^{'}L^{'}-((1-\bar{\rho})\bar{R}^{'}-1)\bar{S}+\bar{\rho}^{'}\bar{V}^{'}$, then this limit tends to $-\infty$ and we get a contradiction since it implies that for k sufficiently large, investment goes to negative infinity.

So we get that $\alpha r^{'}_1\bar{w}^{'}L^{'}+(1-\alpha)r^{'}_2\bar{w}^{'}L^{'} \leq (1-\rho^{'})\bar{R}^{'}(\bar{w}^{'}L^{'}-\bar{S})+\bar{S}+\bar{\rho}^{'}\bar{V}^{'}$ is the unconditional constraint that must hold in expectation and with equality in equilibrium. Define $\bar{S}^{'}=(\bar{w}L-\bar{I})$ and $\bar{S}^{*}=(\bar{w}^{*}L^{*}-\bar{I}^{*})$ and using this, we can write the constraint as:

$$
\begin{aligned}
\alpha r^{'}_1\bar{w}^{'}L+(1-\alpha)r^{'}_2\bar{w}^{'}L & \leq \\
\lambda(1-\bar{\rho})\bar{R}_tI_t+\lambda^{*}(1-\bar{\rho}^{*})\bar{R}_t{}^{*}I^{*}_t+\bar{S}+\bar{\rho}\bar{V}+\bar{\rho}^{*}\bar{V}^{*} & = \\
\lambda(1-\bar{\rho})\bar{R}_t(\bar{w}L-\bar{S})+\lambda^{*}(1-\bar{\rho}^{*})\bar{R}_t{}^{*}(\bar{w}^{*}L^{*}-\bar{S}^{*})+\bar{S}+\bar{\rho}\bar{V}+\bar{\rho}^{*}\bar{V}^{*} &
\end{aligned}
$$

To see that the banks must offer the same deposit rates since the representative banks are assumed to operate in a perfectly competitive environment so that:

$$
(1-\bar{\rho}^{'})\bar{R}^{'}(\bar{w}^{'}L^{'}-\bar{S}^{'})+\bar{S}^{'}+\bar{\rho}^{'}\bar{V}^{'}=(1-\bar{\rho}^{'f})\bar{R}^{'f}(\bar{w}^{'f}L^{'f}-\bar{S}^{'f})+\bar{S}^{'f}+\bar{\rho}^{'f}\bar{V}^{'f}
$$

Notice that if they did not, then it would be possible for the bank that offers the higher rate to attract a greater market share by offering marginally higher rates so that the portfolio return is still greater than that of the other bank.

### 9.1.3 Proof of Lemma 0

*Lemma 0. Assume that for any investment allocation, there is a uniquely optimal $S_t$. Then the aggregate per capita treatment of banking flows equilibrium is equivalent to any other potential equilibrium. In other words, given a set of feasible $\{I_t, I^{*}_t, S_t, S^{*}_t, \rho_t, \rho^{*}_t, \lambda, \lambda^{*}, \gamma_t, \gamma^{*}_t, r_1, r_2, r^{*}_1, r^{*}_2\}$ that constitutes an equilibrium, then there is a per capita treatment equilibrium that replicates the aggregate allocations, portfolio payoffs, and hence deposit rates.*

Under the per capita portfolio flow assumption, the fraction of home deposits that are invested abroad are equal for both banks. Intuitively, to see that there is always an equivalent per capital allocation, simply consider the case where there is one multinational bank.Then we have that $\gamma^a = \lambda\gamma_t + (1-\lambda)\gamma_t^*$. Therefore, net capital flows to each country are the same so this means that the expected rate of return must also be the same. The international banking case also results in the greatest aggregate diversification level. Therefore, this equilibrium is equivalent to any other possible equilibrium. Moreover, if for any investment level, the optimal choice of $S_t$ is unique, then any equilibrium allocation of $\{\lambda, \lambda^*, \gamma_t, \gamma_t^*\}$ attains the same aggregate realizations of $\{I_t, I_t^*, S_t, S_t^*, \rho_t, \rho_t^*, r_1, r_2\}$ . Another way to state this is that any equilibrium allocation must attain the same aggregate allocations as the one bank equilibrium.

*proof*

Assume that there is a unique optimal level of the short asset $S_t$ for any level of investment $I_t$. Let an equilibrium $\{I_t, I_t^*, S_t, S_t^*, \rho_t, \rho_t^*, \lambda, \lambda^*, \gamma_t, \gamma_t^*\}$ be given and assume that without loss of generality that $\gamma_t, \gamma_t^* > 0$. To see that there is an equivalent allocation, take $\gamma_t^a = \lambda\gamma_t + (1-\lambda)\gamma_t^*$ to get the weighted capital flow which is equivalent to the per capita capital flow. Then let $R_t^a = R_t$, $R_t^{*a} = R_t^*$, $I_t = I_t^h + I_t^{f*}$, and $I_t^* = I_t^f + I_t^{h*}$ so we have that aggregate investment flows and returns are equal to the equilibrium allocation. Similarly, let $S_t^a = (S_t + S_t^*)$ and $\rho_t^a = \rho_t^h V_t^h + \rho_t^{f*} V_t^h$ , $\rho_t^{*a} = \rho_t^{h*} V_t^f + \rho_t^{*f} V_t^f$ to get the representative portfolio. These are the aggregate allocations which are equal to the equilibrium give above.

Then for any per capital equilibrium $0 \le \lambda^a, \lambda^{*a} \le 1$, we have investment in the home country is $\lambda^a I_t^a$ and $\lambda^{*a} I_t^{*a}$ in the foreign country. Therefore, the rate of return on the portfolio is $(1-\rho_t^a)\lambda^a R_t^a I_t^a + (1-\rho_t^{*a})\lambda^{*a} R_t^{*a} I_t^{*a}$. Moreover, if $\lambda = \lambda^* = 1$ , then total investment in the short asset must be equal to $S_t^a$ and the equilibrium expected liquidation is $\rho_t^a V + \rho_t^{*a} V$. This per capita outcome attains the same aggregate outcomes, expected returns, and hence deposit rates in equilibrium. Any other per capita equilibrium allocation must attain this aggregate allocation. Any other potential equilibrium must attain a rate of return

$$E\left[(1-\rho_t^a)R_t^a I_t^a + (1-\rho_t^{*a})R_t^{*a} I_t^{*a} + \rho_t^a + \rho_t^{*a} + S_t^a\right]$$

to maximize deposit rates or else it is not an equilibrium since it does not maximize the banker's portfolio problem. Also, notice that our assumption that $S_t$ is uniquely optimal for the level of investment is critical here. Suppose that $S_t^a$ is not equal to the optimal amount of the short asset when $\lambda^a, \lambda^{*a} = 1$. But then this means that there is another value of the short asset that attains the necessary equilibrium rate of return. Then this means that the level of $S_t^a$ is not unique or the allocation does not attain the one country bank optimum so it cannot be an equilibrium. Hence, it must be that the aggregate allocation replicates the allocation if it is an equilibrium. Notice that if we allow for the existence of one holding company, then any possible equilibrium must replicate this aggregate allocation.

## 9.2 Proof of Lemma 1

*Lemma 1. Under the per capital treatment of banking flows, since $\gamma_t = \gamma_t^*$, any $0 \le \lambda = \lambda^* \le 1$ will constitute an equilibrium and mimic the special case where there is just one multinational bank. Both banks hold the same portfolio in this case.*

This is relatively straightforward to see. Since both countries are the same size, having equal amounts invested in both countries will generate the same diversification effects since the optimal amount invested in the short asset is proportional up to a constant. The bank also holds the same portfolio since with a per capita treatment of banking flows, $\gamma_t = \gamma_t^*$ so they have identical per capita capital flows. To generate the same returns, banks must have the same fraction of their funds invested in the liquid asset.

*Proof*

To see that any $\lambda = \lambda^*$ generates the same equilibrium as the case where $\lambda = \lambda^* = 1$, simply consider the expected amount of liquidation:

(1) $$\Upsilon(I_{t-1}, S_t) = E(\rho_t I_{t-1} V_t) =$$

(2) $$\frac{1}{V_t}\int_0^{a^*_{max}} \int_0^{\frac{\beta}{\lambda f(I_{t-1},L)}} \left(a\lambda f(I_{t-1},L) + S_t + \lambda^* a^* f(I_{t-1}^*,L) - (\lambda+\lambda^*)(\alpha r_1 wL + (1-\alpha)r_2 wL)\right) f(a)\,da\,g(a^*)\,da^*$$

From proposition 3, we will see that the solution with constant expected returns becomes:

$$S_t = (\lambda + \lambda^*)(\alpha r_1 wL + (1-\alpha) r_2 wL) - \eta(\lambda f(I_{t-1}, L) + \lambda^* f(I^*_{t-1}, L))$$

So we see that summing over $S_t$ and $S^*_t$ will give the same allocation as when $\lambda = \lambda^*$ as desired since

$$S^{agg}_t = (2)(\alpha r_1 wL + (1-\alpha) r_2 wL) - \eta(f(I_{t-1}, L) + f(I^*_{t-1}, L))$$

so $S_t$ is proportional up to a constant to the aggregate liquid asset holding $S^a_t$. Moreover, both banks will hold the same portfolio. Therefore, any value of $0 \leq \lambda = \lambda^* \leq 1$ can achieve the same aggregate outcome as the case where$\lambda = \lambda^* = 1$.

Also for any per capita equilibrium where $\lambda = \lambda^*$, it must be that portfolio returns are equalized across the two countries. If $\gamma_t = \gamma^*_t$, then this can only hold the banks hold the same portfolio.

### 9.2.1 Proof of Proposition 2

***Irrelevance Therorem*** *If the probability of liquidation is zero and the expected return to capital is equal in both countries, then there are no gains from multinational banking. The aggregate equilibrium is equivalent to that under autarchy. Even in the case where there is perfect capital mobility, and differential rates of returns in both countries, the determination of* $\lambda$ *and* $\lambda^*$*in the absence of other frictions is irrelevant for the aggregate equilibrium outcome. Capital will equate rates of returns in both countries but the aggregate allocation of investment, wages, and returns will be equivalent for any values of* $0 \leq \lambda, \lambda^* \leq 1$.

The intuition here is simple: in the case where the expected return to capital is equal under autarky and the probability of liquidation is zero, then the rate of return to depositors is the same as that under autarky. This is because returns are already equated so there are no gains from capital mobility and similarly, since there is no threat of liquidation, there are no diversification gains. Even when there are differential returns under autarky, the banking structure does not impact the aggregate equilibrium outcome since optimal capital flows are driven by relative differences in productivity. To see this, simply note that investment will also be made to equate the expected rate of return on return on capital. Therefore, the optimal deposit rates $r_1$and $r_2$will also be equal across both countries. So we have that the equilibrium deposit rates, capital flows, and return on capital are independent of the banking structure.

*proof*

For simplicity, I assume that investment abroad is done on a per capita basis. The equilibrium in this model when $\bar{\rho} = 0$ and $\alpha r_1 < w_t L$ is given as:

$$S_t = \begin{cases} 0 & for\, t \epsilon Z^{++} \end{cases}$$

$$I^{agg}_t = I^h_t + I^{h*}_t = \begin{cases} max\{\lambda \left[ w_t L + R_t I_{t-2} - \alpha r_1 w_{t-1} L - (1-\alpha) r_2 w_{t-2} \right], & for\, t \epsilon Z^{+} \\ +\lambda^* \left[ w^*_t L + R_t I^*_{t-2} - \alpha r^*_1 w^*_{t-1} L - (1-\alpha) r^*_2 w^*_{t-2} \right], 0\} \end{cases}$$

and that the steady state feasible budget constraint $\alpha r_1 \bar{w}^{agg} L + (1-\alpha) r_2 \bar{w}^{agg} L \leq \bar{R}$ must hold. Note that investment in the short asset is zero when there is no probability of liquidation

Therefore, the original budget constraint when $\bar{\rho} = 0$ becomes:

$$\alpha r_1 w^{agg}_{t-1} L + (1-\alpha) r_2 w^{agg}_{t-2} + I^{agg}_t \leq R^{agg} I^{agg}_{t-2} + w^{agg}_t L$$

which is the budget constraint from the one country model so equilibrium is obtained from plugging in our values for $w^{agg}_t$m $I^{agg}_t$and $R^{agg}$. Therefore, the solution is defined as above.

Here $\bar{R} = \mu \frac{\partial f}{\partial k_t} = \mu^* \frac{\partial f^*}{\partial k^*_t}$ which is greater than the rate of return in the home country under autarcky but lower than the rate of return in the closed foreign country. However, production in the foreign country has increased so expected total labor income has increased as well since it is a fixed share of production with the cobb douglas production function.

Investment in each country can therefore be defined as:

$$I^h_t = \begin{cases} (1-\gamma_t)\lambda max \left\{ w_t L + (R_t I_{t-2} - \alpha r_1 w_{t-1} L - (1-\alpha) r_2 w_{t-2}), 0 \right\} & for\, t \epsilon Z^{+} \end{cases}$$

and

$$I_t^{h*}=\begin{cases}\gamma_t\lambda max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\} & for\, t\epsilon Z^+\\ +\lambda^* max\left\{w_t^*L+\left(R_t^*I_{t-2}^*-\alpha r_1w_{t-1}^*L-(1-\alpha)r_2w_{t-2}^*\right),0\right\}\end{cases}$$

Since $\gamma_t$is the fraction of capital that flows abroad, then this result follows immediately.
So note that aggregate investment at home is

$$\begin{aligned}I_t^h+I_t^{f*} &= (1-\gamma_t)\lambda max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\}\\ &\quad +(1-\gamma_t)(1-\lambda)max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\}\\ &= (1-\gamma_t)max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\}\end{aligned}$$

and similarly, aggregate investment in the foreign country is

$$\begin{aligned}I_t^f+I_t^{h*} &= \left[\gamma_t(1-\lambda)+\gamma_t\lambda\right]max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\}\\ &\quad +\left[(1-\lambda^*)+\lambda^*\right]max\left\{w_t^*L+\left(R_t^*I_{t-2}^*-\alpha r_1w_{t-1}^*L-(1-\alpha)r_2w_{t-2}^*\right),0\right\}\\ &= \gamma_t max\left\{w_tL+\left(R_tI_{t-2}-\alpha r_1w_{t-1}L-(1-\alpha)r_2w_{t-2}\right),0\right\}\\ &\quad +max\left\{w_t^*L+\left(R_t^*I_{t-2}^*-\alpha r_1w_{t-1}^*L-(1-\alpha)r_2w_{t-2}^*\right),0\right\}\end{aligned}$$

Investment in the short asset at home us$S_t+S_t^*=0$. Therefore, aggregate investment in the risky and short assets are independent of $\lambda$ and $\lambda^*$. Since wages in each country are determined by production (a function of capital investment) and the price of capital, it is also independent of $\lambda$ and $\lambda^*$. In the case where $\bar{\gamma}=0$ so that expected returns to capital are already equalized, then the aggregate equilibrium is the same as that of the one country model under autarky.

For the optimal deposit rate calculation, the derivation is given in Liu (2010). Furthermore, since $E(\rho_t)=E(\rho_t^*)=0$ and $S_t=0$, the deposit rate bound is simply $\mu$ if we normalize labor income to equal one.

### 9.2.2 Proof of Proposition 3

This proof for proposition 3 uses the result from lemma 1 and lemma 2 and solves for the investment function using a per capita bank flow treatment.

*Derivation of* $S_t$ We know that the shocks $A_t\sim U(0,x)$and $A_t^*\sim U(0,x^*)$ are uniformly distributed and independent and $V_t=V$.

Let $\beta=(\lambda+\lambda^*)(\alpha r_1w_{t-1}L+(1-\alpha)r_2w_{t-1}L)-S_t-\lambda^*a^*rf(I_{t-1}^*,L)$ and conditional expected liquidation amount at time $t$ becomes:

$$\Upsilon(I_{t-1},S_t)=E(\rho_tI_{t-1}V_t)=$$
$$\frac{1}{r\lambda f(I_{t-1},L)r\lambda^*f(I_{t-1}^*,L)}\frac{1}{V}\int_0^{x^*\lambda^*f(I_{t-1}^*,L)}\int_0^{\beta}(a\lambda rf(I_{t-1},L)-\beta)f(a)\,da\,g(a^*)\,da^* \quad =$$
$$\frac{1}{r\lambda f(I_{t-1},L)r\lambda^*f(I_{t-1}^*,L)}\frac{1}{V}\int_0^{x^*\lambda^*f(I_{t-1}^*,L)}\Phi(a\lambda rf(I_{t-1},L)-\beta)g(a^*)\,da^*$$

For $A_t$ with pdf $f(a)$ and $A_t^*$ with pdf $g(a^*)$.

$$\begin{aligned}
\Phi(a\lambda f(I_{t-1},L)-\beta) &= |_0^{\frac{\beta}{\lambda f(I_{t-1},L)}} \frac{a^2}{2}\lambda f(I_{t-1},L)-\beta a \\
&= -\frac{1}{x}\frac{\beta^2}{2\lambda f(I_{t-1},L)} \\
&= -\frac{1}{x}\frac{((\lambda+\lambda^*)(\alpha r_1 wL+(1-\alpha)r_2 wL)-S_t-\lambda^* a^* f(I^*_{t-1},L))^2}{2\lambda f(I_{t-1},L)} \\
&= -\frac{1}{x}\frac{\lambda^{*2}a^{*2}f(I^*_{t-1},L)^2-2\lambda^* a^* f(I^*_{t-1},L)(\lambda+\lambda^*)(\alpha r_1 wL+(1-\alpha)r_2 wL)-S_t)}{2\lambda f(I_{t-1},L)} \\
&\quad +\frac{1}{x}\frac{((\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)-S_t))^2}{2\lambda f(I_{t-1},L)}
\end{aligned}$$

Now integrating over $A^*_t$, we get that the unconditional liquidation amount $\Upsilon(I^*_{t-1},I_{t-1},S_t)$ is equal to:

$$\begin{aligned}
-\Upsilon(I^*_{t-1},I_{t-1},S_t) &= -(\frac{1}{Vxx^*})[a^{*3}\frac{\lambda^{*2}f(I^*_{t-1},L)^2}{6\lambda f(I_{t-1},L)}-a^{*2}\frac{f(I^*_{t-1},L)\lambda^*\left((\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)-S_t\right)}{2\lambda f(I_{t-1},L)} \\
&\quad +a\frac{((\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)-S_t))^2}{2\lambda f(I_{t-1},L)}]_0^{x^*} \\
&= -\frac{x^{*2}}{Vx}\frac{\lambda^{*2}f(I^*_{t-1},L)^2}{6\lambda f(I_{t-1},L)}-\frac{1}{Vx}\frac{((\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)-S_t)^2}{2\lambda f(I_{t-1},L)} \\
&\quad +\frac{x^*}{Vx}\frac{\lambda^* f(I^*_{t-1},L)\left((\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)-S_t\right)}{2\lambda f(I_{t-1},L)}
\end{aligned}$$

$$\frac{\partial\Upsilon(I^*_{t-1},I_{t-1},S_t)}{\partial S_t} = \frac{S_t-(\lambda+\lambda^*)(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L)}{Vx\lambda f(I_{t-1},L)}+\frac{x^* f(I^*_{t-1},L)\lambda^*}{Vx2\lambda f(I_{t-1},L)}$$

So the bank must liquidate an amount $\Upsilon(I_{t-1},S_t)$ of assets from either country. Since labor is immobile, the bank will expect to liquidate $\frac{\Upsilon(I_{t-1},S_t)}{2}$ in each country

Consider the case when the price of capital is a constant amount $\mu=\mu^*$ in each period. Then the maximization problem at each point in time is:

$$\begin{aligned}
max_{S_t} \quad & \beta\mu\left(I_t-\frac{1}{2}\Upsilon(I^*_{t-1},I_{t-1},S_t)\right)+\beta\mu^*(I^*_t-\frac{1}{2}\Upsilon(I^*_{t-1},I_{t-1},S_t))+S_t+\Upsilon(I^*_{t-1},I_{t-1},S_t)V \\
& =\beta\mu\left(I_t+I^*_t-\Upsilon(I^*_{t-1},I_{t-1},S_t)\right)+S_t+\Upsilon(I^*_{t-1},I_{t-1},S_t)V \\
subject\,to \quad & S_t\le\lambda A_t(1-\rho_{t-1})I_{t-2}+\lambda^* A^*_t(1-\rho^*_{t-1})I^*_{t-2}+S_{t-1}-(\lambda+\lambda^*)(\alpha r_1\bar{w}L-(1-\alpha)r_2\bar{w}L) \\
& S_t\ge 0
\end{aligned}$$

So the FOC are:

$$\begin{aligned}
-\beta\mu\frac{\partial\Upsilon(I^*_{t-1},I_{t-1},S_t)}{\partial S_t}++-\beta\mu(\lambda+\lambda^*)+1+\frac{\partial\Upsilon(I^*_{t-1},I_{t-1},S_t)}{\partial S_t}V+\Upsilon(I^*_{t-1},I_{t-1},S_t)\frac{\partial V}{\partial S_t} &= 0 \\
\theta_1\left(\lambda A_t(1-\rho_{t-1})I_{t-2}+\lambda^* A^*_t(1-\rho^*_{t-1})I^*_{t-2}+S_{t-1}-(\lambda+\lambda^*)(\alpha r_1\bar{w}L-(1-\alpha)r_2\bar{w}L)\right) &= 0 \\
\theta_2 &= 0
\end{aligned}$$

So if we have an interior solution then,

$$\frac{\partial\Upsilon(I^*_{t-1},I_{t-1},S_t)}{\partial S_t} = \frac{(1-\beta\mu(\lambda+\lambda^*))}{(\beta\mu-V)}$$

$$S_t = (\lambda+\lambda^*)(\alpha r_1 wL+(1-\alpha)r_2 wL)-\frac{x^*}{2}\lambda^* f(I^*_{t-1},L)+-\frac{(\beta\mu(\lambda+\lambda^*)-1)xV}{(\beta\mu-V)}\lambda f(I_{t-1},L)$$

By symmetry, we get that the aggregate holding is:

$$S_t=\pi_{t+1}-(\frac{x^*}{4}f(I^*_{t-1},L)-\frac{(\beta\mu-1)x^*V}{(\mu-V)}f(I_{t-1},L))-(\frac{x}{4}f(I^*_{t-1},L)-\frac{(\beta\mu-1)xV}{(\mu-V)}f(I_{t-1},L))$$

Since banks must hold the same portfolio and we have that:

$$S^*_t=\pi_{t+1}-(\lambda+\lambda^*)\left(\frac{x}{4}+\frac{(\beta\mu-1)xV}{(\beta\mu-V)}\right)(f(I^*_{t-1},L)+f(I_{t-1},L))$$

*Derivation of* $I_t = I^h_t + I^{h*}_t$

$$I_t=\begin{cases} max\{A_t f(I_{t-2},L)+A^*_t f(I^*_{t-2},L)+S_{t-1}-S_t-\sigma_t,\,0\} & \rho_t=0\\ 0 & \rho_t>0\end{cases}$$

*where*

$$I^h_t=\begin{cases}(1-\gamma_t)\left[A_t f(I_{t-2},L)\right]-\lambda(\alpha r_1 w_{t-1}L+(1-\alpha)r_2 w_{t-2}L) & \rho_t=0,\\ 0 & \rho_t>0\end{cases}$$

*and*

$$I^{h*}_t=\begin{cases}\lambda^* A^*_t f(I^*_{t-2},L)+\gamma_t\lambda A_t f(I_{t-2},L) & \rho_t=0\\ -\lambda^*(\alpha r_1 w^*_{t-1}L+(1-\alpha)r_2 w^*_{t-2}L)+S_{t-1}-S_t & \\ 0 & \rho_t>0\end{cases}$$

Subject to the budget constraint: $\alpha r_1^{'}\bar{w}^{'}L+(1-\alpha)r_2^{'}\bar{w}^{'}L\leq(1-\bar{\rho}^{'})\bar{R}^{'}(\bar{w}^{'}L^{'}-\bar{S}^{'})+\bar{S}^{'}+\bar{\rho}^{'}\bar{V}^{'}$ and the intertemporal constraint

$$\omega_t+I^h_t+I^{h*}_t+S_t\leq(1-\rho_{t-1})R_t I^h_{t-2}+(1-\rho^*_{t-1})R^*_t I^{h*}_{t-2}$$

$$+S_{t-1}+\lambda w_t L_t+\lambda^* w^*_t L^*_t+\rho_t\bar{V}_{t-1}+\rho^*_t\bar{V}^*_{t-1}$$

To see that this is budget feasible, rewrite the constraint as:

$$\alpha r_1^{'}w_{t-1}^{'}L+(1-\alpha)r_2^{'}w_{t-2}^{'}+S_t^{'}+I_t^{'}\leq(1-\rho_t^{'})R^{'}I_{t-2}^{'}+w_t^{'}L+S_{t-1}^{'}+\rho_t^{'}V_t^{'}$$

If the constraint from proposition 1 holds with equality, we get that:

$$\begin{aligned}E(I_t^{'}) &\leq \bar{w}^{'}L^{'}-\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}E(S_{2i}^{'})\\ &+\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}(1-\bar{\rho}^{'})\bar{R}^{'}S^{'}\end{aligned}$$

To get the formulas for investment, just plug in the expected values for $S_{2i}$ and $S_{2i+1}$

$$\begin{aligned}E(I_{2k}) &\leq \bar{w}^{'}L^{'}-\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}\bar{S}^{'}+\sum_{i=0}^{k}\left((1-\bar{\rho}^{'})\bar{R}^{'}\right)^{k-i}(1-\bar{\rho}^{'})\bar{R}^{'}\bar{S}^{'}\\ &= \bar{w}^{'}L^{'}-\bar{S}^{'}\end{aligned}$$

So that $E(I_t) \leq \bar{w}L - \bar{S}$ so anything below this bound is budget feasible.

Also note that the intertemporal budget constraint is satisfied with equality since assume without loss of generality that $I_{t-2} = (1-\bar{\rho}^{'})(\bar{w}^{'}L^{'}-\bar{S}^{'})$ and define $\tau = Pr\left[(1-\rho_{t-1}^{'})R_t^{'}I_{t-2}^{'} + w_t^{'}L \leq \alpha r_1^{'}w_{t-1}^{'}L^{'} + (1-\alpha)r_2^{'}w_{t-2}^{'}L^{'} + S_{t-1}^{'}\right]$ to be the average probability that liquidation occurs. Then we have that

$$\begin{aligned} E(I_t) &= (1-\tau)E(I_t^{'}|\rho_t = 0) + \tau E(I_t^{'}|\rho_t > 0) \\ &= E[w_t^{'}L^{'} + R_t^{'}I_{t-2}^{'} + S_{t-1}^{'}] + (1-\tau)\left[-\frac{\bar{S}^{'}}{1-\tau} - \alpha r_1^{'}\bar{w}^{'}L - (1-\alpha^{'})r_2^{'}\bar{w}^{'}L^{'}\right] \\ &\quad + \tau\left[E(\rho_t^{'}V_t^{'}|\rho_t^{'} > 0) - \alpha r_1\bar{w}^{'}L^{'} - (1-\alpha)r_2^{'}\bar{w}^{'}L^{'}\right] \\ &= (\bar{w}^{'}L^{'} - \bar{S}^{'}) + \left[(1-\bar{\rho}^{'})\bar{R}^{'}(\bar{w}^{'}L^{'} - \bar{S}^{'}) + \bar{S}^{'} + \bar{\rho}^{'}\bar{V}^{'} - \alpha r_1^{'}\bar{w}^{'}L^{'} - (1-\alpha)r_2^{'}\bar{w}^{'}L^{'}\right] \\ &= (\bar{w}^{'}L^{'} - \bar{S}^{'}) \end{aligned}$$

Since the intertemporal constraint must hold with equality for the allocation to be an equilibrium. Therefore $I_t$ is budget feasible and satisfies the constraints so that the goods market clears. Also, the given value of $I_t$ attains the maximum feasible bounds. Notice that the amount of investment that is expected to hold over to the next period is $(1-\bar{\rho}^{'})(\bar{w}^{'}L^{'} - \bar{S}^{'})$.

*Derivation of Optimal Liquidation Policy*

To see why this is true, consider two options: to meet a shortfall in production, the intermediary can either liquidate an amount $\triangle$ today for investment and get $\triangle V$ today which will pay off $E(R_{t+2}|S_t)\triangle V$ or it can choose not to liquidate, in which case, it will get $E(R_{t+1}|S_t)\triangle$ and by assumption, $V < 1$. The expected price of capital is invariant so the return to reinvesting is less then expected proceeds from production in one period. Therefore, it is clearly not optimal to liquidate unless the bank must do so to avoid a run.

### 9.2.3 Derivation of Predictions 3 and 5

First note that an equilibrium can exist where banks only experience asset shocks. If we let $\lambda = 1$ and $\lambda^* = 0$ so that the bank raises all its deposits abroad and assume that production follows a cobb douglas form where $(1-\beta)$ is the wage share of production. Then if the bank invests a fraction $1 - \frac{1}{2\beta}$ in the home country and $\frac{1}{2\beta}$ abroad, then this constitutes an equilibrium. Under this equilibrium, that it receives $\frac{1}{2}$ of the production abroad and at home in each period. Similarly, the foreign bank raises all its deposits in its own country and invests a fraction $\frac{1}{2\beta}$ in the home country. Therefore, a low productivity draw in the foreign country will only be felt as a shock to assets in the home country whereas the foreign country will receive both a shock to deposits and assets.

Now I show proposition 4 formally. Rewrite the capital level explicitly as:

$$\begin{aligned} \kappa &= (1-\rho)\mu_{t+2}(\lambda A_t f(I_{t-2}^h) + \lambda^* A_t^* f(I_{t-2}^{h*}) - \sigma_t + S_{t-1} - S_t) + S_t + \rho V + \mu(\lambda I_{t-1}^h + \lambda^* I_{t-1}^{h*}) \\ &\quad -\sigma_{t+1} - \lambda(1-\alpha)r_2 w_t L + -\lambda^*(1-\alpha)r_2 w_t^* L \end{aligned}$$

Where $\mu_{t+2} = \mu_{t+2}^*$ is the expected return to investment in two periods, $\mu = \mu^*$ is the expected price in the next period. Total assets in are given as the sum of bank capital and liabilities:

$$\nu = (1-\rho)\mu_{t+2}(\lambda A_t f(I_{t-2}^h) + \lambda^* A_t^* f(I_{t-2}^{h*}) - \sigma_t + S_{t-1} - S_t) + S_t + \rho V + \lambda\mu I_{t-1}^h + \lambda^*\mu^* I_{t-1}^{h*} + \sigma_t$$

First, I will show that a shock to both assets and liabilities may result in a smaller decrease in the capital ratio $\tau = \frac{\kappa}{\nu - S_t}$.

Assume without loss of generality that $\rho = 0$ so that the expected liquidation amount is zero in the next period so $S_t^* = 0$ as well. It is immediate that a negative shock to capital returns decrease this ratio since a shock to returns $\lambda R_t I_{t-2}$decreases the capital ratio by $\frac{\partial \tau}{\partial \lambda R_t I_{t-2}} = \frac{(1-\rho)\mu_{t+2}(\nu - S_t - \kappa)}{(\nu - S_t)^2} > 0$ . However, the opposite can be true for a shock to labor income since when $(1-\rho)\mu_{t+2} - (\alpha r_1 + (1-\alpha)r_2) < (1-\rho)\mu_{t+2}\tau$, we have that:

$$\frac{\partial \tau}{\partial(\lambda w_t L)} = \frac{\partial \tau}{\partial(\lambda^* w_t^* L)} = \frac{((1-\rho)\mu_{t+2} - \alpha r_1 - (1-\alpha)r_2)(\nu - S_t) - (1-\rho)\mu_{t+2}\kappa}{(\nu - S_t)^2} < 0$$

Therefore, if the bank only has asset exposure, then a negative shock will lower this capital ratio and if there is some exogenous requirment for $\tau$ to meet some threshhold level $\bar{c}$, then it may cause this constraint to become binding. However, if the bank faces experiences a negative shock to both assets and deposit inflows so that

$$\frac{\partial \tau}{\partial A_t} = \frac{\partial \tau}{\partial(\lambda w_t L + \lambda R_t I_{t-2})} = \frac{\partial \tau}{\partial(\lambda w_t L)} + \frac{\partial \tau}{\partial \lambda R_t I_{t-2}} < \frac{\partial \tau}{\partial \lambda R_t I_{t-2}}$$

so the decline in liabilities can actually increase our reserve ratio, thus offseting the decline induced by the fall in returns. As a result, asset exposure leads to a greater decline in the capital ratio when there is not a corresponding decline in liabilities .

We also see that since for a given weighting,

$$\tau = \frac{\kappa + (1-r)\triangle}{\nu}$$

if we invest the proceeds entirely in the safe asset but if we invest this, the ratio becomes

$$\tau = \frac{\kappa + (\mu - r)\triangle}{\nu + \triangle}$$

So we have that $\frac{\partial \tau}{\partial S_t} > \frac{\partial \tau}{\partial I_{t-2}}$ if

$(\kappa + (1-r)\triangle)(\nu + \triangle) > \upsilon(\kappa + (\mu - r)\triangle)$ or $\upsilon + \kappa > \mu\upsilon + (r-1)\triangle$. So due to the risk weighting, banks actually have an incentive to invest in the liquid asset to inflate their capital ratio.

Assume that we are now in the case where the bank is capital constraind. I will now show that the ratio can be increasing in the complementarity between labor and capital.

If a bank is subject to deposit exposure, a drop in liabilities will actually loosen this bank capital constraint so that the bank can invest greater funds. This is because if $\frac{\partial \tau}{\partial \lambda w_t L} < 0$ , then to increase the ratio, the bank must allocate the new inflows for investment in the liquid asset.

So consider a change of $\triangle$ in deposit inflows $\lambda w_t L$ that are allocated entirely for investment in $S_t$. The change in our ratio $\tau$ becomes:

$$\tau' = \frac{\kappa + \triangle - (\alpha r_1 + (1-\alpha)r_2)\triangle}{\nu}$$

So if our $\tau$ is binding, then $\tau' < \tau$ when

$$(1 - \alpha r_1 - (1-\alpha)r_2)\triangle < \tau\upsilon - \kappa$$

Therefore, we need for

$$1 < \alpha r_1 + (1-\alpha)r_2$$

Since this condition is generally true, the bank actually has to increase its holding of the liquid asset by more than the additional deposit inflows to meet the capital requirement constraint. Therefore, if we have lower complementarity following a negative shock and this constraint is binding, there will be greater deposit inflows but lower investment if the constraint is binding.

### 9.2.4 Derivation of Prediction 4

Suppose that instead, production follows a cobb douglas form so that our maximization problem becomes:

$$max_{S_t} \quad \mu\left(\lambda I_t - \frac{1}{2}\Upsilon(I^*_{t-1}, I_{t-1}, S_t)\right)^{\beta} L^{1-\beta} + \mu^*(\lambda^* I^*_t - \frac{1}{2}\Upsilon(I^*_{t-1}, I_{t-1}, S_t))^{\beta} L^{1-\beta} + S_t + \Upsilon(I^*_{t-1}, I_{t-1}, S_t)V$$

The FOC in this case becomes:

$$\begin{aligned} -\mu L^{1-\beta}\left[\lambda I_t - \frac{1}{2}\Upsilon(S_t, I_{t-1})\right]^{\beta-1}(\lambda + \frac{1}{2}\frac{\partial\Upsilon(S_t, I_{t-1})}{\partial S_t}) & \\ -\mu^* L^{*1-\beta}\left[I^*_t - \frac{1}{2}\Upsilon(S_t, I_{t-1})\right]^{\beta-1}(\lambda^* + \frac{1}{2}\frac{\partial\Upsilon(S_t, I_{t-1})}{\partial S_t}) + 1 + V\frac{\partial\Upsilon(S_t, I_{t-1})}{\partial S_t} &= 0 \\ \theta_1(S - \bar{w}L) &= 0 \\ \theta_2 S &= 0 \end{aligned}$$

So consider when $\lambda = \lambda^*$ and $\mu = \mu^*$ so that we will have a symmetric equilibrium so that $I_t = I^*_t$. In this case, the first condition becomes:

$$\mu L^{1-\beta}(\lambda + \lambda^* + \frac{\partial\Upsilon(S_t, I_{t-1})}{\partial S_t})\left[I_t - \frac{1}{2}\Upsilon(S_t, I_{t-1})\right]^{\beta-1} = 1 + \frac{\partial\Upsilon(S_t, I_{t-1})}{\partial S_t}V$$

We also have investment smoothing. if $I_t > E(I_{t+1})$ (a detailed description of this is given in Liu (2010). Therefore, to derive the optimal amount of the short asset, notice that if $E(R_{t+3}) > E(R_{t+2})$), then it will be optimal to accumulate the safe asset to reinvest until returns are equalized which occurs when

$$\begin{aligned} I_t - \Upsilon(S_t, I_{t-1}) &= \lambda(I^h_t - \frac{1}{2}\Upsilon(S_t, I_{t-1})) + \lambda^*(I^{h*}_t - \frac{1}{2}\Upsilon(S_t, I_{t-1})) \\ &= \lambda(I^h_{t+1} - \frac{1}{2}\Upsilon(S_{t+1}, I_t)) + \lambda^*(I^{*h}_{t+1} - \frac{1}{2}\Upsilon(S_{t+1}, I_t)) = I_{t+1} - \Upsilon(S_{t+1}, I_t) \end{aligned}$$

So we need for

$$\begin{aligned} &\lambda A_t f(I_{t-2}, L) + \lambda^* A_t f(I^*_{t-2}, L) + S_{t-1} - S_t - \Upsilon(S_t, I_{t-1}) = \\ &\lambda\mu f(I_{t-1}, L) + \lambda^*\mu f(I^*_{t-1}, L) + S_t - S_{t+1} - \Upsilon(S_{t+1}, I_t) \end{aligned}$$

$$\begin{aligned} S_t &= \frac{\lambda A_t(I_{t-2}, L) + \lambda^* A_t f(I_{t-2}, L) - (\lambda+\lambda^*)\mu f(I_{t-1} - \Upsilon(S_t, I_{t-1})) + S_{t-1} + S_{t+1}}{2} \\ &\quad -\frac{1}{2}\Upsilon(S_t, I_{t-1}) + \frac{1}{2}\Upsilon(S_{t+1}, I_t) \end{aligned}$$

Therefore, the optimal liquid asset holding is:

$$S_t = \begin{cases} \frac{\lambda A_t(I_{t-2},L)+\lambda^* A_t f(I_{t-2},L)-(\lambda+\lambda^*)\mu f(I_{t-1}-\Upsilon(S_t,I_{t-1}))+S_{t-1}+S_{t+1}}{2} & if\, I_t > E(I_{t+1}) \\ -\frac{1}{2}\Upsilon(S_t, I_{t-1}) + \frac{1}{2}\Upsilon(S_{t+1}, I_t) & \\ & \\ S\; s.t.\; \mu L^{1-\beta}\left[\lambda + \lambda^* + \frac{\partial\Upsilon(S,I_{t-1})}{\partial S}\right] = \left(1 + V\frac{\partial\Upsilon(S,I_{t-1})}{\partial S}\right)(I_t - \Upsilon(S, I_{t-1}))^{1-\beta} & if\, I < E(I_{t+1}),\, \mu_1 = \mu_2 = 0 \\ w_t L + (1-\rho_{t-1})R_t I_{t-2} + S_{t-1} - \alpha r_1\bar{w}L - (1-\alpha)r_2\bar{w}L & if\, I_t < E(I_{t+1}),\, \mu_1 > 0 \\ 0 & if\, I_t < E(I_{t+1}),\, \mu_2 > 0 \end{cases}$$

The investment in the risky asset and optimal liquidation strategy remain the same. This is because I have imposed restrictions on the liquidation value so that it is only optimal to liquidate if the bank is forced to do so to avoid a bank run.

*Comparative Statics*

To see that the shock dynamics are greater in the case when wages are linked to the capital level, simply note that in the cobb douglas case labor income is a constant share of total output. Therefore, since labor and capital are multiplicative inputs, a decrease in investment will generate a proportional decline in output. In the case where labor and capital have no complementarity so that production can be given as $f(I, L) = A_t L + A_t r I$, deposit inflows are not dependent on capital levels in the economy. So there will be a smaller decline in output in two periods. Additionally, we will see increase the optimal liquid asset holding. Therefore, there will be a greater decline in investment at time $t$ and $t+1$ following a negative shock.

## 9.3 Regressions

Notice that our differences in differences regression can be rewritten as:

$$y_{it} = \gamma_1^a \sum_j AEXPOS_{i,j} * CRISIS_{j,t} + \gamma_1^d \sum_j DEXPOS_{i,j} * CRISIS_{j,t} + \beta X_{i,t} + \epsilon_{it}$$

Since inclusion of holding company and year fixed effects eliminates $\sum_j AEXPOS_{i,j}$,$\sum_j DEXPOS_{i,j}$, and $\sum_j CRISIS_{j,t}$. Here, I am restricting $\gamma_{ij} = \gamma_{ik} \, \forall k, j$ which are separate estimates for $DEXPOS_{i,j} * CRISIS_{j,t}$ for each of our j crises and I do the same for $AEXPOS_{i,j} * CRISIS_{j,t}$ and $DEMO_i * CRISIS_{j,t}$. I therefore estimate the average treatment effect and I make this assumption since I am investigating the impact of multiple crises on our variables of interest. Another way to interpret this regression is that I am making the implict assumption that exposure to each crisis has an equal impacts on our lhs variable. Since the focus of this paper is not on the differential impact of each crisis, I make the assumption to get average effects. Similarly, the triple differences regression can be rewritten as

$$\begin{aligned} y_{it} \quad = \quad & \beta_1^a \sum_{,j} AEXPOS_{i,j} * CRISIS_{j,t} * DEMO_i + \beta_1^d \sum_{,j} DEXPOS_{i,j} * CRISIS_{j,t} * DEMO_i \\ & + \beta_2^a \sum_j AEXPOS_{i,j} * CRISIS_{j,t} + \beta_2^d \sum_j DEXPOS_{i,j} * CRISIS_{j,t} \\ & + \beta_3 \sum_j DEMO_i * CRISIS_{j,t} + \beta X_{i,t} + \epsilon_{it} \end{aligned}$$

And the same terms drop out. Similarly, for this triple differences specification, I add the additional restriction that $\beta_{ij} = \beta_{ik} \, \forall k, j$ so the values for $\beta_1$ and $\beta_1^*$ measure the average treatment effect of exposure to each crisis.

### 9.3.1 Exogeneity of Financial Crises

For the differences in differences and triple differences equations to be unbiased, we need for the financial crisis to be exogenous. I argue that it indeed exogenous since I consider a large sample of financial crises so although different banks may have different investment profiles, the likelihood that they will have exposure to one of the countries that experience a crisis is unlikely to be systematically correlated with subsample characteristics. This can be infered from Table I where we see that multinational banks with different country exposures do not have different profiles when it comes to lending and deposit taking. Furthermore, I control for bank and holding level fixed effects so we actually need for the lagged deviation in the growth rate to be correlated with crisis exposure to bias the results. To formalize this argument, I regress exposures on lagged lending and other banking attributes and present the results in Table XIV(a) of the appendix. I estimate both a continuous version as well as a logit regression. I find that past lending and portfolio allocations are not correlated with exposure to a financial crisis so there does not appear to be selection bias.

### 9.3.2 Regressions for Recessions.

I run:

$$
\begin{aligned}
y_{it} \quad = \quad & \beta_1^r \sum_{,j} AEXPOS_{i,j} * DEV_{j,t} * DEMO_i + \beta_1^{r*} \sum_{,j} DEXPOS_{i,j} * DEV_{j,t} * DEMO_i \\
& + \beta_2^r \sum_{j} AEXPOS_{i,j} * DEV_{j,t} + \beta_2^{r*} \sum_{j} DEXPOS_{i,j} * DEV_{j,t} \\
& + \beta_3^r \sum_{j} DEMO_i * DEV_{j,t} + \beta^r X_{i,t} + \epsilon_{it}
\end{aligned}
$$

Where $DEV_{jt}$ is the deviation from the Hodrick Prescot trend for country j at time t. I sum over all countries in the sample.

Table I (a)

Crisis Country Level Exposure Summary Statistics

All values are in millions US. DEXPOS is total financial institution assets in the crisis country over GDP. AEXPOS is total industrial institution assets over GDP. PDEXOS and PAEXPOS are the analogous quantities for crisis country bank in the home country.

| | | DEXPOS | | AEXPOS | | | PDEXPOS | | PAEXPOS | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | NUM | MAX | MEAN | MAX | MEAN | PNUM | MAX | MEAN | MAX | MEAN |
| Argentina | 6 | 3.90 | 0.72 | 0.00 | 0.00 | 18 | 2.58 | 0.35 | 1.08 | 0.08 |
| Belarus | 7 | 0.01 | 0.00 | 0.09 | 0.02 | 16 | 26.48 | 3.05 | 4.12 | 0.56 |
| Brazil | 10 | 1.08 | 0.38 | 0.79 | 0.21 | 26 | 2.09 | 0.18 | 5.19 | 0.35 |
| Bulgaria | 2 | 0.01 | 0.01 | 0.00 | 0.00 | 13 | 16.56 | 3.23 | 0.86 | 0.22 |
| China | 11 | 26.69 | 4.08 | 0.05 | 0.01 | 24 | 1.41 | 0.13 | 0.80 | 0.08 |
| Colombia | 4 | 18.75 | 8.20 | 0.62 | 0.16 | 8 | 2.31 | 0.29 | 0.59 | 0.13 |
| Costa Rica | 3 | 3.78 | 1.61 | 0.00 | 0.00 | 3 | 0.09 | 0.06 | 0.00 | 0.00 |
| Finland | 23 | 3.26 | 0.31 | 0.92 | 0.05 | 19 | 86.70 | 5.29 | 0.98 | 0.25 |
| Hungary | 15 | 7.44 | 0.72 | 1.28 | 0.14 | 19 | 9.84 | 1.05 | 3.67 | 0.61 |
| India | 17 | 30.35 | 2.20 | 0.58 | 0.06 | 24 | 0.09 | 0.02 | 2.30 | 0.19 |
| Indonesia | 4 | 0.21 | 0.07 | 0.00 | 0.00 | 23 | 0.77 | 0.10 | 0.76 | 0.09 |
| Jamaica | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 3 | 5.99 | 3.93 | 0.00 | 0.00 |
| Japan | 43 | 5.73 | 0.53 | 0.84 | 0.08 | 27 | 2.47 | 0.21 | 3.63 | 0.27 |
| Korea | 15 | 0.76 | 0.08 | 0.82 | 0.07 | 25 | 3.95 | 0.21 | 4.00 | 0.29 |
| Latvia | 10 | 1.18 | 0.23 | 0.04 | 0.00 | 12 | 9.24 | 1.38 | 4.59 | 0.40 |
| Malaysia | 13 | 3.54 | 0.39 | 0.23 | 0.02 | 23 | 12.29 | 1.17 | 2.46 | 0.30 |
| Mexico | 5 | 1.23 | 0.27 | 0.0008 | 0.0002 | 18 | 5.58 | 0.58 | 1.31 | 0.15 |
| Norway | 33 | 2.13 | 0.07 | 2.17 | 0.15 | 20 | 12.25 | 1.00 | 1.33 | 0.22 |
| Philippines | 4 | 0.14 | 0.04 | 0.0013 | 0.0003 | 19 | 0.25 | 0.06 | 0.98 | 0.10 |
| Poland | 9 | 0.59 | 0.08 | 0.32 | 0.04 | 21 | 2.00 | 0.31 | 1.20 | 0.26 |
| Slovakia | 2 | 0.11 | 0.05 | 0.09 | 0.04 | | | | | |
| Slovenia | 17 | 6.05 | 0.45 | 2.54 | 0.18 | 11 | 12.92 | 2.86 | 12.92 | 1.22 |
| Sweden | 57 | 86.70 | 2.90 | 12.68 | 0.44 | 23 | 3.26 | 0.23 | 2.87 | 0.50 |
| Thailand | 9 | 1.34 | 0.17 | 0.01 | 0.00 | 19 | 2.84 | 0.33 | 3.22 | 0.28 |
| Turkey | 15 | 1.96 | 0.23 | 0.32 | 0.04 | 26 | 3.36 | 0.33 | 3.34 | 0.26 |
| Ukraine | 8 | 0.91 | 0.21 | 0.01 | 0.00 | 18 | 1.64 | 0.36 | 1.28 | 0.11 |
| Ukraine | 75 | 50.52 | 4.48 | 9.81 | 1.32 | 57 | 26.15 | 1.20 | 29.15 | 0.86 |
| Uruguay | 5 | 0.01 | 0.00 | 0.09 | 0.02 | 10 | 3.90 | 1.17 | 2.32 | 0.24 |
| USA | 80 | 16.55 | 0.56 | 19.23 | 1.81 | 40 | 6.32 | 0.50 | 6.27 | 0.31 |
| Venezuela | 3 | 1.22 | 0.41 | 0.00 | 0.00 | 6 | 0.21 | 0.04 | 0.12 | 0.02 |
| Vietnam | 4 | 0.00 | 0.00 | 4.86 | 1.24 | 12 | 25.36 | 2.29 | 5.30 | 0.92 |
| Average | 16.45 | 22.99 | 3.26 | 6.38 | 1.07 | 188 | 10.45 | 1.81 | 5.49 | 0.61 |

Table II(a)
Regional Level Summary Statistics

All Values are in Millions US.

| Region | N | Avg GDP | Avg Percent R+D Expenses | Avg Percent Capital Investment |
|---|---|---|---|---|
| Australia | 9 | 115,340 | 1.87 | |
| Austria | 10 | 47,542 | 1.58 | 31.71 |
| Belgium | 4 | 145,255 | 1.77 | 37.18 |
| Canada | 13 | 131,394 | 1.22 | 21.72 |
| Chile | 6 | 206,237 | | |
| Czech Republic | 9 | 38,611 | 1.19 | 33.78 |
| Denmark | 6 | 52,490 | | 38.12 |
| Estonia | 1 | 16,295 | | |
| Finland | 6 | 45,367 | 2.67 | 34.03 |
| France | 23 | 137,815 | 1.50 | 36.34 |
| Germany | 17 | 255,975 | 2.06 | 45.37 |
| Greece | 5 | 87,455 | 0.48 | 14.43 |
| Hungary | 8 | 34,482 | 0.60 | 34.36 |
| Iceland | 2 | 96,719 | | 12.61 |
| Ireland | 3 | 80,587 | 1.18 | 40.01 |
| Italy | 22 | 136,430 | 0.86 | 30.83 |
| Japan | 11 | 565,301 | | |
| Korea | 8 | 186,379 | 1.87 | 12.35 |
| Luxembourg | 1 | 25,089 | 1.63 | 14.11 |
| Mexico | 21 | 63,148 | | |
| Netherlands | 1 | 478,942 | 1.80 | 29.80 |
| New Zealand | 1 | 81,673 | | |
| Norway | 1 | 167,312 | 1.62 | 33.29 |
| Poland | 1 | 431,598 | 0.42 | 24.47 |
| Portugal | 1 | 181,455 | 0.70 | 17.01 |
| Slovak Republic | 1 | 68,941 | 0.01 | 30.62 |
| Slovenia | 1 | 34,201 | | |
| Spain | 1 | 948,048 | 0.92 | 28.48 |
| Sweden | 1 | 243,270 | 3.67 | 43.50 |
| Switzerland | 1 | 238,072 | | 47.19 |
| Turkey | 1 | 1,073,731 | | |
| United Kingdom | 1 | 1,629,414 | 1.78 | 41.63 |
| United States | 50 | 187,417 | 2.50 | |
| Total | 205 | 497,876 | 1.47 | 31.58 |

Table VIII (a)

Regional Level Triple Differences Regression

Dependent variable is growth in per capita investment (1)+(2)+(3), consumption (4)+(5)+(6), and output (7)+(8)+(9). Cell display the point estimate and standard error for the OLS coefficient. All regressions include country and year fixed effects. Standard errors are clustered by country. PDEXPOS is equal to average total depository institution assets owned by the crisis country divided by GDP. PAEXPOS is equal to total non-depository assets owned by the crisis country divided by GDP. HCRISIS is a dummy for whether the crisis occured in that country. DEMO is the average percentage of seniors. Rec is a dummy for the for a recession.

| | Investment Growth | | | Consumption Growth | | | Output Growth | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\text{PDEXPOS}_{it} * CRISIS_t$ | 0.004 | | -0.001 | -0.117 | | 1.114 | 0.017 | | -0.751* |
| | (0.020) | | (0.019) | (0.067) | | (2.714) | (0.076) | | (0.398) |
| $\text{PAEXPOS}_{it} * CRISIS_t$ | -0.216 | | 0.064 | 1.544*** | | 1.47** | -0.017 | | 4.443** |
| | (0.106) | | (0.068) | (0.491) | | (0.596) | (0.314) | | (1.921) |
| $\text{PDEXPOS}_{it} * CRISIS_t * DEMO_i$ | | | 0.046*** | | | 0.179* | | | 0.048* |
| | | | (0.013) | | | (0.084) | | | (0.026) |
| $\text{PAEXPOS}_{it} * CRISIS_t * DEMO_i$ | | | -0.133 | | | -1.667*** | | | -0.262* |
| | | | (0.090) | | | (0.441) | | | (0.119) |
| $\text{HCRISIS}_t$ | -0.020 | -0.074*** | -0.078*** | -0.007 | -0.186** | -0.116*** | -0.096** | -0.026 | -0.013 |
| | (0.037) | (0.015) | (0.020) | (0.055) | (0.079) | (0.023) | (0.034) | (0.050) | (0.051) |

Table XIII(a)

Country Level Recession Triple Differences Regression

Dependent variable is growth in per capita investment (1)+(2)+(3), consumption (4)+(5)+(6), and output (7)+(8)+(9). Cell display the point estimate and standard error for the OLS coefficient. All regressions include country and year fixed effects. Standard errors are clustered by country. PDEXPOS is equal to average total depository institution assets owned by the crisis country divided by GDP. PAEXPOS is equal to total non-depository assets owned by the crisis country divided by GDP. DEV is the deviation from the Hodrick Prescott trend. REC is a dummy that equals one if the Dev is more than one standard deviation from the trend.

| | Investment Growth | | | Consumption Growth | | | Output Growth | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| DEXPOS$_{it} * DEV_t$ | -0.0094** | | 0.0088 | -0.0019** | | 0.0024 | 0.0016 | | 0.0019 |
| | (0.005) | | (0.008) | (0.001) | | (0.003) | (0.003) | | (0.004) |
| AEXPOS$_{it} * DEV_t$ | 0.0168* | | -0.1002 | 0.0036* | | -0.0209 | -0.0232 | | -0.0237 |
| | (0.009) | | (0.071) | (0.002) | | (0.024) | (0.023) | | (0.027) |
| DEXPOS$_{it} * DEV_t * DEMO_i$ | | | -0.0241*** | | | -0.0098 | | | -0.0103 |
| | | | (0.008) | | | (0.013) | | | (0.013) |
| AEXPOS$_{it} * DEV_t * DEMO_i$ | | | 0.1286* | | | 0.0429 | | | 0.0207 |
| | | | (0.070) | | | (0.040) | | | (0.065) |
| PDEXPOS$_{it} * DEV_t$ | 0.0011 | | 0.0092*** | 0.0001 | | -0.0005 | 0.0009* | | 0.0011 |
| | (0.001) | | (0.002) | (0.000) | | (0.002) | (0.000) | | (0.001) |
| PAEXPOS$_{it} * DEV_t$ | -0.0013 | | -0.028*** | -0.0013 | | 0.0001 | -0.003** | | -0.0064**** |
| | (0.002) | | (0.008) | (0.001) | | (0.004) | (0.001) | | (0.003) |
| PDEXPOS$_{it} * DEV_t * DEMO_i$ | | | -0.0095*** | | | -0.0002 | | | -0.0006 |
| | | | (0.002) | | | (0.002) | | | (0.002) |
| PAEXPOS$_{it} * DEV_t * DEMO_i$ | | | 0.0298*** | | | -0.0004 | | | 0.0051 |
| | | | (0.008) | | | (0.004) | | | (0.003) |
| DEV$_t * DEMO_i$ | | -0.0001 | -0.0001 | | 0.0001 | 0.0001 | | -0.0002 | -0.0000 |
| | | (0.0001) | (0.000) | | (0.0001) | (0.000) | | (0.0003) | (0.000) |
| REC$_t$ | -0.0237** | -0.0225** | -0.023** | -0.029*** | -0.0287*** | -0.0186** | -0.0241*** | -0.0239*** | -0.0236*** |
| | (0.011) | (0.0110) | (0.011) | (0.006) | (0.0058) | (0.007) | (0.006) | (0.0060) | (0.006) |
| Observations | 3,002 | 3,002 | 3,002 | 3,002 | 3,002 | 3,002 | 3,002 | 3,002 | 3,002 |
| R-squared | 0.059 | | 0.061 | 0.043 | | 0.037 | 0.248 | | 0.257 |

Table XIV(a)

Selection Bias Regressions

Dependent variables are aexpos (1) (non-depository asset exposure over total assets), dexpos (2) (depository institution exposure over total assets), and texpos (3)+(4)+(5) (aexpos+dexpos). EXPOSURE is a (5) is a dummy that equals one if the bank has exposure to a crisis country. (1)+(2)+(3)+(4) are OLS regressions. probit regression. (1)+(2)+(3) include firm and year fixed effects. (4) includes holding company and year fixed effects. Standard errors are clustered by firm for all regressions.

| | aexpos | dexpos | texpos | | EXPOSURE |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $Loans_{t-1}$ | 0.0000000015 | 0.0000000010 | 0.0000000006 | -0.0000000017 | -0.0000000017 |
| | (0.0000000018) | (0.0000000010) | (0.0000000014) | (0.0000000011) | (0.0000000011) |
| $Deposits_{t-1}$ | 0.0003 | 0.0003 | -0.0017 | -0.00074 | -0.10 |
| | (0.0006) | (0.0003) | (0.0011) | (0.00087) | (0.11) |
| $Securities_{t-1}$ | 0.0018 | 0.0004 | -0.0015 | -0.00074 | -0.09 |
| | (0.0017) | (0.0008) | (0.0010) | (0.00080) | (0.09) |
| Capital $Ratio_{t-1}$ | -0.0000031 | -0.0000060 | -0.0000071 | 0.000013 | 3.73 |
| | (0.0000053) | (0.0000042) | (0.0000121) | (0.000015) | (4.49) |
| $Assets_{t-1}$ | -0.0000007 | -0.0000000 | 0.0000007 | 0.00000084 | 0.00096 |
| | (0.0000004) | (0.0000003) | (0.0000005) | (0.00000078) | (0.00090) |
| Constant | 0.0583*** | 1.1411*** | 0.0243 | -0.00492 | 3.73*** |
| | (0.0026) | (0.0028) | (0.0144) | (0.00379) | (0.49) |
| Observations | 110,264 | 110,264 | 110,264 | 110,264 | 110,264 |
| R-squared | 0.05 | 0.06 | 0.05 | 0.03 | 0.2967 |

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