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International Financial Regulation: The Role of Banking Sector Sizes

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International Financial Regulation: The Role of Banking Sector Sizes*

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Working Paper

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Abstract

This paper presents a simple two-region banking model of liquidity mismatch to study the strategic interactions between national regulators. Banks hold insufficient liquidity, which leads to a fire-sale externality in an international financial market, justifying coordinated prudential regulation. However, joint regulation is not necessarily a Pareto improvement, as jurisdictions with a smaller banking sector have an incentive to free-ride on foreign regulation. The framework eludes to several arrangements that could bring jurisdictions closer to the efficient outcome, if they cannot agree on common standards: partial global agreements, intermediate agreements among free-riders only, transfers, and capital controls imposed on free-riders. An empirical section demonstrates that key issues around the implementation of the Basel Agreements and the European Banking Union are consistent with the implications from the model.

Keywords: International Regulation; Free-Riding; Banking Sector Sizes

JEL: D62, F36, F42 G15, G21

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1. Introduction

Safeguarding financial stability is a matter of global collective responsibility. [...] Preserving global financial stability requires jurisdictions to cooperate in identifying and mitigating risks to the financial system.

Pablo Hernández de Cos, Chair Basel Committee, 2020

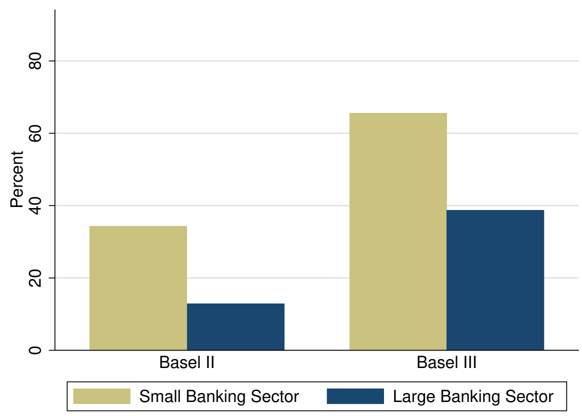
Major banking crises cause significant damage to the domestic economy and result in international spillovers. For this reason, supranational frameworks such as the Basel Initiative or the European Banking Union set regulatory standards that are meant to increase international financial resilience. However, the European Banking Union, which was initially proposed in 2012, is still incomplete as member countries cannot agree on a common insurance mechanism. The Basel framework, in contrast, provides voluntary guidelines that set international minimum standards and do not require a transfer of responsibility. Nevertheless, the adoption has been centered around the 28 Basel member countries, even though the World Bank, IMF, and BIS urged non-member countries to implement core principles (Drezner, 2007; Cos, 2020). Figure 1, Panel (a) highlights that a substantial share of non-member countries did not implement the two most recent proposals, the Basel II and III standards. Though most of these under-regulated financial sectors are small, they aggregate to a significant portion of the global financial market (see Table 1). A lack of regulation in these countries could therefore affect global financial stability. In this article, I argue that the reluctance to adhere to international guidelines can be explained by the size of the domestic financial sector. In this regard, Figure 1, Panel (b) emphasizes that banking sector sizes among Basel non-members are more heterogeneous with a large left tail in the size distribution than among members of the Basel Accord or the European Banking Union.

My first contribution is to rationalize why countries with larger, more developed banking sectors are more likely to follow international standards, while countries with a smaller banking sector are unlikely to implement regulatory standards. International regulation is therefore not necessarily a Pareto improvement, even when it improves global welfare. This poses challenges for implementing common rules across countries and explains the sluggish implementation of the Basel Agreements, as well as certain features of the European Banking Union.

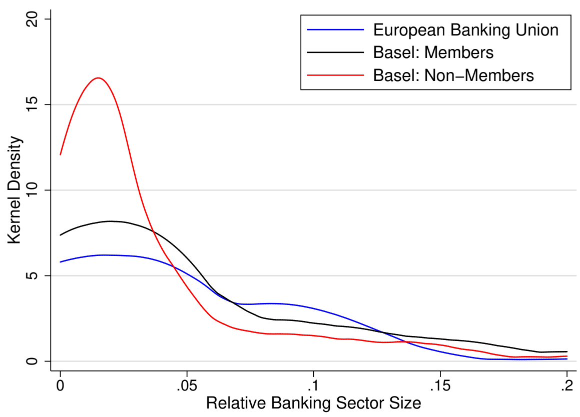
The idea is that national authorities only internalize their own benefits from regulation. As such, they disregard the stabilizing effect of regulation on the foreign banking sector, which constitutes a positive externality. A country that is heavily invested in international financial markets internalizes a significant share of the externality. Domestic regulators who oversee a small banking sector barely internalize any gains from regulation. This leads to asymmetric preferences and may prevent a cooperative agreement.

Figure 1: *Motivation*

(a) *Reluctance to Implement Basel Guidelines*



(b) *Financial Sector Size Distribution*



Notes: *Panel (a) portrays the share of Basel non-members (in %) that did not implement any Basel guidelines as of 2015. The sample is split by the size of the domestic banking sector proxied by the amount of domestic credit to the private sector by banks (in constant USD, threshold based on median). A list of included countries is available in Table A1 in the appendix. Panel (b) portrays kernel densities for the size of each banking sector (proxied by domestic credit) relative to the size of the largest country in each subsample. The figure zooms-in on the left tail of the distribution.*

Table 1: *Unregulated/Partially Regulated Financial Sector Size relative to the US*

N	0	1	2	3	4	5	6	7	8	9	10
Basel II	.06	.07	.1	.11	.11	.21	.26	.27	.37	.41	.48
Basel III	.14	.21	.31	.34	.38	.47	.48	.48	.48	.	.

Notes: The table highlights the cumulative financial sector size of all all Basel non-members relative to the US with less or equal to the specified number of implemented Basel II (row 1) or III (row 2) components. Basel II (III) has 10 (8) subcomponents. Calculations are for the year 2015. Financial sector sizes are proxied by the amount of domestic credit to the private sector by banks (in constant USD).

The second contribution of this paper is to provide several resolutions to the aforementioned dilemma. I show that partial agreements improve welfare and are generally feasible. In these agreements free-riders impose some regulatory standards in exchange for even tighter standards among regulating jurisdictions. On a high level, such an outcome may already be implemented: Some Basel member countries tend to impose tighter restrictions than required, while some non-member countries implement core principles. The chair of the Basel committee also supports this approach and *"encourage[d] jurisdictions in Africa [i.e. non-member countries] to pursue a proportionate approach to their implementation of the Basel framework"* (Cos, 2020).

Another resolution if jurisdictions cannot agree on common standards are regional regulatory agreements among fee-riders. Agreements among free-riders are feasible and can ultimately lead to a coordinated global agreement, precisely because they create a more leveled playing field among now organized free-riders and larger jurisdictions that already regulate.

I also explore transfers. Due to inefficient international spillovers, gains from cooperation are positive on aggregate but potentially unequally distributed. Transfers can solve this discrepancy. Because explicit transfers may be challenging to implement in practice, adoption of common regulatory standards by smaller, mostly emerging market economies could be linked to implicit transfers such as open trade agreements, or tied to rescue packages by the IMF or World Bank. In either case, free-riders are more invested and may be willing to agree on financial regulation that is not beneficial to them on its own.

Last but not least, I consider capital controls imposed by regulating countries on free-riders. Intuitively, in my model capital controls reduce negative spillovers from under-regulated countries and ensure that free-riders cannot benefit from financial stability provided by regulating countries. Whether capital controls are welfare improving for the regulating jurisdiction depends on whether the aforementioned gains outweigh costs from reduced financial market depth. However, if credible, capital controls may induce non-cooperating countries to adopt regulation in order to maintain access to international financial markets. Though such measures are difficult to implement in practice, the motivation differs from the existing literature which stresses that capital controls may be implemented to mitigate a purely domestic externality (see, for example, Bianchi, 2011; Schmitt-Grohe and Uribe, 2016).

The third contribution of the paper is an empirical exercise that links the model to the data. Using survey data from the BIS (2015) I show that internationally integrated countries with a small banking sector are indeed less likely to adhere to Basel II or III standards, despite a variety of control variables that proxy for obstacles identified in the existing literature. I also show that countries with a smaller banking sector are not just more reluctant to implement certain Basel guidelines, but also lack transparency and inclusiveness during the rule-making process, which could undermine the effectiveness of implemented regulatory guidelines. This exercise thus complements existing work exploring the stringency of Basel capital requirements across time and jurisdictions (Kara, 2016a) and the overall complexity of rules (Jones and Zeitz, 2017). I also examine the implementation of the European Banking Union and find several characteristics that are consistent with the model: First, most member countries have relatively similar financial sector sizes (see Figure 1, Panel (b)). Second, the Union is primarily centered around eurozone countries, which are already more integrated to begin with. Third, the European Banking Union is incomplete and lacks a deposit insurance which prevents proper risk sharing. Cited reasons for the delay include moral hazard concerns and the supposedly poorly regulated financial sectors in some periphery member countries (Tümmler, 2022), which is exactly the reason why regulating jurisdictions may wish to disintegrate with free-riders in my framework.

I evaluate coordination in a tractable two-region model of financial intermediation that loosely follows the seminal works of Diamond and Dybvig (1983) and Allen and Gale (2005). The model has four crucial features: First, banks are exposed to idiosyncratic liquidity shocks. This generates heterogeneity ex-post and hence a rationale for a global financial market in which distressed banks sell illiquid assets in exchange for liquidity. Second, distressed banks are subject to a balance sheet constraint which forces them to sell assets below their fair value. This leads to a fire-sale externality and justifies ex-ante (macroprudential) regulatory intervention via liquidity requirements, precisely because banks do not internalize the dependence between the equilibrium asset price, fire-sales and initial investments.[1] Third, fire-sales spread globally via general equilibrium effects in the international asset market and ultimately justify cooperative regulation.[2] In my model, banks are integrated in a global financial market and balance sheets depend on international asset prices. As a consequence, fire-sales by banks in either jurisdiction affect the required fire-sales in the other jurisdiction due to indirect balance sheet price effects. National regulators who only maximize domestic welfare do not internalize this dependency. Fourth, countries are heterogeneous in terms of their financial sector size and internalize varying degrees of the fire-sale externality. This generates asymmetric portfolio choices in an uncoordinated equilibrium and may ultimately impede cooperation.

This paper is closest to a smaller literature on international financial regulation. My paper differs from this literature in its focus on banking sector size heterogeneity as an obstacle for the implementation of common regulatory standards. I also analyze

[1] A by now large literature analyses fire-sales and related regulatory interventions. See, for example, Shleifer and Vishny (1992, 1997) and Kiyotaki and Moore (1997) for early work on fire-sales. Mendoza (2002), Lorenzoni (2008), Bianchi (2011), Stein (2012), Jeanne and Korinek (2019) among many others examine the implications of fire-sales for macroprudential intervention due to pecuniary externalities.

[2] Empirical support for international asset fire-sales during financial crises has been articulated in Krugman (2000), Aguiar and Gopinath (2005), Devereux and Yetman (2010) or more recently Duarte and Eisenbach (2021). International fire-sales represent frictions in international financial markets and are a crucial ingredient to justify cooperation (Korinek, 2016).

several possible resolutions to mitigate regulatory free-riding and link the model to the data. The literature has proposed several explanations why national regulation may be inefficiently low: moral hazard when foreign countries have an incentive to forgive debt (Farhi and Tirole, 2018), fickle capital flows (Caballero and Simsek, 2020), terms of trade manipulations (Bengui, 2014), monopolistic competition in loan markets (Dell'ariccia and Marquez, 2006), or because national regulators do not internalize international fire-sales as in Bengui (2014), Kara (2016b), or my paper. Importantly, with an international externality, but without region specific asymmetries, coordination is strictly welfare improving for national regulators. I focus on heterogeneous banking sectors. Kara (2016b) emphasizes different investment opportunities and the presence of international investors. Dell'ariccia and Marquez (2006) argue in favor of distinct preferences regarding the trade-off between financial stability and profits.

I structure the remaining paper as follows: Section 2 lays out the model and highlights the inefficiency related to the competitive equilibrium. Section 3 analyzes the behaviour of national regulators with respect to investment choices and cooperation. Section 4 discusses alternative arrangements when countries are not willing to cooperate on harmonized standards. Section 5 provides empirical support for key implications from the model by analyzing the implementation of the Basel Agreements and the European Banking Union. Section 6 concludes. All proofs and derivations are delegated to the appendix.

2. Framework

2.1. Environment

The model features three periods $t = 0, 1, 2$, two assets, and two agents: investors and banks, each of measure one. Each investor is linked to one local bank, but each bank engages in an international asset market. A share $\omega \in (0, 1)$ of investors/banks reside in one region and the remaining 1-ω in the second region. Banks invest on behalf of investors into a short and long asset, which are traded on two financial markets: a collateralized asset market and an unsecured loan market. The model structure is illustrated in Figure 2. I subsequently characterize the environment.

Investors: Investors consume in period 2 and possibly in period 1. They also receive an endowment e of consumption goods at t=0. Utility for investor j is given by:

$$U_j = s_j h(c_{j1}) + c_{j2}.$$

The variable s_j captures a random idiosyncratic 'liquidity shock', which materializes at the beginning of period 1. The shock follows a binomial distribution with two distinct realizations, zero and one. If s_j=1, which occurs with probability q, investor j values consumption in period 1. Preferences for period 1 consumption are determined by $h(c_{j1})$ and follow:

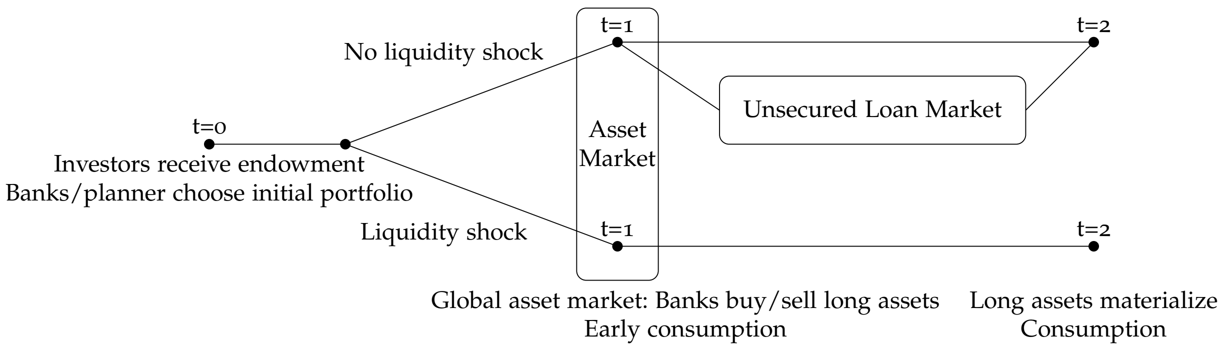
$$\begin{aligned} h'(c_{j1}) \gg 1 \quad &\text{if} \quad c_{j1} \leq c \\ 0 < h'(c_{j1}) < 1 \quad &\text{if} \quad c_{j1} > c, \end{aligned}$$

where c_{jt} is individual consumption at date t. The specific functional assumption on $h'(c_{j1})$ is optional and introduced to ease the exposition: If investors want to consume in period 1, they always request c with $c < e$.[3]

I interpret period 1 as a global liquidity crisis. Due to the Law of Large Numbers, q investors demand payouts, which puts q banks in distress. This perspective matches empirical regularities: Even during severe international financial crises, only a limited number of banks are actually in distress.

All endowment is deposited at the local bank. In the appendix, I introduce a production technology which provides a real investment opportunity to investors in the first period, which breaks the link between the size of the domestic banking sector and endowments. This will be helpful to distinguish the size of the domestic banking sector from the size of the economy.

Figure 2: *Model Structure*



Banks: Banks act in the interest of local investors, which may be motivated by free entry. As a consequence, banks maximize expected t=2 consumption for investors and internalize the early consumption request if s_j=1. Crucially, banks cannot insure

[3]With this simplification it is no longer necessary to derive an intertemporal optimality condition for c_{j1}. A section in the appendix explains how to solve the model with more general preferences.

themselves ex-ante against the liquidity shock, which is a standard assumption in the literature (see, for example, Holmström and Tirole, 1998; Caballero and Krishnamurthy, 2001; Lorenzoni, 2008; Stein, 2012). If banks cannot meet the early consumption outlay c, they go bankrupt, vanish from the market and all resources are lost. No bank will go bankrupt in equilibrium.

The distinctive feature of banks is their ability to transform initial endowments into t=1 or t=2 consumption. In period 0, before the liquidity shock is realized, they decide upon two assets, a short asset (the 'liquid' asset) (l_j) and a long asset (the 'illiquid' asset) (k_j). The short asset yields one unit of consumption in t+1 per unit invested in period t and can be accessed both at date 0 and date 1. Long assets provide a gross return of $R>1$ consumption goods in t=2 per unit of investment in t=0. Long assets are therefore more profitable, however not available for early consumption.

Asset Market: Banks may access an international asset market in period 1, where they can buy ('demand') (x_j^D) or sell ('supply') (x_j^S) unfinished long investment projects in exchange for consumption goods from matured short assets. The equilibrium price is denoted as p and satisfies $p<1<R$.[4] The market is fully collateralized. As a consequence, all banks are able to trade on this market, including banks that are threatened to go bankrupt if they cannot meet the early consumption request ('distressed' banks). I will provide more details in Section 2.2.

Loan Market: Banks which are not subject to potential default ('intact' banks) have also access to an unsecured loan market between periods 1 and 2. In this market, intact banks are able to access unsecured lines of credit ($\tilde{l}_j$). Credit corresponds to t=1 consumption goods from other intact banks which are exchanged for future consumption claims. Loans can be used to purchase unfinished investment projects on the asset market. I introduce this market as some intact banks would not have enough liquidity to purchase long assets from distressed banks, despite sufficient aggregate liquidity. This complicates aggregation on the asset demand side. Because I focus on an environment with excess aggregate liquidity, but a shortage for some banks, there will always be enough supply of funds on the loan market. The gross interest rate ($\tilde{R}$) on loans consequently equals one, that is, the opportunity cost associated with short assets in t=1. Constrained intact banks will rationally borrow and provide the proceeds to distressed banks, while unconstrained intact banks are willing to provide these loans. Specifics on the functioning of this market, in particular how the equilibrium is determined ($\tilde{R}$=1), are available in the appendix.

[4]If $p>1$, long assets provide a higher return in t=1 than short assets. Consequently, there would be no incentive to hold short assets.

Solution Strategy: I solve this model via backward induction. Hence, I first derive the equilibrium in period 1 for a given initial asset mix (Section 2.2). Conditional on period 1 supply and demand schedules, I then proceed backward and define the period 0 equilibrium from three different perspectives: the laissez-faire competitive equilibrium, a global social planner, and national regulators who interact in a Cournot Nash equilibrium (Section 2.3).

2.2. Asset Market Equilibrium

Banks enter period 1 with a portfolio of long and short assets (k_j, l_j). Once investors reveal their type, banks can access a global asset market in order to meet investors' consumption demand in period 1 and to maximize period 2 consumption. Because self-insurance is not optimal, distressed banks will obtain consumption goods on the asset market, while intact banks supply consumption goods in exchange for long assets.[5] I subsequently characterize the optimization problem for intact and distressed banks.

Intact Banks: There are two relevant modeling choices for intact banks. First, newly purchased long assets provide a lower return compared to retained long assets. To be precise, x_j^D units of assets transform into $R\phi(x_j^D) < Rx_j^D$ consumption goods in period 2. I assume that $\phi(x_j^D) = ln(1 + x_j^D)$, which implies an increasingly lower return for newly acquired long assets and hence a downward sloping demand curve. This is a standard assumption in the literature (see, for example, Lorenzoni, 2008, Stein, 2012 and Kara, 2016b). Second, intact banks also pay a fee $\gamma(\eta)$ per unit of purchased long asset that depends on the share η of banks operating in the asset market. I assume that $\gamma'(\eta) < 0$. The fee is a shortcut to introduce gains from financial market deepening. In a more structural sense, this fee may represent transaction costs like bid-ask spreads, or the time to find a counter-party, which diminishes with more players in the market.[6] In my baseline analysis, all banks participate in the market and I normalize this fee such that $\gamma(1) = 0$. This fee will thus only become relevant in a later section when I analyze policies that exclude free-riding jurisdictions from the international financial market.

[5] If $l_j \geq c$, a marginal shift in the investment mix towards the long asset provides a positive return with certainty.

[6] Interbank markets are Over-the-Counter (OTC) markets with search frictions. Duffie et al. (2005) show how bid-ask spreads depend on the availability of counter-parties in OTC markets. Experimental evidence in Lamoureux and Schnitzlein (1997) supports this finding. For a comprehensive overview on the interplay between financial intermediation and asset values, see Lagos et al. (2017).

With that said, intact banks maximize period 2 consumption $c_{j2}^{s=0}$ as follows:

$$c_{j2}^{s=0}(k_j, l_j; L) = \max_{x_j^D, \tilde{l}_j}\{R\,\underbrace{(k_j + \phi(x_j^D))}_{\text{Long Assets}} + \underbrace{l_j + \tilde{l}_j - (1+\gamma(\eta))px_j^D}_{\text{Short Assets}} - \underbrace{\tilde{R}\tilde{l}_j}_{\text{Loan Payment}}\} \quad \text{(P1:D)}$$

subject to a cash-in-the-market constraint

$$(1+\gamma(\eta))px_j^D \leq l_j + \tilde{l}_j. \tag{1}$$

Period 2 consumption by intact banks is the sum of returns on period 0 and newly acquired long projects, $R(k_j + \phi(x_j^D))$, the amount of reinvested short assets $l_j + \tilde{l}_j - px_j^D$ minus loan repayments in period 2. The cash-in-the-market constraint (1) limits long asset expenditures by the amount of own and borrowed consumption goods.

The price for long assets p is taken as given. Further, as explained above, the gross return on loans is one because I focus on an equilibrium with excess aggregate liquidity. As a consequence, the optimal loan size is indeterminate.

The first order condition for x_j^D determines long asset demand:

$$(1+\mu_j)(1+\gamma(\eta))p = R\phi'(x_j^D).$$

The variable μ_j denotes the Lagrange multiplier associated with equation (1). In equilibrium, equation (1) will not bind, hence μ_j=0 $\forall\ j$ (see Lemma 2). This emerges for three reasons: First, distressed banks sell long assets exclusively to satisfy early consumption needs, as intact banks are only willing to purchase these at a discount. Second, the equilibrium will feature enough aggregate liquidity to cover early consumption needs. Third, the loan market ensures that all intact banks have enough liquidity, even with different initial portfolio choices.

Distressed Banks: Banks in distress maximize investors' period 2 consumption ($c_{j2}^{s=1}$) subject to the withdrawal request. The optimization problem is summarized as:

$$c_{j2}^{s=1}(k_j, l_j; L) = \max_{x_j^S}\{R\,\underbrace{(k_j - x_j^S)}_{\text{Long Assets}} + \underbrace{l_j + px_j^S - c}_{\text{Short Assets}}\} \quad \text{(P1:S)}$$

subject to

$$px_j^S + l_j \geq c \tag{2}$$

$$x_j^S \leq k_j. \tag{3}$$

Period 2 consumption for investors hit by the liquidity shock is the sum of the returns on the remaining long projects, $R(k_j - x_j^S)$ and the amount of reinvested short assets $l_j + px_j^S$ minus the period 1 compensation c. Equation (2) captures the requirement for banks to obtain sufficient consumption goods and essentially represents a balance sheet constraint. Banks can use their own resources from initial short investments (l_j) plus consumption goods obtained from trading in the asset market (px_j^S). The second constraint, equation (3), is a feasibility constraint. Banks in distress must sell their long assets in exchange for additional consumption goods. However, if the asset price p is low, distressed banks might have to sell more than k_j assets in order to purchase $c - l_j$ consumption goods. Thus, if equation (3) binds, distressed banks are not able to raise enough consumption goods on the asset market.

Because $R > R\phi'(\cdot) = p$ and because self-insurance is not rational, equation (2) binds. The supply of illiquid assets is hence characterized by:

$$x_j^S = \frac{c - l_j}{p} \quad \text{if} \quad x_j^S \leq k_j.$$

As p decreases, the balance sheet deteriorates and distressed banks are required to sell more long assets. This balance sheet effect together with the downward sloping demand curve leads to the fire-sale externality embedded in the asset market. As a final remark, the supply constraint $x_j^S \leq k_j$ may prevent the liquidation of sufficient long assets. This is ruled out via a mild constraint on the parameter space as I explain in Lemma 2.

Equilibrium

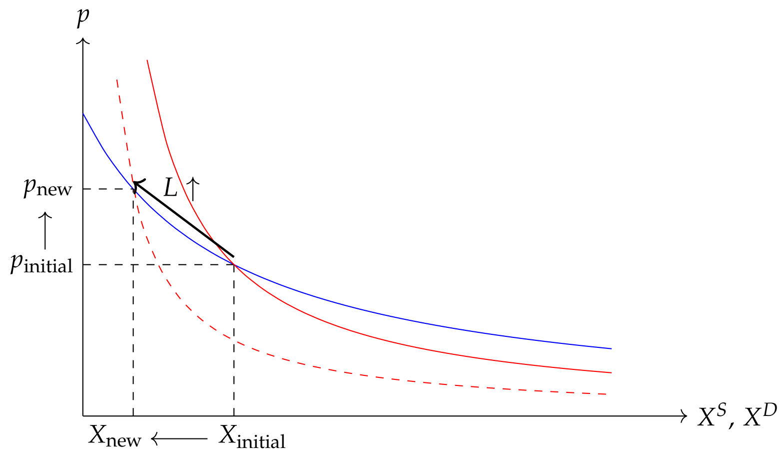
I use capital letters to denote aggregate variables. In equilibrium aggregate demand for illiquid assets (X^D) must equal aggregate supply (X^S), hence:

$$X^D(p) = (1-q)\phi'^{-1}\left(\frac{(1+\gamma(\eta))p}{R}\right) = q\frac{c-L}{p} = X^S(p, L). \tag{4}$$

The variable L denotes aggregate liquidity ($\int_0^1 l_j dj$). The equilibrium (solid lines) is portrayed in in Figure 3. The chart also illustrates the interdependence between the initial portfolio and the equilibrium asset price. Consider a simple experiment in which all banks exogenously increase their liquid asset investment. The new equilibrium is associated with a higher asset price and a lower transaction volume. The aggregate supply curve shifts left as distressed banks purchase less consumption goods, or equivalently sell less long assets for a given price. On the other hand, the additional liquidity in period 1 does not affect the demand schedule, since intact banks' cash-in-the-market constraint is slack.[7] Liquidity therefore limits asset fire-sales and stabilizes the fire-sale price. Lemma 1 summarizes these results.

Lemma 1 *The equilibrium asset price $p(L)$ is increasing in aggregate liquidity, $\frac{\partial p(L)}{\partial L} > 0$. The transaction volume $X(L)$ is decreasing in aggregate liquidity, hence $\frac{\partial X(L)}{\partial L} < 0$.*

Figure 3: *Period 1 Asset Market*



Notes: *The solid lines correspond to the initial inverse aggregate demand (blue) and supply (red) schedules. More liquidity reduces the supply of long assets (dashed line) but does not affect demand.*

Existence: The equilibrium as portrayed in Figure 3 exists if constraints (1) and (3) do not bind. Both conditions require sufficient liquid asset holdings, which in turn requires an upper bound on the profitability of long assets R. Lemma 2 establishes these requirements formally. I will assume that these conditions hold throughout the paper.

Lemma 2 *Constraints (1) and (3) are slack if $qc \geq \phi'^{-1}\left(\frac{q}{R-1+q}\right)\frac{qR}{R-1+q}$ and $\frac{c}{e} \leq \frac{qR}{R-1+q}$.*

2.3. Portfolio Choices

Banks or regulators in period 0 maximize expected t=2 consumption, anticipating that banks will either supply or demand long assets in t=1 depending on the realization of the liquidity shock. I solve for the optimal t=0 portfolio mix of short and long assets from the perspective of individual banks (competitive equilibrium), a global regulator who chooses the asset mix on behalf of all banks, and national regulators who only choose the asset mix for banks in their jurisdiction. I thus follow the common approach of a constrained social planner who achieves a second best solution by allocating

[7] In an environment without abundant liquidity, asset demand would be constrained by equation (1). In this case, more liquidity would also improve welfare for intact banks if they were previously constrained.

resources efficiently given the set of markets operating (Stiglitz, 1982; Geanakoplos and Polemarchakis, 1986). The solution is second best in the sense that the social planner does not intervene in the asset market in period 1 and therefore acknowledges the inefficiency embedded in the asset market. Relative to the second best global planner allocation, a national regulator has limited influence on the equilibrium asset price and therefore internalizes a smaller share of the externality. Further, a national regulator disregards the stabilizing effect of liquidity on asset prices for banks in the foreign jurisdiction.

Competitive Equilibrium

Each bank maximizes:

$$W_j^{CE} = \max_{k_j \geq 0, l_j \geq 0} E_0[c_{j2}(k_j, l_j; L)] \tag{P0:CE}$$

subject to

$$k_j + l_j = e. \tag{5}$$

Expectations are taken with respect to the liquidity shock s_j. Crucially, banks treat the asset price $p(L)$ as given. Without loss of generality, I focus on a symmetric equilibrium in which all banks make the same choice.[8]

Definition: Symmetric Competitive Equilibrium

1. *In period* 1*, intact and distressed banks optimally choose their demand and supply* $\{x_j^D, x_j^S\}$ *according to (P1:D) and (P1:S), and the asset market clears;*
2. *in period* 0*, banks optimally determine their portfolio* $\{k^{CE}, l^{CE}\}$ *according to (P0:CE), taking the asset price as given.*

Global Planner Equilibrium

A global planner chooses long and short assets on behalf of every bank and therefore effectively determines the aggregate portfolio $\{K, L\}$. This in turn implies that a global planner internalizes the dependence between the period 0 portfolio and the equilibrium price in period 1. Further, because each bank is ex-ante identical,

[8] The optimization problem for banks is linear in l_j. p^{CE} makes every bank indifferent between liquid and illiquid assets and pins down L^{CE} via equation (4).

the planner allocates the same asset mix to each bank. Optimization is therefore characterized by:

$$W^{GP} = \max_{K \geq 0, L \geq 0} \int_0^1 E_0[c_{j2}(k_j, l_j; L)]dj \tag{P0:GP}$$

subject to

$$K + L = E. \tag{6}$$

Definition: Global Planner Equilibrium

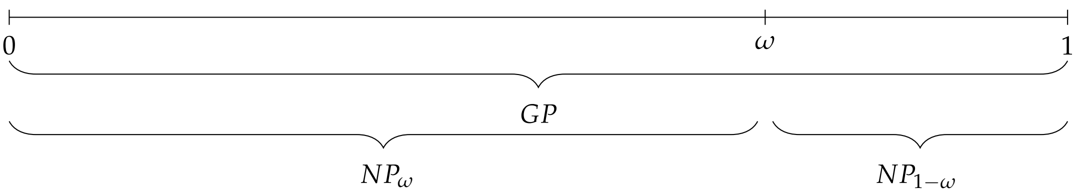
1. *In period* 1*, intact and distressed banks optimally choose their demand and supply* $\{x_j^D, x_j^S\}$ *according to (P1:D) and (P1:S), and the asset market clears;*
2. *in period* 0*, the global planner optimally determines the aggregate portfolio* $\{K^{GP}, L^{GP}\}$ *according to (P0:GP). The planner internalizes the dependency between the asset price and aggregate liquidity. Each bank receives the same portfolio, thus* $k_j^{GP} = K^{GP}$ *and* $l_j^{GP} = L^{GP}$.

National Planner Equilibrium

National regulators form a Cournot duopoly and only maximize welfare in their own jurisdiction, which is a standard assumption in the literature (see, for example, Dell'ariccia and Marquez, 2006; Bengui, 2014; Kara, 2016b).

Figure 4 contrasts the national planner setup with a single global planner. In terms of notation, one national regulator, henceforth denoted as ω-planner, supervises a share ω of banks with $0 < \omega < 1$, and the second regulator, referred to as 1-ω-planner, the remaining 1-ω banks.

Figure 4: *Global Planner vs. National Planners*



With this in mind, the ω-planner maximizes:

$$W_\omega^{NP} = \max_{K_\omega \geq 0, L_\omega \geq 0} \int_0^\omega E_0[c_{j2}(k_j, l_j; L)]dj \tag{P0:NP}$$

subject to

$$K_{\omega} + L_{\omega} = \omega E. \tag{7}$$

K_{ω} and L_{ω} refer to the aggregate amount of long and short assets in the ω-jurisdiction. The setup for the 1-ω-planner is symmetric.

Definition: National Planner Equilibrium

1. *In period 1, intact and distressed banks optimally choose their demand and supply $\{x_j^D, x_j^S\}$ according to (P1:D) and (P1:S), and the asset market clears;*

2. *in period 0, national planners interact in a Cournot duopoly and determine their aggregate portfolios $\{K_{\omega}^{NP}, L_{\omega}^{NP}\}$ and $\{K_{1-\omega}^{NP}, L_{1-\omega}^{NP}\}$ according to (P0:NP). National planners internalize the dependency between the asset price and domestic aggregate liquidity. Each bank in the same jurisdiction receives the same portfolio.*

Costs and Benefits from Liquidity

Before I characterize the different equilibria and elude to the implications of size asymmetry for regulation, it is worthwhile to look a the social costs and benefits from liquidity for each bank:

$$\underbrace{q\,R\left[-\left(\frac{\partial x_j^S}{\partial l} + \frac{\partial x_j^S}{\partial P}\frac{\partial p}{\partial L}\right)\right]}_{\text{MB when Distressed}} + (1-q)\underbrace{\left[1 + \left(R\phi'(\cdot) - p\right)\frac{\partial x_j^D}{\partial p}\frac{\partial p}{\partial L} - x_j^D\frac{\partial p}{\partial L}\right]}_{\text{MB when Intact}} = \underbrace{R}_{\text{MC}}$$

The first term on the left hand side captures the marginal benefit from liquidity if a bank becomes distressed. More liquidity directly reduces the asset supply. More liquidity on aggregate also improves the equilibrium asset price which further decreases asset supply. The second term represents the marginal benefit from liquidity when the bank is not exposed to the liquidity shock. Because of sufficient aggregate liquidity, short assets are rolled over at the margin, providing a gross return of one. More aggregate liquidity also reduces the demand for illiquid assets due to a higher asset price. However, banks already choose the asset demand optimally in t=1, so this quantity effect cancels out, that is, $R\phi'(\cdot) = p$. A higher asset price further directly increases expenditures for a given demand. Last but not least, the marginal benefits form holding liquid assets must equal the opportunity cost, which is simply R. All terms involving aggregate liquidity and its effect on the asset price are not internalized by individual banks in the competitive equilibrium, and only partially internalized by national regulators. Regulators thus understand that more aggregate liquidity helps banks when they are distressed but hurts them when they turn out to be intact. This generates a trade-off, however, the first effect dominates the second, precisely because illiquid assets are sold at a discount in the asset market.

3. Equilibrium Allocations and Gains from Coordination

This section consists of three parts: First, I compare aggregate portfolio choices in the national planner equilibrium with the competitive and global planner equilibrium. Second, I analyze how the liquidity provision of a national planner varies as a function of the banking sector size. Third, I characterize the incentives of a national regulator to follow the second best global planner allocation.

3.1. Aggregate Liquidity

Proposition 1: (Aggregate Liquidity)

Aggregate liquidity in the global planner equilibrium exceeds aggregate liquidity in the national planner equilibrium, which in turns exceeds aggregate liquidity in the competitive equilibrium: $L^{GP} > L^{NP} > L^{CE}$.

This result is not surprising. As explained earlier, banks do not internalize the effect of additional liquidity on the equilibrium asset price, and its interaction with the balance sheet constraint of distressed banks. In other words, the competitive equilibrium is inefficient. Further, independent domestic regulation is also inefficient in an environment with international spillovers from asset fire-sales. However, national regulators realize that more short assets benefit distressed banks in their jurisdiction by more than it harms intact banks. Hence, national regulation is more efficient than the competitive equilibrium.[9]

Implementation of Regulatory Standards

The distinctive valuation of liquidity in the different equilibria also translates to bank-specific liquidity requirements as studied in the next section. Importantly, these bank-specific provisions can be decentralized via, for example, a liquidity requirement like the Liquidity Coverage Ratio of the Basel III framework, or a Pigouvian tax on illiquid assets. These policies are macroprudential since they would be imposed in

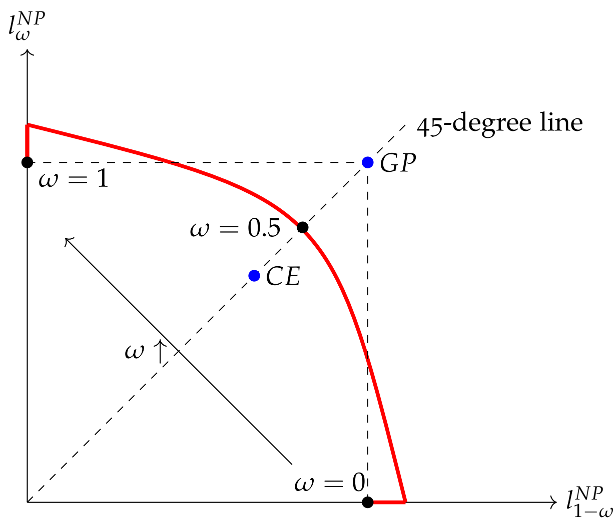
[9]This result contrasts with Bengui (2014) who shows that national regulation can be less efficient than the competitive equilibrium. The different result in his model is a consequence of terms of trade manipulations, which only arise if jurisdictions are asymmetrically exposed to shocks.

period 0, that is, prior to the liquidity crisis, and address systemic risk in financial markets. Because I focus on characterizing regulator preferences, I abstract from describing the implementation in detail. However, importantly, there is a one to one mapping between liquidity preferences and regulation. If a planner values liquidity more than banks, it is optimal to impose macroprudential regulatory standards. If a planner prefers less liquidity than banks, it is optimal to lower standards or even encourage banks to take on more risk.

3.2. Bank-Specific Liquidity Provision

How much liquidity do national planners allocate to individual banks and how does that choice depend on the influence on global financial markets? To address this question, I analyze bank-specific allocations as ω varies from 0 to 1. The different National Planner equilibria are displayed in Figure 5. The solid line depicts the amount of liquidity chosen by both national planners for each of their banks $\{l_{\omega}^{NP}, l_{1-\omega}^{NP}\}$ as a function of the relative banking sector size ω. The two dots represent the global planner and competitive equilibrium. As mentioned in Proposition 1, a global planner provides strictly more liquid assets than national planners, who in turn jointly provide strictly more liquidity than banks in the competitive equilibrium. I subsequently summarize the key takeaway from the National Planner equilibrium.

Figure 5: *National Planner Equilibria*



Notes: *The solid line depicts optimal bank-specific liquidity $\{l_{\omega}^{NP}, l_{1-\omega}^{NP}\}$ by national planners as a function of the relative banking sector size ω. The competitive (CE) and global planner equilibrium (GP) are marked for comparison.*

Proposition 2: (Free-Riding)

A regulator that internalizes a larger share of the global externality imposes tighter liquidity standards for each bank, that is, $l_{\omega}^{NP} > l_{1-\omega}^{NP}$ *when* $\omega > 0.5$.

A jurisdiction with a larger banking sector tilts the bank-specific portfolio towards liquid assets. More influence on international asset markets grants planners more impact on equilibrium prices. Per se this does not justify a higher liquidity provision. However, due to the international aspect of the pecuniary externality, larger regulators internalize more of the inefficiency, which effectively increases the regulator's marginal return on liquid assets.

As another feature of the model, and as evident form Figure 5, the free-riding behaviour of the smaller jurisdiction leads to a corner solution in which the non-negativity requirement on liquid asset holdings binds (see Lemma B2 in the appendix). Hence, it can be optimal to fully rely on foreign liquidity provision. Further, a larger planner may provide more bank-specific liquidity than a global planner. This surprising result emerges due to the free-riding behaviour of the regulator overseeing a smaller banking sector combined with the 'public goods property' of liquidity, which implies that domestic and foreign liquidity are substitutes (see Lemma C1 in the appendix). This feature introduces a notion of over-regulation and is illustrated by the section of the red line outside the dashed square.

3.3. Coordination

In this section, I examine if national regulators would be willing to coordinate and achieve a more efficient outcome. The natural benchmark for coordination is the global planner solution which is by construction constrained efficient as it internalizes the entire externality. The main takeaway from this analysis is that coordination on an efficient benchmark is generally not feasible, unless domestic financial markets are of similar size.

It is a well-known fact from the Cournot games literature that each national planner has an incentive to deviate from cooperation. In other words, a global solution is not a Nash equilibrium. For this reason, I assume the existence of a commitment mechanism which ensures that national planners cannot deviate once both decided to surrender their authority. Alternatively, one could think about a repeated game between regulators, that is, an infinite sequence of the three period model in this paper. With appropriate punishment strategies when one planner deviates from the cooperative agreement, a cooperative solution can be achieved as a Nash equilibrium.

Some additional notation is necessary to set the stage for the subsequent analysis. I define gains from cooperation for both jurisdictions $\{\triangle_{\omega}, \triangle_{1-\omega}\}$ as:

$$\triangle_{\omega} = \omega W^{GP} - W_{\omega}^{NP}$$
$$\triangle_{1-\omega} = (1-\omega) W^{GP} - W_{1-\omega}^{NP}.$$

If national planners cooperate, a central regulator chooses the global planner solution. The period 2 consumption attributed to each jurisdiction in a global solution simply equals total t=2 consumption (W^{GP}) multiplied by the relative size of each jurisdiction. If regulators do not cooperate, they continue to interact via Cournot competition and maximize period 2 consumption for their banks. Cooperation is only feasible if $\triangle_{\omega} > 0$ and $\triangle_{1-\omega} > 0$. It is worth stressing that aggregate gains from cooperation are always positive, that is, $\triangle_{\omega} + \triangle_{1-\omega} > 0 \ \forall \ \omega$. However as I show in the following proposition, the benefits from an agreement are disproportionately distributed, which may ultimately prevent coordination on international standards.

Proposition 3 (Coordination on Harmonized Standards)

(i) If national regulators oversee banking sectors of similar size ($\omega \approx 0.5$), both jurisdictions gain from cooperation, that is, $\triangle_{\omega} > 0$ and $\triangle_{1-\omega} > 0$.

(ii) If banking sector sizes are too asymmetric, cooperation is not optimal from the perspective of the jurisdiction with a small banking sector, that is, either $\triangle_{\omega} < 0$ if $\omega < \underline{\underline{\omega}} < 0.5$ or $\triangle_{1-\omega} < 0$ if $\omega > \overline{\overline{\omega}} = 1 - \underline{\underline{\omega}} > 0.5$. As a consequence, coordination, albeit desirable from a global perspective, does not necessarily constitute a Pareto improvement.

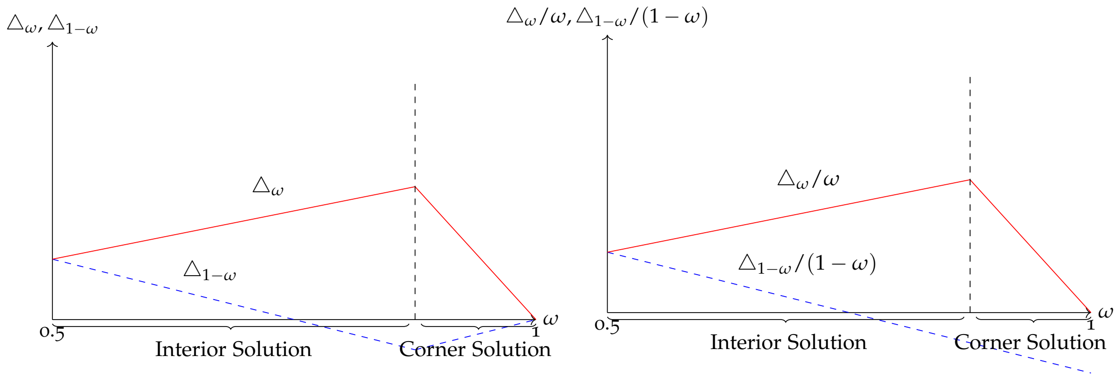
Figure 6 illustrates Proposition 3. Panel (a) displays aggregate gains from cooperation for each jurisdiction $\{\triangle_{\omega}, \triangle_{1-\omega}\}$ as ω expands from 0.5 (symmetry) to 1, while Panel (b) displays gains from cooperation for individual banks within each jurisdiction $\{\triangle_{\omega}/\omega, \triangle_{1-\omega}/(1-\omega)\}$.

If both banking sectors are of similar size, both jurisdictions gain a similar amount by coordinating their regulatory efforts, that is, $\triangle_{\omega} > 0$ and $\triangle_{1-\omega} > 0$. In contrast, a country with a small financial sector is less willing to adopt global standards which would require to increasingly scale up less profitable liquid investments relative to the uncoordinated equilibrium. This is captured by the downward sloping dashed line. In both panels, gains from cooperation turn negative, but they converge back to zero when considering jurisdiction-wide benefits (Panel (a)). This effect is purely driven by the aggregation of an increasingly smaller share of banks in the 1-ω-jurisdiction.

On the contrary, the planner who internalizes a large share of the fire-sale externality needs to subsidize the other planner which results in positive gains from

***Figure 6:** Gains from Cooperation*

***(a)** Aggregate* ***(b)** Individual Bank*



***Notes:** Panel (a) displays gains from cooperation for jurisdictions $\{\triangle_\omega, \triangle_{1-\omega}\}$ as a function of the relative financial sector size ω. Panel (b) shows gains from cooperation for individual banks of each jurisdiction $\{\triangle_\omega/\omega, \triangle_{1-\omega}/(1-\omega)\}$. ω varies from 0.5 (symmetry) to 1. The solid (dashed) line refers to the ω (1-ω)-jurisdiction. The corner region corresponds to equilibria where $l_{1-\omega}^{NP} = 0$.*

cooperation. Gains are first rising due to the growing free-riding behaviour of the other planner. As such, the large jurisdiction consistently increases implicit subsidies in terms of international liquidity provision. In a corner solution where the small jurisdiction decides to supply zero liquidity, gains from cooperation start to decrease but remain positive. Further, in the limit as ω approaches one, the Cournot solution of the large national planner converges to the solution of a single global planner and gains from cooperation are zero.

Figure 6, Panel (a) also speaks to the overall welfare implications from coordination. As apparent, aggregate gains from coordination are largest when jurisdictions are of similar size. In contrast, an agreement between a large and a small jurisdiction provides rather small gains. The large jurisdiction already behaves almost like a global planner and the free-riding behaviour of the small jurisdiction has limited aggregate implications. Related to the Basel standards, one may be inclined to argue that it is not worthwile to convince non-members into an agreement. While this might be true on a country-by-country basis, this does not necessarily generalize to multiple free-riding countries with a small financial sector which combined aggregate to a non-trivial financial sector (see Table 1).

4. Implications

The previous analysis emphasized aggregate gains from cooperation on regulatory standards in a model with an international externality. However, coordination on common standards may not be feasible as small jurisdictions prefer to free-ride on jurisdictions with a sizable banking sector. In this section I discuss several alternative arrangements that can produce an outcome that is closer to the constrained efficient resolution when coordination on common standards is not optimal. I consider four arrangements: partial agreements between regulating and free-riding jurisdictions, agreements among free-riders as an intermediate step before free-riders may eventually follow global standards, transfers that entice a free-riding country to follow regulatory standards, and an outright ban of free-riding jurisdictions.

4.1. Partial Agreements

This section shows that partial agreements are generally feasible even when free-riders rationally decline to coordinate on common standards. However, such an agreement may require a disproportional increase in regulation by the large jurisdiction, that is, the jurisdiction that already imposes regulatory standards on its own banks. The analysis in this section therefore supports a tailored approach with regard to international regulatory agreements. A tailored approach related to the Basel implementation receives considerable support among policymakers, for example, the BIS, IMF, and World Bank as mentioned in the Introduction. Intuitively, if free-riders are not willing to implement common standards, they could still agree to implement core-principles, while already regulating countries support former free-riders. From a welfare perspective, such an outcome will not be constrained efficient, but it does improve welfare relative to no agreement.

Gains from partial coordination for both jurisdictions $\{\triangle_\omega^p, \triangle_{1-\omega}^p\}$ correspond to:

$$\begin{aligned}\triangle_\omega^p &= W_\omega^p - W_\omega^{NP} \\ \triangle_{1-\omega}^p &= W_{1-\omega}^p - W_{1-\omega}^{NP},\end{aligned}$$

which resembles the difference in welfare from partial coordination (W^p) relative to the uncoordinated national planner equilibrium. In this analysis I focus on feasible partial agreements.

Definition: Partial Agreements

1. *A partial agreement is a contract* $\{l_\omega^p, l_{1-\omega}^p\}$ *between the* ω *and 1-*ω*-planner that improves aggregate welfare,* $\triangle_\omega^p + \triangle_{1-\omega}^p > 0$.
2. *A feasible partial agreement requires* $\triangle_\omega^p > 0$ *and* $\triangle_{1-\omega}^p > 0$, *and thus welfare gains for both jurisdictions.*

A feasible partial agreement satisfies the following two conditions up to a first order approximation:[10]

$$\begin{aligned}\triangle_{\omega}^{p} \approx & \frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}} \Delta l_{\omega}^{p} + \frac{\partial W_{\omega}^{NP}}{\partial l_{1-\omega}} \Delta l_{1-\omega}^{p} > 0 \\ \triangle_{1-\omega}^{p} \approx & \frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}} \Delta l_{1-\omega}^{p} + \frac{\partial W_{1-\omega}^{NP}}{\partial l_{\omega}} \Delta l_{\omega}^{p} > 0.\end{aligned}$$

The two equations correspond to the total differential of welfare in each jurisdiction after substituting in the resource constraint and recognizing that the asset price is a function of liquidity. Each derivative is evaluated at the national planner equilibrium and $\Delta l_i^p = l_i^p - l_i^{NP}$ for $i \in \{\omega, 1\text{-}\omega\}$ represents the change in liquidity between the partial agreement and the national planner allocation.

Many contracts satisfy the aforementioned conditions. However, the design of such contracts differs depending on whether the smaller jurisdiction supplies a positive amount of liquidity or not. In what follows, I first explore partial agreements in an interior solution, before moving to a corner solution.

Proposition 4 (Partial Agreements in an Interior Equilibrium)

(i) A feasible agreement always exists. Every contract requires both planners to increase liquidity requirements relative to the uncoordinated national planner equilibrium, hence $\Delta l_{\omega}^{p} > 0$ *and* $\Delta l_{1-\omega}^{p} > 0$.

(ii) Banks in the smaller jurisdiction benefit disproportionally, that is, if $\Delta l_{\omega}^{p} = \Delta l_{1-\omega}^{p}$ *and* $\omega > 0.5$, *then* $\triangle_{\omega}^{p}/\omega < \triangle_{1-\omega}^{p}/(1-\omega)$.

Two features explain these findings. First, a national planner does not incur a cost for providing additional liquidity at the margin. Intuitively, the planner arbitrages between illiquid and liquid assets and must therefore be indifferent between the two investment opportunities. In other words, $\frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}} = \frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}} = 0$. More liquidity in turn benefits the other jurisdiction, precisely because it increases the equilibrium asset price and therefore reduces fire-sales. Second, for the same change in liquidity among both jurisdictions, the smaller jurisdiction gains disproportionally. This result emerges as an increase in bank-specific liquidity of a large jurisdiction has a larger effect on the equilibrium asset price.

Figure 7 illustrates Proposition 4. The red line in Panel (a) displays the national planner equilibria $\{l_{\omega}^{NP}, l_{1-\omega}^{NP}\}$ as a function of ω. The blue shaded areas represent two admissible sets for a partial agreement. In the first example when $\omega = 0.5$, it

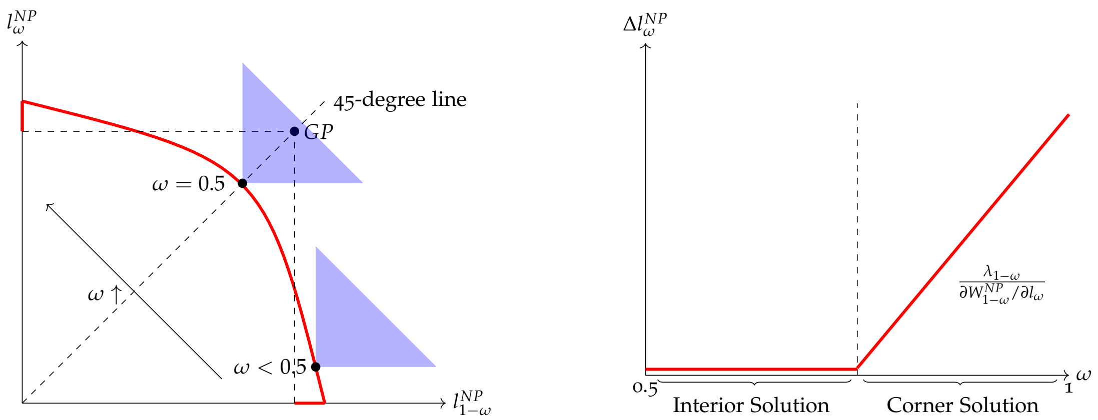
[10]The conditions hold exactly if $\Delta l_{\omega}^{p} \to 0$ and $\Delta l_{1-\omega}^{p} \to 0$.

would be feasible to agree on the constrained efficient global planner equilibrium. In the second example, liquidity in the 1-ω-jurisdiction exceeds the constrained efficient outcome. Therefore, the region for partial agreements excludes the constrained efficient resolution. Put differently, Proposition 4 also elaborates on the requirements for coordination on common standards. In order to move towards common standards, it must be that both regulators increase their liquidity requirements, which I summarize in the lemma below.

Lemma 4: *National planners are only willing to coordinate on global standards if $l_{\omega}^{NP} < l^{GP}$ and $l_{1-\omega}^{NP} < l^{GP}$.*

Figure 7: *Partial Agreements*

(a) *Admissible Regions: Interior Solution* ***(b)*** *Required Compensation for Free-Riders*



Notes: *The shaded areas in Panel (a) illustrate admissible regions for partial agreements $\{l_{\omega}^{p}, l_{1-\omega}^{p}\}$ for two different values of ω. The solid line depicts optimal bank-specific liquidity $\{l_{\omega}^{NP}, l_{1-\omega}^{NP}\}$ by national planners as a function of the relative banking sector size ω. The global planner equilibrium (GP) is marked for comparison. Panel (b) highlights the minimum required compensation by the regulating ω-jurisdiction if $\Delta l_{1-\omega}^{NP} = 1$ as a function of the banking sector size ω. The corner region corresponds to equilibria where $l_{1-\omega}^{NP} = 0$. $\lambda_{1-\omega}$ denotes the Lagrange multiplier associated with the non-negativity constraint on liquidity.*

Proposition 5 (Partial Agreements in an Corner Solution)

Suppose without loss of generality that $l_{1-\omega}^{NP} = 0$. A feasible agreement in a corner solution requires the regulating ω-jurisdiction to tighten restrictions disproportionally. Further, such an equilibrium exists if the required change in liquidity is not too large.

The key result in this proposition is that when a jurisdiction is constrained by the non-negativity requirement in liquidity, the other planner will have to provide more liquidity as an incentive for the free-riding jurisdiction to provide some regulation. Intuitively, a free-rider will need to impose regulatory standards for any partial agreement. But if the Lagrange multiplier associated with the non-negativity constraint is large, regulation becomes very 'costly' for the free-rider and a larger compensation is necessary. More formally, assuming that the 1-ω-jurisdiction is constrained, this requirement can be stated as:

$$\Delta l_{\omega}^{p} / \Delta l_{1-\omega}^{p} > \frac{\lambda_{1-\omega}}{\partial W_{1-\omega}^{NP} / \partial l_{\omega}},$$

where $\lambda_{1-\omega} > 0$ refers to the tightness of the non-negativity constraint, which increases with the size asymmetry. Therefore, the smaller a jurisdiction, the larger the required compensation by the already regulating jurisdiction. This is illustrated in Figure 7, Panel (b). Further, if the required increase in liquidity is large, the large jurisdiction is no longer willing to partially coordinate as it would have to move further away from the preferred asset mix in the national planner equilibrium.

It is worthwhile to discuss these findings in light of the Basel standards. The analysis suggests that it may be easier to convince partially regulating countries to enhance their efforts, than to convince a country which does not impose any standards to implement core-principles. Both would require some concessions, but in the latter case, accommodations would have to be even larger, to the extent that such agreements could not be feasible anymore. Alternatively, the implementation of the Basel standards may already reflect partial agreements. Indeed, some member countries at least partially exceed the Basel requirements (see, for example, Acharya, 2012), while some non-member countries implemented core principles, but not more advanced guidelines.

4.2. Agreement among Free-Riders

This section extends the model to a 'many-country' setup. In more detail, I consider a large jurisdiction (for example, the group of Basel member countries), henceforth the ω-jurisdiction, and a continuum of small open economies with an aggregate size of 1-ω, all of which are free-riding and therefore choose $l^{FR} = 0$. The key message is that an agreement among free-riders is always feasible and may set the stage for a more comprehensive agreement with the large jurisdiction.

Proposition 6 (Agreement among Free-Riders)

(i) An agreement among the 1-ω free-riders weakly increases welfare for free-riders, that is, $W_{1-\omega}^{NP} \geq (1-\omega)W^{FR}$. The inequality holds strictly if coordination leads to an interior National Planner equilibrium.

(ii) If the regulatory union among free-riders is large enough, coordination with the ω-jurisdiction on the constrained efficient allocation may become feasible.

(iii) Partial agreements between free-riders and the ω-jurisdiction have a larger range of support after free-riders formed a union, that is, $\lambda_{1-\omega} < \lambda_{FR}$.

What drives the results from the proposition? The first part is rather trivial: If free-riders cooperate, they would form a regulatory union that resembles the 1-ω-planner from previous sections. Because a national planner internalizes part of the externality, the outcome can be no worse, and is strictly better, if the planner chooses a positive amount of liquidity. The second part of the proposition highlights that an intermediate agreement can ultimately result in a constraint efficient outcome. The reason for this result is that, if the union of free-riders decides to impose some regulation, the ω-jurisdiction would lower standards as liquidity is a public good (see Lemma C1). Intuitively, the large jurisdiction would be able to reduce implicit subsidies for the 1-ω-union, which creates a more leveled playing field. In turn it becomes easier to agree on common standards (see Lemma 4). The third part of the proposition tackles the case when common standards are still not feasible. In this case, partial agreements receive more support. Intuitively, the free-rider union internalizes part of the externality and has therefore a lower shadow value associated with the non-negativity constraint. This in turn may facilitate an agreement if it was not feasible before (Proposition 5).

From an empirical perspective, most Basel free-riders are emerging markets or developing economies. While regional financial regulatory agreements among emerging markets are not in place as of the writing, regional trade agreements are rather common (see, for example, Freund and Ornelas, 2010), which could serve as a blueprint.

4.3. Transfer Payments

Transfer payments can resolve the discrepancy between aggregate benefits from cooperation and the unequal jurisdiction-specific distribution thereof. If free-riding prompts a jurisdiction to decline cooperation, then gains from coordination for the other jurisdiction necessarily outweigh the losses for the free-riding planner. As such, countries that already regulate could provide a compensation towards free-riding countries in return for cooperation.

Proposition 7 (Transfers)

There exists a level of transfers originating from the regulating jurisdiction towards the free-riding jurisdiction that makes both better-off with cooperation.

The idea of transfer payments has a long tradition particularly in the environmental economics literature (Markusen, 1975). But pure transfers in the realm of financial regulation to entice free-riders to regulate seem to be politically challenging. As a more realistic alternative, regulatory standards could be tied to other agreements, which are primarily beneficial for free-riders such as free trade agreements. Both, the US and the European Union maintain such agreements with a variety of emerging economies. The framework introduced earlier also points to a potential role of the IMF and World Bank. Both institutions frequently aid distressed countries and demand reforms in exchange. This paper makes a case to include regulatory requirements in return for financial assistance.

4.4. Financial Disintegration

The next instrument I discuss is a ban of free-riders from international financial markets. This sharp definition allows me to derive a series of analytical results and is best viewed as a benchmark. However, the main point underlying the exclusion argument is that it may reduce inefficient spillovers from free-riders. Thus, all policies that restrict access to international markets, but not necessarily ban a country, would roughly fall into this category. Either way, capital flow restrictions would be imposed by regulating jurisdictions on free-riding jurisdictions.[11]

The motivation for this approach is intuitive: A free-riding country benefits from liquidity of regulated banks, without making a similar contribution to financial stability. As such, a ban of free-riders will have positive effects on regulated banks due to an on average higher liquidity in the remaining market. It further makes existing regulation more targeted thus increasing its efficiency. Of course, this will come at a cost as financial market depth declines. In the model, these costs are summarized by $\gamma(\eta)$ with η referring to the size of the market. Thus, restrictions on free-riders may not improve welfare for the regulating jurisdiction imposing the ban.

It is worth mentioning that the aforementioned motivation for capital controls is distinct from the literature. In the literature, capital controls are imposed to improve domestic welfare by addressing a domestic externality (see, for example, Bianchi, 2011; Schmitt-Grohe and Uribe, 2016) or by gaining an advantage relative to other countries

[11] Capital controls can be implemented via quantity or price based restrictions (Fernández et al., 2016). Further, many countries are/were periodically subject to very tight capital flow restrictions. Some restrictions follow from geopolitical tensions (for examples Iran, North Korea or Russia). But this is not always the case: Argentina, for example, imposed tight restrictions after the currency crisis in 2002. These restrictions severely limited capital inflow and outflows (Batini et al., 2020). Another country with tight restrictions is China, which for the most part prohibits domestic investors investing abroad and vice versa. Erten et al. (2021) and Rebucci and Ma (2019) summarize the capital control literature.

via terms of trade manipulations (De Paoli and Lipinska, 2012; Costinot et al., 2014). In the context of this paper however, capital controls are imposed on free-riders that do not properly internalize an externality, causing adverse spillovers on the regulating jurisdiction.

I subsequently highlight two sets of results: First, I analyze the implications for the jurisdiction imposing the ban, that is, the regulating jurisdiction. Then I analyze the consequences for free-riders.

Consequences for Regulating Jurisdiction

Proposition 8 (Large Jurisdiction)

Suppose $\omega > 0.5$, and banks from the 1-ω jurisdiction are excluded from the financial market.

(i) Regulation among banks in the ω-jurisdiction becomes more efficient, that is, $\frac{\partial p_\omega}{\partial L_\omega} > \frac{\partial p}{\partial L_\omega}$, where p_ω denotes the asset price in autarky.

(ii) The consequence for the equilibrium asset price and hence fire-sales is ambiguous and depends on the trade-off between financial market depth and the increase in average liquidity in the market.

(iii) If disadvantages from reduced financial market depth are small, then welfare in the ω-jurisdiction rises.

(iv) In the limit as $\omega \to 1$, the large jurisdiction neither benefits nor incurs costs from introducing capital controls.

Part (i) of the proposition emphasizes that regulation becomes more targeted once free-riders are excluded. Intuitively, liquidity can no longer flow abroad to support free-riders. This disproportionately reduces the supply of illiquid assets and therefore stabilizes the asset price. Regulation hence becomes more 'efficient'.

However, the effect on the asset price remains ambiguous as part (ii) of the proposition highlights. There are two opposing effects at play: on the one hand, banks in the regulated jurisdiction hold more liquidity (see Proposition 2). However, at the same time the market overall becomes more inefficient as financial market depth declines. Since fire-sales are inversely related to the asset price, the same trade-off caries over, and the exclusion of free-riders does not necessarily reduce fire-sales. That said, it is reasonable to assume that larger jurisdictions maintain sufficient financial market depth, rendering these costs small. However, for a large jurisdiction the average liquidity among domestic banks will also approximate the average liquidity among both jurisdictions ($l_\omega^{NP} \approx L^{NP}$), so this trade-off remains irrespectively of the size.

Because of the ambiguous effect on asset prices and fire-sales, it is also unclear whether welfare increases. However, if the asset price increases and if costs from reduced financial market depth are small, welfare increases, as part (iii) of the proposition emphasizes. Underlying this result is that a higher asset price reduces inefficient fire-sales, which supports distressed banks more than it harms intact banks. Last but not least, part (iv) highlights that the large jurisdiction is indifferent between imposing capital controls on a small open economy. A small open economy does not influence aggregate liquidity and in the limit does not cause any spillovers.

Consequences for Free-Riders

Proposition 9 (Free-Riding Jurisdiction)

The free-riding 1-ω-jurisdiction prefers to follow international regulatory guidelines as a third best outcome when threatened with capital controls. Formally, $W_{1-\omega}^{FR} > W_{1-\omega}^{CO} > W_{1-\omega}^{AU}$ *when* $\omega > \overline{\overline{\omega}}$.

The takeaway from this proposition is that in the relevant region where a coordination on common standards is not possible ($\omega > \overline{\overline{\omega}}$, see Proposition 3), a free-rider would rather cooperate than operate in autarky. Thus, a threat to impose capital controls on the free-riding jurisdiction might be sufficient to persuade the smaller jurisdiction to follow international guidelines. The proposition thus highlights the tension of a small jurisdiction between access to international financing and the desire to free-ride on foreign regulation. To see this, it is worthwhile to distinguish two scenarios in which the 1-ω jurisdiction is either a small open economy or a somewhat larger jurisdiction. A small open economy is formally described by $\omega \to 1$ and forms the backbone for much of the capital control literature (see, for example, Bianchi, 2011; Benigno et al., 2013; Korinek, 2018). Importantly, in this setting, the Law of Large Numbers (LLN) does not longer hold for the free-rider. In the other scenario, the 1-ω-jurisdiction is unwilling to coordinate on common standards, but at the same time large enough to accommodate fire-sales on its own due to the continuum of banks in each region. However, because of reduced financial market depth, both scenarios lead to the same conclusion.

In more detail, if $\omega \to 1$ and if capital controls are imposed on a free-riding small open economy, it would no longer be able to accommodate liquidity shocks as $l_{1-\omega}^{NP} = 0$ (Lemma B2). In other words, the jurisdiction depends on access to international financial markets during a domestic financial crisis, or alternatively would need to self-insure.[12] Self-insurance is however dominated by an access to financial markets (Lemma B1), as the asset market allows banks to hold more profitable long assets.

[12]This feature has empirical resemblance: While aggregate capital flows to emerging markets are counter-cyclical, private flows are pro-cyclical, suggesting that private funds flow into an emerging market during a downturn (Kim and Zhang, 2023).

Thus, from the perspective of the free-rider, cooperation would be third best.

In the second scenario, where $\omega \in (\overline{\overline{\omega}}, 1)$ the same conclusion applies but for a different reason. In this region, the 1-ω-jurisdiction is able to accommodate fire-sales on its own, but at a cost due to reduced financial market depth. This friction lowers the equilibrium asset price and distorts the incentives to hold liquidity, which in turn leads to an outcome that is inferior to a coordinated solution.

Given these considerations, why do we not see such measures in reality? As highlighted above, a threat to impose restrictions on free-riders may not be credible. The model also abstracts from a number of additional political and coordination issues: in particular, a ban would need to be imposed by many countries. Otherwise, an individual ban would not be effective.

5. Empirical Support

This section provides two applications to the previous analysis. First, I evaluate the implementation of Basel standards. The Basel framework provides a rich environment to quantitatively examine some predictions from the model and compare them with previously studied factors that may influence the decision to adhere to common regulatory standards. Second, and towards the end of this section, I explore characteristics of the European Banking Union.

5.1. The Basel Agreements

The Basel agreements are the most comprehensive cross-sectional regulatory effort for banks and hence an obvious candidate to evaluate the framework from this paper and other models in the literature. I use survey data on the implementation of Basel II and III standards from the BIS (2015) to extract information about cooperative behaviour. The survey is restricted to non-member countries, which have been repeatedly encouraged by the Basel Committee, World Bank and IMF to comply with regulatory standards (Drezner, 2007; Cos, 2020).

The adherence to regulatory standards can be explored among several dimensions. The most fundamental decision pertains to the extensive margin: Does a country implement certain policies or not? However, given that Basel guidelines are relatively flexible and allow countries considerable discretion, it is also interesting to analyze the stringency of implemented policies. Further, regulatory requirements require monitoring and due diligence to make sure banks properly implement regulatory requirements. In this paper, I examine the binary choice to implement various aspects of the Basel agreement. In particular, I provide empirical evidence that open economies with a smaller banking sector are less likely to implement Basel standards. I also show that countries with smaller banking sectors exert less due diligence on the policies that they actually implemented based on additional survey data from the World Bank (Johns and Saltane, 2016). Unfortunately, data on the stringency of regulatory standards is more limited for Basel non-member countries. In complementary work, Kara (2016a) analyzed the determinants for the stringency of capital regulation – an important part of the Basel regulations – for a set of middle and high income countries and finds that countries with high average returns to investment and a high ratio of government ownership of banks choose less stringent standards.

The Basel framework goes well beyond liquidity regulation and hence my model. In fact, liquidity regulation is only part of the Basel III framework. I discuss the Basel framework and details regarding the empirical exercise in the appendix. I show that the overall size of the domestic banking sector is positively associated with cooperation on liquidity regulation. However, the idea that national regulators internalize varying degrees of an international externality, which in turn determines the willingness to regulate should extend beyond liquidity regulation and should also extent to regulatory due diligence more general.

Adherence to Basel Standards

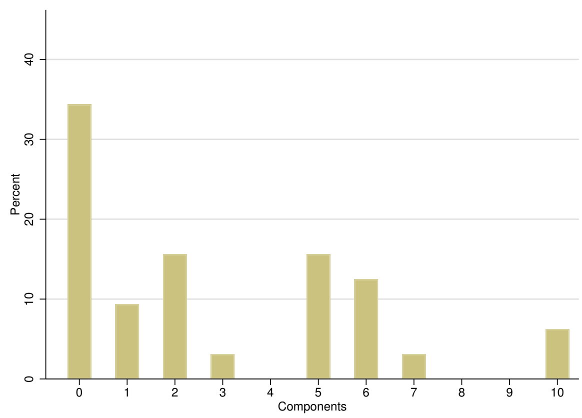
In what follows, I capture the adherence to Basel standards based on a simple statistic which I refer to as the Basel II or III Index. The index counts the number of Basel II or III guidelines that each country implemented at each point in time. No country withdrew certain guidelines. The indices are hence weakly increasing over time for each country. Two additional comments are in order: First, certain Basel guidelines are complex and hence challenging to implement for emerging markets and developing countries (see, for example, FSB, IMF and World Bank, 2011 Gottschalk, 2016; Jones and Knaack, 2019). A partial implementation of the Basel frameworks is therefore expected. The relevant question is hence whether countries with a larger banking sector are more likely to adhere to a larger set of the regulatory guidelines. The Basel Index measures this non-binary choice. Second, several countries in the survey have a negligible financial sector, which renders financial regulation obsolete. To be conservative, I therefore truncate the original sample and exclude jurisdictions with a banking sector size below the 25 percentile which yields a sample of 63 countries listed in Table A1.

Figure 8 plots the Basel II Index for the year 2015, the last year of available data.

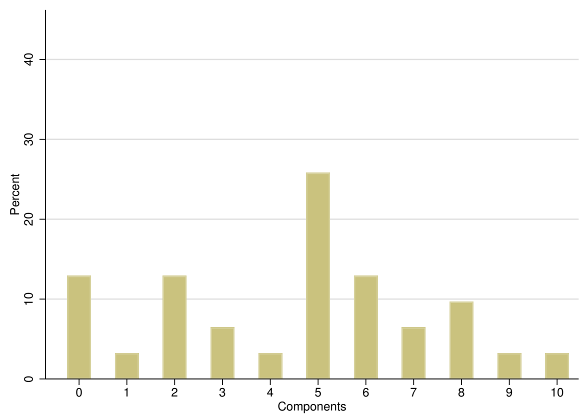
Panel (a) focuses on countries with a small banking sector (proxied by domestic credit) while Panel (b) provides the distribution for countries with a large banking sector (see Figure E2 for the Basel III Index). The Basel II framework is split into 10 components, hence the specific range on the horizontal axis. Each bar represents the share of countries that incorporated a specific number of policies. Clearly, the vast majority of countries did not follow the lead of the Basel Committee on Basel II standards. Further, and related to this paper, countries with a sizable banking sector tend to be less reluctant to adopt Basel II policies. On average countries with a large banking sector adopt 4.5 policies, while countries with a smaller banking sector implement 2.9 policies.

Figure 8: *Basel II Implementation for Non-members as of 2015*

(a) *Low Credit Countries*



(b) *High Credit Countries*



Notes: *The vertical axes portray the share of countries (in %) that implemented a specific number of Basel II components. Panel (a) (Panel (b)) considers countries with low (high) domestic credit to the private sector by banks (in constant USD, threshold based on median) as a proxy for the size of the domestic banking sector.*

Regression: Variables

I estimate several ordered logit models with the Basel II or III Index as the dependent variable. Regarding the independent variables, the literature has proposed several factors that could prevent a cooperative agreement. My contribution is to emphasize different domestic banking sector sizes as an important obstacle. I proxy the size of the banking sector based on the amount of domestic credit towards the private sector by banks in constant USD. Domestic credit has been frequently used to proxy for the development/size of the financial sector and is available for all countries in this sample (Beck et al., 2010). The analytical framework introduced earlier emphasized the international interlinkages of the domestic banking sector. As such, the previous results technically only apply to countries with an internationally integrated financial sector. To make headway on this issue, I analyze countries with open financial markets as a robustness check. Reassuringly, I find that banking sector size effects are primarily relevant for countries without tight capital controls.

I also include GDP (in constant USD) as a control variable in some regressions in order to distinguish the banking sector from simple country size effects. Just to be clear, it is important to distinguish these two. The willingness to cooperate on standards in my model is based on the degree to which national regulators internalize a global externality in the banking sector. The relevant metric is hence the size of the domestic banking sector and not the credit to GDP ratio that some studies use to proxy for financial development (see, for example, Jones and Zeitz, 2017). To make this point clear, consider Israel and Panama. Both countries have about the same credit to GDP ratio, but the absolute size of the banking sector as measured by domestic credit is about 5.5 times larger in Israel. Israel implemented half of the Basel II guidelines while Panama only 1 out of 10 components as of 2015.[13]

The literature on international financial cooperation stresses multiple obstacles: different legal or political systems and informational asymmetries (Barth et al., 2006; Beck and Wagner, 2016; Ostry and Ghosh, 2016), different risk versus return trade-offs (Dell'ariccia and Marquez, 2006; Kara, 2016b), varying profitability of the banking sector (Kara, 2016b), or the market concentration in the banking sector (see, for example, Allen and Gale, 2004; Repullo, 2004; Schaeck et al., 2009).

I proxy political considerations with an institutional quality index. This index accounts for the quality of governance, the degree of corruption, the establishment of a proper legal framework, and the stability of the government. Risk versus return trade-offs are based on preferences, which are challenging to measure in reality. To obtain some, albeit imperfect insights, I include a financial crisis indicator. If a country experienced a crisis, it may prefer less risk at the expense of lower returns.[14] The profitability of banks is proxied by the returns on assets. From an opportunity cost perspective, one would expect that regulators avoid tight standards if the banking sector is very profitable. Last but not least, I consider a variable that measures the asset share of the three largest banks in order to test for agglomeration effects. The literature has not reached a consensus as to whether market concentration actually increases or decreases the willingness to regulate the financial market.

[13] More formal evidence on this distinction is available in Tables E2 and E3 in the appendix, where I show that credit has more explanatory power than the credit to GDP ratio among Basel non-member countries in determining the adherence to the Basel II and III standards. The tables also highlight that credit remains the only significant variable when both variables are added to the regression.

[14] This notion is supported by Aizenman (2009) who finds that prolonged periods of financial stability are associated with a lower regulation intensity. Related, Anginer et al. (2019) find that countries which experienced a systemic banking crisis during the Global Financial Crisis were more likely to increase capital requirements, but surprisingly loosened the stringency of the Tier 1 capital definition.

Regression: Results

Table 2 provides estimates from an ordered logit model. The dependent variable corresponds to the Basel II Index for the year 2015. All explanatory variables (except for the banking crisis indicator) represent averages over the 2003-2015 period, which reflects the initial publication of the Basel II framework and the last year of available survey data. This reduces the noise in the data and accounts for the notion that fundamental decisions to adopt financial regulation tend to be based on medium or long-run considerations. That said, I derive very similar results based on pooled regressions. Details are available in Tables E5 and E6.[15] Credit, institutional quality and GDP are further standardized. The concentration and return on asset measures are expressed in %.

Based on Table 2, domestic credit as a proxy for banking sector size is able to explain the adoption of Basel standards at the 1% level of significance while all other explanatory variables except for GDP are insignificant (columns (1)-(6)). To be more precise, a one standard deviation increase in domestic credit increases the odds of implementing more Basel II components by a factor of $exp(1.06) = 2.89$ (column (1)). The remaining explanatory variables are insignificant but have the predicted sign. A previous banking crisis and a better institutional quality are loosely associated with more implemented Basel II policies, though both explanatory variables have essentially zero or opposite effects once more regressors are added. On the contrary, a higher average return on assets represents opportunity costs in adopting standards and are associated with insignificantly less adopted Basel guidelines. The degree of banking sector concentration in the economy has no explanatory power.

Because GDP predicts the adoption of Basel standards (column (6)), one might be worried that credit simply proxies for the size of the economy. However, once all regressors are considered, the credit variable remains the only significant variable (column (9)). In other words, the credit variable is not just a proxy for the overall size of the economy.

As a further robustness check, I exclude all countries with tight capital controls in column (8). Tight capital controls in this context refer to restrictions above the 75 percentile across all countries in the sample. Domestic credit remains the most

[15] Fixed effects are not suitable for this analysis as several countries do not implement any Basel guidelines, implying zero variation in the dependent variable. Further, the number of implemented Basel policies is weakly increasing and does not change more than once or twice until 2015. There is thus limited variation over time within a country. To be conservative and to not artificially inflate observations I therefore only consider the number of implemented policies as of 2015. Non reported results further indicate that the size of the banking sector does not explain why a country decided to implement guidelines earlier than another country.

Table 2: Adherence to Basel II Standards: Ordered Logit Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Avg. Credit	1.06***						1.01***	1.71***	0.78*
	(0.27)						(0.30)	(0.54)	(0.41)
Banking Crisis		0.12					-0.00	-0.34	0.03
		(0.45)					(0.62)	(0.70)	(0.64)
Avg. Inst. Quality			0.30				-0.03	-0.24	0.05
			(0.29)				(0.29)	(0.38)	(0.34)
Avg. ROA				-0.70			-0.62	-1.01*	-0.60
				(0.43)			(0.51)	(0.61)	(0.52)
Avg. Concentration					0.01		0.03	0.05	0.03
					(0.02)		(0.02)	(0.03)	(0.02)
Avg. GDP						0.79***			0.25
						(0.25)			(0.29)
Pseudo R^2	0.06	0.00	0.01	0.02	0.00	0.04	0.10	0.22	0.10
Countries	All	All	All	All	All	All	All	Open	All
Observations	63	63	55	62	61	63	54	30	54

Notes: Dependent variable: Basel II Index as of 2015. The independent variables represent averages (Avg.) over the 2003-2015 period except for the Banking Crisis indicator which is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) excludes economies with tight capital controls. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

relevant predictor and becomes even more quantitatively important. The coefficient on credit increases from 1.01 to 1.71 (columns (7) and (8)). The return on asset variable turns slightly significant at the 10% level and keeps its negative sign. Overall, the explanatory power of the regression improves by a factor of 2.2, which is consistent with the narrative of this paper. The framework analyzes two open jurisdictions. The explanatory power of the banking sector size should therefore primarily apply to open economies.[16]

A closely related pattern emerges for Basel III standards. Results are displayed in Table 3. Domestic credit continues to be the dominant factor while proxies capturing alternative explanations in the literature are not able to predict the adoption of Basel III standards. However as column (9) suggests, it is more challenging to distinguish the size of the banking sector from GDP. Though credit is no longer significant at the 10% level, it maintains a z-statistic above one. Nevertheless, given that Basel III

[16]Emerging markets, which constitute the majority of the Basel non-member countries, frequently resort to capital controls. However there is no statistically significant relationship between the use of capital controls and the adherence to Basel II or III standards as evident from Table E4. Capital controls are therefore not a substitute for traditional regulation. Domestic credit also does not explain the usage of capital controls.

Table 3: Adherence to Basel III Standards: Ordered Logit Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Avg. Credit	0.67***						0.57***	0.56***	0.48
	(0.21)						(0.20)	(0.18)	(0.41)
Banking Crisis		0.44					-0.06	-0.66	-0.05
		(0.50)					(0.56)	(0.72)	(0.56)
Avg. Inst. Quality			0.05				-0.10	-0.29	-0.06
			(0.33)				(0.37)	(0.46)	(0.44)
Avg. ROA				-0.37			-0.43	-0.69	-0.43
				(0.29)			(0.34)	(0.84)	(0.34)
Avg. Concentration					0.00		0.02	0.07*	0.02
					(0.02)		(0.02)	(0.04)	(0.02)
Avg. GDP						0.60***			0.11
						(0.21)			(0.40)
Pseudo R^2	0.05	0.00	0.00	0.01	0.00	0.04	0.06	0.13	0.06
Countries	All	All	All	All	All	All	All	Open	All
Observations	63	63	55	62	61	63	54	30	54

Notes: Dependent variable: Basel III Index as of 2015. The independent variables represent averages (Avg.) over the 2003-2015 period except for the Banking Crisis indicator which is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) further excludes economies with tight capital controls. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

requirements were just about to be implemented in 2015, generally lower significance levels are somewhat expected.[17]

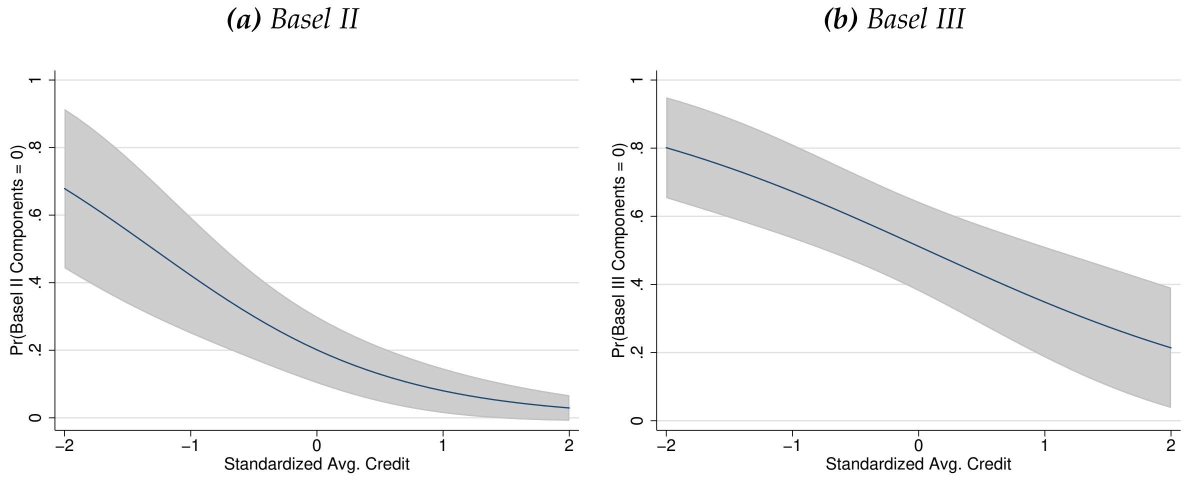
The dependence between the adherence to Basel guidelines and the size of the domestic banking sector is visualized in Figure 9. Specifically, I compute the probability of adhering to zero (vertical axes) versus at least one Basel II or III policy by the end of 2015 as a function of domestic credit (standardized, averaged over the period 2003-2015). The plots reveal a negative relationship between domestic credit and the probability of implementing zero policies. This is particularly true for Basel II (Panel (a)) but also visible when examining Basel III standards (Panel (b)). In other words, the larger the banking sector, the more likely a country adopts at least one component of the Basel II or III framework.

Regulatory Governance and the Basel Implementation

In the remainder of this section, I emphasize that countries that do not or only partially implement the Basel agreements also lack regulatory due diligence, which

[17]Further evidence on this is presented in the appendix. The distribution of Basel III standards across countries does not appear stationary as of 2015 (Figure E4).

Figure 9: Conditional Probability of Implementing Zero Basel Policies



Notes: The vertical axes display the probability of installing zero Basel II (Panel (a)) or III policies (Panel (b)) by the end of the year 2015. The horizontal axes represent the amount of domestic credit (standardized, averaged over the period 2003-2015). Shaded areas indicate 95% confidence intervals. The plot is based on an ordered logit regression with credit as the only control variable.

could make implemented principles less relevant in practice. I resort to the regulatory governance score published by the World Bank. The measure consists of several sub-indexes and ranges from 0 to 5, where 5 means best practices. Among other things, the index evaluates the transparency and inclusiveness of rule-making processes, as well as government accountability.

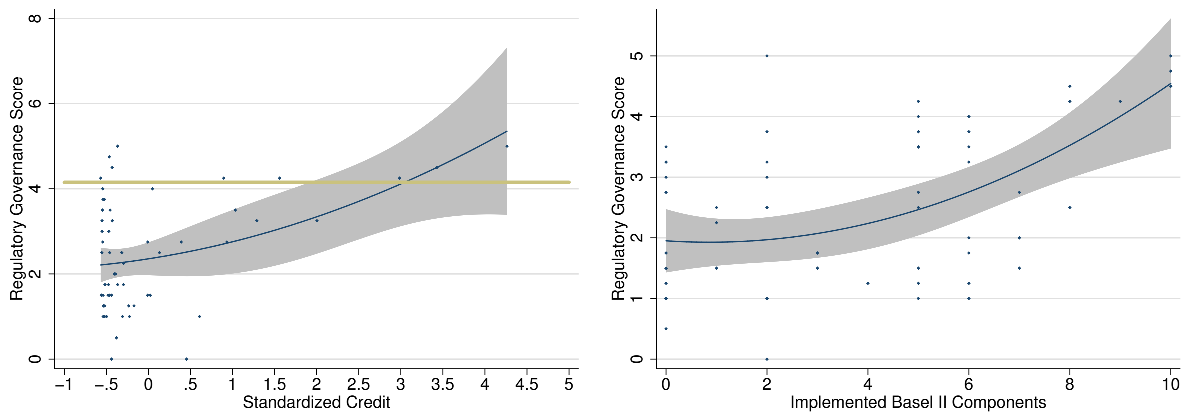
Figure 10, Panel (a) portrays the size of the domestic banking sector and the regulatory governance score for Basel non-members (blue dots and line of best fit). Clearly, countries with a smaller banking sector have a lower score and indicated by the regression line. I further added a horizontal line which displays the average score for Basel members. Clearly, most non-members have a lower score than Basel members. Panel (b) zooms in on Basel non-member countries and displays a bivariate scatter plot, along with a line of best fit, between the number of implemented Basel II components and the regulatory governance score. As apparent, countries that implement more Basel II components also exert more due diligence and do a better job at monitoring and interacting with the banking community.

5.2. European Banking Union

The European Banking Union was first proposed in 2012 as a means to break a "circle between banks and sovereigns". In a nutshell, the proposal seeks to alleviate two issues among European banks: Most banks have close ties with their home country

Figure 10: Regulatory Governance, Basel Implementation, and Banking Sector Size

(a) Regulatory Governance and Banking Sector Size | *(b) Regulatory Governance and Basel II Implementation*



Notes: Panel (a) portrays the relationship between the amount of domestic credit (standardized, as of 2015) and regulatory governance measured on a scale from 0 to 5, where 5 means best practices. Dots represent individual observations among non-member countries with a line of best fit added. Shaded areas indicate 95% confidence intervals. The horizontal line represents the average level of regulatory governance among Basel members. Panel (b) provides a scatter-plot with a line of best fit between the number of implemented Basel II policies (as of 2015) and the regulatory governance index. Shaded areas indicate 95% confidence intervals.

and are protected by domestic legislation. Sovereign distress can therefore transmit to domestic banks, and at the same time, a banking crisis can become a large burden for the sovereign.[18]

By 2016, two key elements of the banking union were implemented: the Single Supervisory Mechanism (SSM) and the Single Resolution Mechanism (SRM). The SSM grants the European Central Bank stronger powers to monitor the health of banks, while the SRM sets up a common fund paid by banks themselves to address insolvent institutions. However, a third ingredient, a European wide deposit insurance, has not been implemented and faces political resistance, which is perceived to limit risk sharing among jurisdictions.[19]

A holistic analysis of the Banking Union is beyond this paper. However, there are several noteworthy aspects that can be examined through the lens of my framework.

Similarity among Member Countries

Similar to Basel member countries, participating countries are relatively

[18] https://www.bankingsupervision.europa.eu/about/milestones/shared/pdf/2012-06-29_euro_area_summit_statement_en.pdf

[19] https://www.euronews.com/my-europe/2023/03/27/explained-why-the-eus-banking-union-is-still-unfinished-business

homogeneous in terms of their financial sector size as emphasized in Figure 1, Panel (b). Indeed, there are relatively few countries that have a much smaller domestic banking sector (proxied by domestic credit) relative to the largest country. Though a left tail in the distribution is visible, it resembles the shape of Basel members and is overall much less noticeable than the left tail among Basel non-members. This is consistent with a key prediction from the model: countries with similar financial sector sizes are more likely to cooperate.

The Eurozone

Even though the Banking Union is an initiative by the European Union, it almost exclusively consists of eurozone members, with Bulgaria as the only exception. This is once again consistent with the model: it may be necessary to have other agreements that ensure that countries have 'skin in the game' to strike an agreement that includes financial regulation. In the model, this is captured via transfers. In the context of the European Union, a common currency in generally perceived to provide benefits to all member countries. Such implicit dividends could make it more likely that countries also coordinate on other aspects, such as financial regulation. In this context, a Czech policymaker recently argued that it would be paramount to first join the eurozone and that a banking union is currently not a priority given an above average stable domestic banking sector.[20]

Reluctance to Extend Deposit Insurance

Despite progress in the implementation, the European Banking Union is still incomplete. In particular, policymakers in central European countries appear reluctant to extent deposit insurance to periphery countries (Tümmler, 2022). Concerns primarily center around moral hazard. In Germany for example, policymakers fear that they would have to 'pay for Italian banks'. Through the lens of the model, center countries are reluctant to provide insurance (liquidity flowing abroad) without additional regulatory efforts by smaller jurisdictions, precisely because they are concerned of detrimental spillovers from less regulated financial sectors. This tension is underlying the argument for financial disintegration in Section 4.4.

6. Conclusion

A significant share of the global banking sector is not or only partially regulated. But what determines the adherence to multinational financial regulatory standards?

[20] https://www.euractiv.com/section/politics/short_news/czech-republic-not-interested-in-eu-banking-union-for-now/

In this paper I show that countries with a larger financial sector are more likely to commit to international regulation. Countries with limited influence on international financial markets in contrast may rationally decline to cooperate on common standards and free-ride on foreign regulation, even when cooperation is welfare improving on aggregate. I then apply the model to the Basel Agreements and the European Banking Union and demonstrate that the framework is able to capture key characteristics related to the implementation of both agreements.

Though it may not be feasible to agree on common regulatory standards, the article also provides several alternatives that could bring countries closer to an efficient outcome. First, the analysis shows that partial agreements are generally possible. Partial agreements entail an increase in regulation by participating jurisdictions, but do not match the efficiency of common standards. Another route would be for free-riders to form a regulatory union among themselves. Existing trade agreements could serve as a blueprint. I show that an agreement among free-riders is feasible and may eventually lead to the implementation of global common standards. Another option would be to link the adherence of free-riders to common regulatory standards to other multinational contracts that benefit free-riders, such as free trade agreements, or financial support by the IMF or Wold Bank. Last but not least, the paper provides a novel justification for capital controls: regulating jurisdictions could impose capital controls on free-riders. Such restrictions would reduce spillovers from free-riders, while possibly forcing free-riders to regulate as a third best outcome.

A. Appendix: Introduction

***Table A1:** Country List*

Albania	Costa Rica	Macedonia, FYR	Paraguay
Algeria	Dominican Republic	Malaysia	Peru
Angola	Ecuador	Mauritius	Philippines
Armenia	Egypt	Mongolia	Qatar
Bahamas	El Salvador	Montenegro	Serbia
Bahrain	Georgia	Morocco	Sri Lanka
Bangladesh	Ghana	Mozambique	Tanzania
Barbados	Guatemala	Namibia	Thailand
Belarus	Honduras	Nepal	Trinidad and Tobago
Bolivia	Iceland	New Zealand	Tunisia
Bosnia and Herzigovina	Israel	Nigeria	Uganda
Botswana	Jamaica	Norway	United Arab Emirates
Brunei Darussalam	Jordan	Oman	Uruguay
Chile	Kenya	Pakistan	Vietnam
China, P.R.: Macao	Kuwait	Panama	Zimbabwe
Colombia	Lebanon	Papua New Guinea	.

B. Appendix: Section 2

Relaxing the Assumption on $h(c_{j1})$: Early consumption is inelastic in the baseline model. I subsequently relax this assumption. As a result, the laissez-faire equilibrium becomes more inefficient under reasonable preferences.

To fix ideas, suppose that investors choose their $t = 1$ consumption level at the start of period 1 if they receive a positive liquidity shock.[21] Period 2 consumption as a function of $t = 1$ consumption is:

$$c_{j2}^{s=1}(k_j, l_j; L) = R\left[k_j - \frac{c_{j1} - l_j}{p(L)}\right]. \tag{B.1}$$

Suppose further that preferences for $t = 1$ consumption are characterized by $h(c_{j1})$ with $h'(c_{j1}) > 0$, $h'(0) < \frac{R}{p(L)}$, and $h''(c_{j1}) > 0$. Investors with early consumption demand maximize:

$$\max_{c_{j1}, c_{j2}^{s=1}} \{h(c_{j1}) + c_{j2}^{s=1}\} \tag{B.2}$$

[21]Banks or planners understand how investors determine their early consumption demand. Thus, for the same reasons as in the baseline model, it is not optimal to hoard enough liquidity ex-ante to cover these expenses. The early consumption constraint for banks therefore binds.

subject to equation (B.1). The first order condition yields:

$$p(L)h'(c_{j1}) = R.$$

The term on the left reflects the marginal utility from selling illiquid assets in period 1. The term on the right captures the marginal utility from retaining the illiquid asset. The assumption $h'(0) < \frac{R}{p(L)}$ paired with $h''(c_{j1}) > 0$ guarantees that it is optimal to consume in $t = 1$. All investors demand the same level of consumption, which I denote as $c_1^* = h'^{-1}\left(\frac{R}{p(L)}\right)$.

Period 2 consumption for impatient investors is therefore:

$$c_{j2}^{s=1}(k_j, l_j; L) = R\left[k_j - \frac{h'^{-1}\left(\frac{R}{p(L)}\right) - l_j}{p(L)}\right].$$

Individual banks treat period 1 consumption as given, since it only depends on aggregate liquidity. Consequently, the competitive equilibrium is characterized by the same price as in the baseline model, $p^{CE} = \frac{qR}{R-1+q}$. Regulators however internalize the relationship between $t = 1$ consumption and aggregate portfolio choices. For the sake of brevity, I focus on the global planner. Following the same steps as in the baseline model, the planner's objective function yields the following first order condition:

$$p^{GP} = p^{CE}\left[1 + \frac{c_1^* - l^{GP}}{R}\frac{\partial p}{\partial L}\left[\frac{1}{\phi'(x_j^D)} - 1 + \underbrace{\frac{R}{[p^{GP}]^2 h''(c_{j1})}}_{\text{Feedback Effect}}\right]\right].$$

The baseline formula is hence augmented by the last term on the right. The term can be positive or negative depending on the sign of $h''(c_{j1})$. However, during crises it is reasonably to assume that withdrawals increase with the fragility of the financial system ($h''(c_{j1}) > 0$), which ensures that c_1^* decreases in L. As a consequence, the planner chooses strictly more liquidity than in the baseline model. Because the competitive equilibrium is unchanged, it is optimal to impose tighter liquidity regulation.

The derivations in the baseline model carry over. The only requirement is that $h'''(c_{j1}) < 0$, which provides a sufficient condition for the uniqueness of the global and national planner solution.

Production Economy: I introduce a real production technology that grants investors an alternative to their investment at banks. As a consequence, initial deposits no longer equal endowment, and the size of the domestic banking sector is different from the size of the overall domestic economy. Suppose real investments in period 0 transform into $t = 2$ output according to:

$$y_{j2} = f(i_j).$$

The term i_j reflects the amount of real investment by investor j and $f(\cdot)$ the production technology, which is not investor specific. $f(\cdot)$ is concave.

As an additional feature I assume that financial investments entail an efficiency loss ζ per unit of financial investment which reduces the effective amount of funds directed towards banks to $(1-\zeta)e_j^{\text{bank}}$. ζ can result from poorly developed domestic financial sectors or a poor legal environment. A higher value of ζ makes financial investments less profitable and induces investors to spend more funds on real production. Each investor continues to have an initial endowment of e.

When deciding on whether to physically invest or provide funds to banks, each investor maximizes expected period 2 consumption according to:

$$\max_{i_j, e_j^{\text{bank}}} E_0[c_{2j}(i_j, e_j^{\text{bank}})] = \max_{i_j, e_j^{\text{bank}}} \{f(i_j) + E_0[\overline{R}_j](1-\zeta)e_j^{\text{bank}}\} \tag{B.3}$$

subject to

$$e = i_j + e_j^{\text{bank}}. \tag{B.4}$$

The gross return on financial investments ($\overline{R}_j$) depends on the realization of the liquidity shock among others. The expected return is however not j-specific, as investors are identical from the perspective of $t = 0$.

The first order condition determines real investments:

$$f'(i_j) = E_0[\overline{R}_j](1-\zeta).$$

It is reasonable to assume that $f'(0) = E_0[\overline{R}_j]$. Absent efficiency losses, banks are superior in channelling funds towards productive investments and receive all endowment ($i^* = 0$). However, if $\zeta > 0$, investors will always directly invest in production *and* provide funds to banks.

This setup captures the notion that financially less developed countries (high ζ) have a smaller banking sector relative to the overall size of the economy. More importantly, it delinks deposits from endowments and all derivations of the baseline model carry over, with e replaced by $(1-\zeta)e^{*\text{bank}}$.

Details on Loan Market: The loan market allows intact banks to exchange $t = 1$ consumption goods from matured short assets in exchange for unsecured claims on $t = 2$ consumption goods. The symmetric competitive equilibrium and the global planner equilibrium imply identical period 0 portfolios for all banks. There is consequently no heterogeneity among intact banks and the market is obsolete.

In the national planner equilibrium however, banks generally hold distinct portfolios across both jurisdictions. If short asset investments by banks in one jurisdiction are limited, these banks may not have enough funds to finance the desired amount of illiquid assets in the asset market. To make this point clear, consider the long asset demand function for constrained and unconstrained intact banks. Without loss of generality assume that intact banks in the 1-ω-jurisdiction are financially constrained. Demand for each bank in the ω-jurisdiction is:

$$p = R\phi'(x_\omega^D).$$

Demand for each bank in the 1-ω-jurisdiction is:

$$(1+\mu_{1-\omega})p = R\phi'(x_{1-\omega}^D).$$

Based on these long asset demand functions, it becomes clear that $x_\omega^D > x_{1-\omega}^D$ as $\mu_{1-\omega} > 0$. Further, by purchasing additional illiquid assets from distressed banks, intact banks in the 1-ω-jurisdiction achieve a gross return of $\frac{R\phi'(x_{1-\omega}^D)}{p} > \frac{R\phi'(x_\omega^D)}{p} = 1$ and hence a higher return than banks in the ω-jurisdiction. This naturally motivates a loan market as it is socially optimal for each intact bank to purchase the same amount of illiquid assets x_j^D. Banks in the 1-ω-jurisdiction have therefore an incentive to expand funding to distressed banks relative to banks in the ω-jurisdiction and hence demand funds from unconstrained intact banks in the loan market.

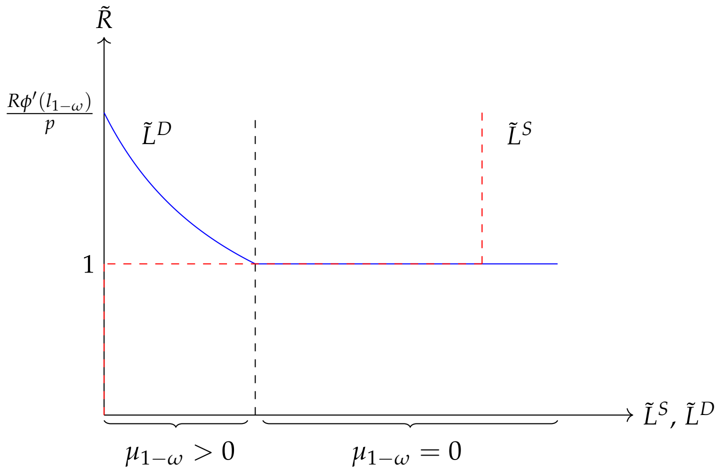
The loan market equilibrium is portrayed in Figure B1. $\tilde{R}$ denotes the gross interest rate for unsecured loans, $\tilde{L}^S$ and $\tilde{L}^D$ the aggregate supply and demand for unsecured funds by banks in the ω-jurisdiction and 1-ω-jurisdiction respectively. Demand intersects the vertical axis at $\frac{R\phi'(l_{1-\omega})}{p}$, that is, the gross return from providing funds to distressed banks if constrained intact banks do not borrow funds on the loan market. As these banks obtain loans they expand asset purchases to $x_{1-\omega}^D = l_{1-\omega} + \tilde{l}_{1-\omega}$ which reduces the gross return from loans. Eventually, banks obtain enough loans and

$\mu_{1-\omega} = 0$. Previously constrained intact banks become unconstrained and their excess return on the asset market vanishes. At this point, funds from additional loans would be invested in the short asset. Intact banks are therefore only willing to pay $\tilde{R} = 1$ when $\mu_{1-\omega} = 0$.

The supply of loans is dictated by the opportunity costs from holding short assets. If $\tilde{R} < 1$, unconstrained intact banks would rather invest in short assets to convert their excess consumption goods from period 1 to period 2. At $\tilde{R} = 1$ unconstrained intact banks are indifferent between providing funds to constrained intact banks and investing into short assets. I assume that banks provide loans if indifferent. At some point, unconstrained intact banks provide loans equal to $\tilde{l}_\omega = l_\omega - x^D_\omega$. They become constrained and cannot increase funding. This is portrayed by the vertical portion of the supply curve when $\tilde{R} > 1$.

As apparent from Figure B1, there are an infinite amount of equilibria. However, each equilibrium coincides with a gross interest rate of one ($\tilde{R} = 1$) and requires that no intact bank is constrained. The latter is a result of sufficient aggregate liquidity in the asset market ($L > qc$) which is assumed throughout the paper.

Figure B1: *Period 1 Loan Market*



Notes: *The solid (dashed) line characterizes the inverse aggregate demand (supply) of unsecured loans.*

Proof of Lemma 1: The proof exploits the market clearing condition (4) in conjunction with the Implicit Function Theorem:

$$\frac{\partial p}{\partial L} = -\frac{\partial X^S/\partial L}{\partial X^S/\partial p - \partial X^D/\partial p}.$$

$\partial X^S/\partial L = -q/p$, $\partial X^S/\partial p = -\frac{X^S}{p}$ and $\partial X^D/\partial p = \frac{1}{\phi''\left(\frac{X^D}{1-q}\right)\frac{R}{1-q}}$. In equilibrium, $X^S =$

$X^D = X$. Therefore:

$$\frac{\partial p}{\partial L} = \frac{q}{-X - \frac{p}{\phi''\left(\frac{X}{1-q}\right)\frac{R}{1-q}}}.$$

Because $p = R\phi'\left(\frac{X}{1-q}\right)$ one obtains:

$$\frac{\partial p}{\partial L} = \frac{-\frac{q}{1-q}\phi''\left(\frac{X}{1-q}\right)}{\frac{X}{1-q}\phi''\left(\frac{X}{1-q}\right) + \phi'\left(\frac{X}{1-q}\right)} = \frac{q}{1-q} > 0. \tag{B.5}$$

The proof for $\frac{\partial X(L)}{\partial L} < 0$ follows a similar logic. The market clearing condition (4) can be expressed in terms of the price differential $p^S(X, L) - p^D(X) = 0$ with $p^S(X, L) = q\frac{c-L}{X}$ and $p^D(X) = R\phi'\left(\frac{X}{1-q}\right)$. As a result:

$$\frac{\partial X}{\partial L} = -\frac{\partial p^S/\partial L}{\partial p^S/\partial X - \partial p^D/\partial X} = \frac{-q}{R\left(\frac{X}{1-q}\phi''\left(\frac{X}{1-q}\right) + \phi'\left(\frac{X}{1-q}\right)\right)} = \frac{q}{R\phi''\left(\frac{X}{1-q}\right)} < 0.$$

■

Proof of Lemma 2: In order to satisfy period 1 consumption demand, available consumption goods by intact banks must be at least as large as the consumption shortage by distressed banks, that is, $(1-q)L \geq q(c-L)$, which is equivalent to $L \geq qc$. If $L \geq qc$, then $c - L \leq c(1-q)$. With asset market clearing, the statement is equivalent to $qc \geq \phi'^{-1}\left(\frac{p}{R}\right)p$. The term on the left is constant, while the term on the right corresponds to the $t = 1$ expenditure by an intact bank which increases in x_j^D. Because demand and prices are inversely related, expenditure decreases with p. The price of the competitive equilibrium, $p^{CE} = \frac{qR}{R-1+q}$, is strictly lower than the price level with global or national planners (Proposition 1). To guarantee $L \geq qc$ I thus set $p = p^{CE}$, which results in $qc \geq \phi'^{-1}\left(\frac{q}{R-1+q}\right)\frac{qR}{R-1+q}$.

With regard to the long asset supply, we must have that $x_j^S = \frac{c-l_j}{p} \leq k_j$, or equivalently $\frac{c-l_j}{e-l_j} \leq p$ since $e = k_j + l_j$. The fraction on the left decreases in l_j as $e > c > l_j$ and is largest when $l_j = 0$. The term on the right obtains its minimum at $p = p^{CE}$. $\frac{c}{e} \leq \frac{qR}{R-1+q}$ is therefore a sufficient condition. ■

Optimality of Asset Market Equilibrium: In period 0 banks choose their investment portfolio anticipating that they will enter a functioning asset market in $t = 1$. Lemma 2 describes conditions under which initial portfolio choices are indeed consistent with the asset market, however the asset market may not be an equilibrium ex-ante. In other words, it could be desirable to not participate in the asset market. However this is not the case, as I state in the following Lemma, which I subsequently prove.

Lemma B1 *The asset market equilibrium and non-participation are Nash equilibria. The asset market equilibrium is payoff dominant (Harsanyi and Selten, 1988), that is, it is Pareto superior to non-participation.*

Intuitively, the asset market equilibrium outperforms non-participation because it allows banks to hold less liquidity than c, which would be the dominant strategy if a bank does not participate in the asset market. Banks anticipate that they would be able to obtain funds from other banks during distress, hence they are able to invest in more profitable long assets. This result rests on two premises: imperfectly correlated liquidity shocks and sufficient aggregate liquidity.[22]

Proof of Lemma B1: If not participating in the asset market, it is optimal for a bank to choose $l_j = c$. To see this, notice that it is never optimal to choose $l_j > c$ and if $l_j < c$, the bank will default whenever $s_j = 1$. Therefore, if a bank decides to hold $l_j < c$, then it is always optimal to set $l_j = 0$. It is hence sufficient to compare the expected period 2 consumption in autarky when $l_j = c$ with $l_j = 0$.

Expected period 2 consumption in autarky with $l_j = c$ is:

$$\begin{aligned} E_0[c_{j2}^{\text{Autarky}} | l_j = c] &= qR(e-c) + (1-q)\left(R(e-c)+c\right) \\ &= qR(e-c) + (1-q)c(1-R) + \underbrace{(1-q)Re}_{E_0[c_{j2}^{\text{Autarky}}|l_j=0]} = R(e-c) + (1-q)c. \end{aligned}$$

Expected period 2 consumption in autarky with $l_j = 0$ is $(1-q)Re$. Therefore:

$$E_0[c_{j2}^{\text{Autarky}} | l_j = c] \geq E_0[c_{j2}^{\text{Autarky}} | l_j = 0]$$

if

$$qR(e-c) + (1-q)c(1-R) \geq 0 \iff \frac{c}{e} \leq \frac{qR}{R-1+q},$$

which is true by assumption (see Lemma 2). The asset market equilibrium provides the following $t = 2$ expected consumption:

[22] In Allen and Gale (2000) banks hold claims on other banks ex-ante to insure themselves against liquidity shocks. Perfect risk-sharing is possible as long as liquidity shocks are imperfectly correlated and aggregate liquidity is sufficient. In this paper, banks only interact with each other ex-post, but the same two ingredients are vital for the asset market to outperform the non-participation equilibrium.

$$
\begin{aligned}
E_0[c_{j2}^{\text{Market}}] &= q\left[R\left[e-l_j-\frac{c-l_j}{p}\right]\right] + (1-q)\left[R\left[e-l_j+\phi\left(x_j^D\right)\right]+l_j-px_j^D\right] \\
&= R(e-l_j) - qR\frac{c-l_j}{p} + (1-q)R\underbrace{\left[\phi\left(x_j^D\right)-\phi'(x_j^D)x_j^D\right]}_{>0} + (1-q)l_j \\
&> \underbrace{R(e-c)+(1-q)c}_{E_0[c_{j2}^{\text{Autarky}}|l_j=c]} + R(c-l_j) - (1-q)(c-l_j) - qR\frac{c-l_j}{p}.
\end{aligned}
$$

The asset market equilibrium dominates the autarky equilibrium if $E_0[c_{j2}^{\text{Market}}] > E_0[c_{j2}^{\text{Autarky}}|l_j = c]$, which based on the previous manipulations requires:

$$
R(c-l_j) - (1-q)(c-l_j) - qR\frac{c-l_j}{p} \overset{!}{\geq} 0.
$$

Because $c > l_j$ in the asset market equilibrium, the statement can be expressed as:

$$
R \overset{!}{\geq} 1 - q + \frac{qR}{p}.
$$

The asset price p is an equilibrium object. Because the equilibrium price of the competitive equilibrium is strictly lower than in the planner's solution (Proposition 1), the right hand side is maximized if $p = p^{CE} = \frac{qR}{R-1+q}$. With this substitution, the equation simplifies to $R \geq R$. The asset market equilibrium is therefore payoff dominant.

However, autarky remains a Nash equilibrium. No individual bank has an incentive to deviate from autarky and participate in the asset market due to potential default with an insufficient mass of banks in the asset market. On the other hand, no bank has an incentive to deviate from the asset market equilibrium. ■

Competitive Equilibrium: Each bank in period 0 maximizes:

$$
\begin{aligned}
W_j^{CE} = \max_{k_j\geq 0, l_j\geq 0} \Bigg\{ & q\left[R\left[k_j - \frac{c-l_j}{p(L)}\right]\right] \\
& + (1-q)\left[R\left[k_j + \phi\left(\phi'^{-1}\left(\frac{p(L)}{R}\right)\right)\right] + l_j - p(L)\phi'^{-1}\left(\frac{p(L)}{R}\right)\right]\Bigg\}
\end{aligned}
$$

subject to

$$
k_j + l_j = e.
$$

Substituting k_j with $e - l_j$, the first order condition implies:

$$\frac{\partial W_j^{CE}}{\partial l_j} = q\left[R\left[-1+\frac{1}{p^{CE}}\right]\right] + (1-q)\left[-R+1\right] \stackrel{!}{=} 0.$$

The equation can be rearranged to $p^{CE} = \frac{qR}{R-1+q}$. This asset price makes every bank indifferent between short and long assets.

Global Planner Equilibrium: A global planner solves:

$$\begin{aligned} W^{GP} = \max_{K\geq 0, L\geq 0} &\left\{ q\left[R\left[K - \frac{c-L}{p(L)}\right]\right]\right. \\ &\left. + (1-q)\left[R\left[K+\phi\left(\phi'^{-1}\left(\frac{p(L)}{R}\right)\right)\right] + L - p(L)\phi'^{-1}\left(\frac{p(L)}{R}\right)\right]\right\} \end{aligned}$$

subject to

$$K + L = E.$$

Substituting K with $E - L$, optimality requires:

$$\begin{aligned} \frac{\partial W^{GP}}{\partial L} =& q\left[R\left[-1+\frac{1}{p^{GP}}+\frac{c-L^{GP}}{[p^{GP}]^2}\frac{\partial p}{\partial L}\right]\right] \\ &+ (1-q)\left[-R+1+\left[\left[R\phi'(\cdot)-p^{GP}\right]\frac{1}{R\phi''(\cdot)} - \phi'^{-1}\left(\frac{p^{GP}}{R}\right)\right]\frac{\partial p}{\partial L}\right] \stackrel{!}{=} 0. \end{aligned}$$

The derivative can be simplified since $p^{GP} = R\phi'(\cdot)$. Further, in equilibrium, $X^D = X^S$, hence $\phi'^{-1}\left(\frac{p^{GP}}{R}\right) = \frac{q}{1-q}\frac{c-L^{GP}}{p^{GP}}$. Consequently:

$$\frac{\partial W^{GP}}{\partial L} = q\left[R\left[-1+\frac{1}{p^{GP}}+\frac{c-L^{GP}}{[p^{GP}]^2}\frac{\partial p}{\partial L}\right]\right] + (1-q)\left[-R+1-\frac{q}{1-q}\frac{c-L^{GP}}{p^{GP}}\frac{\partial p}{\partial L}\right] = 0.$$

Rearranging yields:

$$R-1+q = qR\left[\frac{1}{p^{GP}}+\frac{\partial p}{\partial L}\left[\frac{c-L^{GP}}{[p^{GP}]^2} - \frac{c-L^{GP}}{p^{GP}R}\right]\right].$$

Because $p^{CE} = \frac{qR}{R-1+q}$, the statement is equivalent to:

$$p^{GP} = p^{CE}\left[1 + \frac{c - L^{GP}}{R}\frac{\partial p}{\partial L}\left[\frac{1}{\phi'(\cdot)} - 1\right]\right].$$

I subsequently compute the second derivative. It is convenient to rewrite the first order condition as:

$$\frac{\partial W^{GP}}{\partial L} = 1 - q - R + q\frac{R}{p(L)} + \left[\frac{R}{p(L)}X^S(p(L), L) - X^D(p(L))\right]\frac{\partial p}{\partial L}.$$

The second derivative corresponds to:

$$\begin{aligned}\frac{\partial^2 W^{GP}}{\partial^2 L} =& - q\frac{R}{p^2}\frac{\partial p}{\partial L} + \left[\frac{R}{p}X^S(p, L) - X^D(p)\right]\underbrace{\frac{\partial^2 p}{\partial^2 L}}_{=0} \\ &+ \left[-\frac{R}{p^2}X^S(p, L)\frac{\partial p}{\partial L} + \frac{R}{p}\frac{\partial X^S}{\partial L} + \frac{R}{p}\frac{\partial X^S}{\partial p}\frac{\partial p}{\partial L} - \frac{\partial X^D}{\partial p}\frac{\partial p}{\partial L}\right]\frac{\partial p}{\partial L} < 0.\end{aligned}$$

Because $\frac{\partial^2 p}{\partial^2 L} = 0$ and inserting the formulas for asset demand and supply immediately leads to a negative second derivative. The objective function is therefore strictly concave and the solution is a unique global maximum.

National Planner Equilibrium: I subsequently derive the best response function for the ω-planner. The procedure for the 1-ω-planner is isomorphic and hence omitted. The optimization problem for the ω planner is:

$$\begin{aligned}W_\omega^{NP} =& \max_{K_\omega \geq 0, L_\omega \geq 0}\left\{q\left[R\left[K_\omega - \frac{\omega c - L_\omega}{p(L)}\right]\right]\right. \\ &\left. + (1-q)\left[R\left[K_\omega + \omega\phi\left(\phi'^{-1}\left(\frac{p(L)}{R}\right)\right)\right] + L_\omega - \omega p(L)\phi'^{-1}\left(\frac{p(L)}{R}\right)\right]\right\}\end{aligned}$$

subject to

$$K_\omega + L_\omega = \omega E.$$

I substitute K_ω with $\omega E - L_\omega$. If the non-negativity constraint does not bind, the first order condition satisfies:

$$\begin{aligned}\frac{\partial W_\omega^{NP}}{\partial L_\omega} =& q\left[R\left[-1 + \frac{1}{p^{NP}} + \frac{\omega c - L_\omega^{NP}}{[p^{NP}]^2}\frac{\partial p}{\partial L}\right]\right] \\ &+ (1-q)\left[-R + 1 + \left[\left[R\phi'(\cdot) - p^{NP}\right]\frac{1}{R\phi''(\cdot)} - \phi'^{-1}\left(\frac{p^{NP}}{R}\right)\right]\frac{\partial p}{\partial L}\omega\right] \stackrel{!}{=} 0.\end{aligned}$$

The equation is evaluated in equilibrium, hence $X^D = X^S$ and $\phi'^{-1}\left(\frac{p^{NP}}{R}\right) = \frac{q}{1-q}\frac{c-L^{NP}}{p^{NP}}$. Further, $p^{NP} = R\phi'(\cdot)$. Therefore:

$$\frac{\partial W_{\omega}^{NP}}{\partial L_{\omega}} = q\left[R\left[-1+\frac{1}{p^{NP}}+\frac{\omega c - L_{\omega}^{NP}}{[p^{NP}]^2}\frac{\partial p}{\partial L}\right]\right] + (1-q)\left[-R+1-\frac{q}{1-q}\frac{c-L^{NP}}{p^{NP}}\frac{\partial p}{\partial L}\omega\right] = 0.$$

Rearranging yields:

$$R-1+q = qR\left[\frac{1}{p^{NP}}+\frac{\partial p}{\partial L}\omega\left[\frac{c-l_{\omega}^{NP}}{[p^{NP}]^2}-\frac{c-L^{NP}}{p^{NP}R}\right]\right],$$

which can be further simplified to:

$$p^{NP} = p^{CE}\left[1+\frac{\partial p}{\partial L}\omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]\right].$$

I next prove the uniqueness of an interior Cournot Nash equilibrium. Because $p(L)$ is a function of aggregate liquidity, I can define $BR_{\omega}\left(L_{\omega}(L_{1-\omega}), L_{1-\omega}\right)\right) = 0$ as the first order condition (or best response function) of the ω-planner for a given choice of the 1-ω-planner. The interior equilibrium is unique if both best responses are contractions. If BR_{ω} is a contraction, it must satisfy:

$$\left|\frac{\partial L_{\omega}}{\partial L_{1-\omega}}\right| = \left|-\frac{\frac{\partial BR_{\omega}}{\partial L_{1-\omega}}}{\frac{\partial BR_{\omega}}{\partial L_{\omega}}}\right| \overset{!}{<} 1 \iff \left|\frac{\partial BR_{\omega}}{\partial L_{1-\omega}}\right| \overset{!}{<} \left|\frac{\partial BR_{\omega}}{\partial L_{\omega}}\right|.$$

$\frac{\partial BR_{\omega}}{\partial L_{\omega}}$ is the second derivative of the objective function, $\frac{\partial^2 W_{\omega}^{NP}}{\partial^2 L_{\omega}}$. $\frac{\partial BR_{\omega}}{\partial L_{1-\omega}}$ is the derivative of the first order condition with respect to $L_{1-\omega}$, $\frac{\partial^2 W_{\omega}^{NP}}{\partial L_{\omega}\partial L_{1-\omega}}$. I subsequently derive both expressions.

To derive $\frac{\partial BR_{\omega}}{\partial L_{\omega}}$ it is convenient to re-express the first derivative as:

$$\frac{\partial W_{\omega}^{NP}}{\partial L_{\omega}} = 1-q-R+q\frac{R}{p(L)}+\left[\frac{R}{p(L)}\frac{X_{\omega}^S(p(L),L_{\omega})}{\omega}-X^D(p(L))\right]\frac{\partial p}{\partial L}\omega$$

with $X_{\omega}^S(p(L),L_{\omega}) = q\frac{\omega c - L_{\omega}}{p(L)}$. The second derivative is:

$$\frac{\partial^2 W_{\omega}^{NP}}{\partial^2 L_{\omega}} = -q\frac{R}{p^2}\frac{\partial p}{\partial L}+\left[\frac{R}{p}\frac{X_{\omega}^S}{\omega}-X^D\right]\underbrace{\frac{\partial^2 p}{\partial^2 L}}_{=0}\omega \tag{B.6}$$

$$+\left[-\frac{R}{p^2}\frac{X^S_\omega}{\omega}\frac{\partial p}{\partial L}+\frac{R}{p}\frac{\partial X^S_\omega}{\partial L_\omega}\frac{1}{\omega}+\frac{R}{p}\frac{\partial X^S_\omega}{\partial p}\frac{\partial p}{\partial L}\frac{1}{\omega}-\frac{\partial X^D}{\partial p}\frac{\partial p}{\partial L}\right]\frac{\partial p}{\partial L}\omega.$$

Inserting the formulas for asset demand and supply implies a negative second derivative. The objective function is therefore strictly concave and $\frac{\partial BR_\omega}{\partial L_\omega} < 0$.

I subsequently focus on $\frac{\partial BR_\omega}{\partial L_{1-\omega}}$:

$$\frac{\partial^2 W^{\mathrm{NP}}_\omega}{\partial L_\omega \partial L_{1-\omega}} = -q\frac{R}{p^2}\frac{\partial p}{\partial L}+\left[\frac{R}{p}\frac{X^S_\omega}{\omega}-X^D(p)\right]\underbrace{\frac{\partial^2 p}{\partial^2 L}}_{=0}\omega$$
$$+\left[-\frac{R}{p^2}\frac{X^S_\omega}{\omega}\frac{\partial p}{\partial L}+\frac{R}{p}\frac{\partial X^S_\omega}{\partial p}\frac{\partial p}{\partial L}\frac{1}{\omega}-\frac{\partial X^D}{\partial p}\frac{\partial p}{\partial L}\right]\frac{\partial p}{\partial L}\omega.$$

Once again, based on the specific asset demand and supply functions, this derivative is negative. Thus, $\frac{\partial BR_\omega}{\partial L_\omega} < 0$ and $\frac{\partial BR_\omega}{\partial L_{1-\omega}} < 0$. This implies that:

$$\left|\frac{\partial BR_\omega}{\partial L_{1-\omega}}\right| < \left|\frac{\partial BR_\omega}{\partial L_\omega}\right| \iff \frac{\partial BR_\omega}{\partial L_{1-\omega}} > \frac{\partial BR_\omega}{\partial L_\omega},$$

or,

$$0 > \frac{R}{p}\frac{\partial X^S_\omega}{\partial L_\omega}\frac{\partial p}{\partial L}.$$

Notice that $\frac{\partial X^S_\omega}{\partial L_\omega} < 0$ and $\frac{\partial p}{\partial L} > 0$, so this statement is indeed true. The best response function of the ω-planner is a contraction. Due to symmetry the previous steps generalize to the 1-ω-planner, hence $\left|\frac{\partial L_{1-\omega}}{\partial L_\omega}\right| < 1$. The interior Cournot Nash equilibrium is therefore unique.

Lemma B2 proves the existence of a corner solution in which the smaller jurisdiction provides zero liquidity. Without loss of generality, suppose the non-negativity constraint binds for the 1-ω-planner. I already verified that $\frac{\partial^2 W^{NP}_\omega}{\partial^2 L_\omega} < 0$. The objective function of the ω-planner is therefore strictly concave and the corner solution is a unique maximum.

Lemma B2 *The model features a corner solution where $L^{NP}_{1-\omega} = 0$ when $\omega \geq \overline{\omega}$, or where $L^{NP}_\omega = 0$ when $\omega \leq \underline{\omega}$ with $0 < \underline{\omega} < 0.5 < \overline{\omega} = 1 - \underline{\omega} < 1$.*

Proof of Lemma B2: The best response functions are derived under the premise that the non-negativity constraint does not bind, that is, $\frac{\partial W^{NP}_\omega}{\partial L_\omega} = \frac{\partial W^{NP}_{1-\omega}}{\partial L_{1-\omega}} = 0$. Combining both best response functions yields:

$$\omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]=(1-\omega)\left[\frac{c-l_{1-\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]. \tag{B.7}$$

Without loss of generality, suppose that $\omega \to 1$. Then $l_{\omega}^{NP} \to L^{NP}$ and $L^{NP} \to L^{GP}$ since $\frac{\partial W_{\omega}^{NP}}{\partial L_{\omega}} \to \frac{\partial W^{GP}}{\partial L}$. Further $\left[\frac{c-L^{GP}}{p^{GP}}-\frac{c-L^{GP}}{R}\right]>0$ as $p<R$. The left hand side of (B.7) therefore converges to a finite and positive number by the multiplication rule for limits. The right hand side must converge to the same limit in an interior solution. $(1-\omega)$ converges to 0. The second term $\left[\frac{c-l_{1-\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]$ is finite when $l_{1-\omega}^{NP}\geq 0$. The right hand side of (B.7) therefore converges to 0 for any non-negative value of $l_{1-\omega}^{NP}$. The equality in (B.7) breaks and there is no interior solution in which both planners optimally choose a non-negative amount of liquid assets.

Further, due to continuity, there must exist a $\delta>0$, such that for $\overline{\omega}=1-\delta<1$, $\overline{\omega}\left[\frac{c-l_{\omega}^{NP}}{p^{NP}}-\frac{c-\overline{\omega}l_{\omega}^{NP}}{R}\right]=(1-\overline{\omega})\left[\frac{c}{p^{NP}}-\frac{c-\overline{\omega}l_{\omega}^{NP}}{R}\right]$. Therefore every $\omega\geq\overline{\omega}>0.5$ corresponds to $l_{1-\omega}^{NP}=0$. Similarly, due to symmetry there must be a threshold $\underline{\omega}=1-\overline{\omega}$, such that any $\omega\leq\underline{\omega}$ results in $l_{\omega}^{NP}=0$. ■

C. Appendix: Section 3

Proof of Proposition 1: I first focus on an interior national planner equilibrium and show that $L^{GP}>L^{NP}$. As a preliminary step, I relate the global planner first order condition with the two national planner best response functions:

$$\begin{gathered}\frac{1}{p^{GP}}\left[1+\frac{\partial p}{\partial L}\left[\frac{c-L^{GP}}{p^{GP}}-\frac{c-L^{GP}}{R}\right]\right]\\ =\\ \frac{1}{p^{NP}}\left[1+\frac{\partial p}{\partial L}\omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]\right]\\ =\\ \frac{1}{p^{NP}}\left[1+\frac{\partial p}{\partial L}(1-\omega)\left[\frac{c-l_{1-\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]\right].\end{gathered} \tag{C.1}$$

The second equality is an identity that must hold in any interior Cournot equilibrium. I prove $L^{GP}>L^{NP}$ by contradiction. In particular, I will show that the first equality in (C.1) fails to hold if $L^{GP}=L^{NP}$ or $L^{GP}<L^{NP}$.

Suppose $L^{GP} = L^{NP}$. Then $p^{GP} = p^{NP}$ via Lemma 1. Further notice that $\frac{\partial p}{\partial L} = \frac{q}{1-q}$. If $\omega = 0.5$, both regulators are identical. Hence, $l_{\omega}^{NP} = l_{1-\omega}^{NP} = L^{NP} = L^{GP}$. However this immediately contradicts the first equality of (C.1) because $\omega \neq 1$.

If $\omega \neq 0.5$, $l_{\omega}^{NP} \neq l_{1-\omega}^{NP}$. Without loss of generality assume that $l_{\omega}^{NP} > l_{1-\omega}^{NP}$ and therefore $l_{\omega}^{NP} > L^{NP}$. Then $\left[\frac{c-L^{GP}}{p^{GP}} - \frac{c-L^{GP}}{R}\right] > \omega\left[\frac{c-L^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right] > \omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right]$ which contradicts (C.1). $L^{GP} = L^{NP}$ is not a solution.

Suppose $L^{GP} < L^{NP}$. Then $p^{GP} < p^{NP}$ via Lemma 1. In this case, the equalities in (C.1) require:

$$\frac{c-L^{GP}}{p^{GP}} - \frac{c-L^{GP}}{R} < \omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right] = (1-\omega)\left[\frac{c-l_{1-\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right].$$

If $\omega = 0.5$, $l_{\omega}^{NP} = l_{1-\omega}^{NP} = L^{NP}$. But:

$$[c-L^{GP}]\left[\frac{1}{p^{GP}} - \frac{1}{R}\right] > [c-L^{NP}]\left[\frac{1}{p^{NP}} - \frac{1}{R}\right],$$

a contradiction to (C.1). If $\omega \neq 0.5$, $l_{\omega}^{NP} \neq l_{1-\omega}^{NP}$. Without loss of generality assume that $l_{\omega}^{NP} > l_{1-\omega}^{NP}$ and hence $l_{\omega}^{NP} > L^{NP}$. Then:

$$[c-L^{GP}]\left[\frac{1}{p^{GP}} - \frac{1}{R}\right] > [c-L^{NP}]\left[\frac{1}{p^{NP}} - \frac{1}{R}\right] > \frac{c-l_{\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R},$$

which contradicts (C.1). $L^{GP} < L^{NP}$ is hence not a solution for any level of size asymmetry in an interior solution. I thus proved $L^{GP} > L^{NP}$.

I subsequently verify that $L^{CE} < L^{NP}$ in an interior equilibrium. If $L^{CE} < L^{NP}$, then $p^{CE} < p^{NP}$ via Lemma 1. Using the best response functions, $p^{CE} < p^{NP}$ holds whenever:

$$\omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right] = (1-\omega)\left[\frac{c-l_{1-\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R}\right] \overset{!}{>} 0.$$

If $\omega = 0.5$, $l_{\omega}^{NP} = L^{NP}$. Therefore $\frac{c-l_{\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R} > 0$ since $p^{NP} < R$. If $\omega \neq 0.5$, $l_{\omega}^{NP} \neq l_{1-\omega}^{NP}$. Without loss of generality assume that $l_{\omega}^{NP} > l_{1-\omega}^{NP}$ and hence $l_{1-\omega}^{NP} < L^{NP}$. This implies $\frac{c-l_{1-\omega}^{NP}}{p^{NP}} - \frac{c-L^{NP}}{R} > 0$. I thus proved $L^{CE} < L^{NP}$.

The derivation so far was based on an interior solution which allowed me to equate both best response functions. At a corner solution the smaller national planner provides zero liquidity (Lemma B2). Without loss of generality suppose that $L^{NP}_{1-\omega} = 0$. In this case, $L^{NP} = L^{NP}_{\omega}$. I subsequently show that aggregate liquidity increases with more asymmetry, that is, $\frac{\partial L^{NP}_{\omega}}{\partial \omega} > 0$. I rewrite the first order condition for convenience:

$$\underbrace{p^{CE}\left[1 + \frac{\partial p}{\partial L}\omega\left[\frac{c - L^{NP}_{\omega}/\omega}{p^{NP}} - \frac{c - L^{NP}_{\omega}}{R}\right]\right] - p^{NP} = 0}_{g(L^{NP}_{\omega}(\omega),\omega)=0}.$$

The first order condition contains two endogenous objects, p^{NP} and L^{NP}_{ω}. The equilibrium price $p^{NP}(L^{NP}_{\omega})$ is however only a function of L^{NP}_{ω}. I can therefore apply the Implicit Function Theorem:

$$\frac{\partial L^{NP}_{\omega}}{\partial \omega} = -\frac{\frac{\partial g(\cdot)}{\partial \omega}}{\frac{\partial g(\cdot)}{\partial L^{NP}_{\omega}}}.$$

The numerator $\frac{\partial g(\cdot)}{\partial \omega}$ is positive:

$$\frac{\partial g(\cdot)}{\partial \omega} = p^{CE}\frac{\partial p}{\partial L}\left[\frac{c}{p^{NP}} - \frac{c}{R} + \frac{L^{NP}_{\omega}}{R}\right] > 0,$$

as $R > p^{NP}$ and $\frac{\partial p}{\partial L} > 0$. $\frac{\partial g(\cdot)}{\partial L^{NP}_{\omega}}$ is negative:

$$\frac{\partial g(\cdot)}{\partial L^{NP}_{\omega}} = p^{CE}\left[\underbrace{\frac{\partial^2 p}{\partial^2 L}}_{=0}\omega\left[\frac{c - L^{NP}_{\omega}/\omega}{p^{NP}} - \frac{c - L^{NP}_{\omega}}{R}\right] + \frac{\partial p}{\partial L}\left[\underbrace{-\frac{1}{p^{NP}} + \frac{\omega}{R} - \frac{\omega c - L^{NP}_{\omega}}{[p^{NP}]^2}\frac{\partial p}{\partial L}}_{<0}\right]\right] - \frac{\partial p}{\partial L} < 0,$$

as $\omega < 1$, and $\frac{\partial^2 p}{\partial^2 L} = 0$. Therefore, $\frac{\partial L^{NP}_{\omega}}{\partial \omega} > 0$.

Further, notice that the national planner equilibrium converges to the global planner solution when $\omega \to 1$ and that $L^{NP} > L^{CE}$ in an interior solution. Therefore, the relationship $L^{GP} > L^{NP} > L^{CE}$ holds both in an interior and a corner solution. ■

Proof of Proposition 2: The proposition claims that $l^{NP}_{\omega} > l^{NP}_{1-\omega}$. To see this, I rewrite the first order condition for an individual bank in the ω-jurisdiction:

$$\frac{\partial(W^{NP}_{\omega}/\omega)}{\partial l_{\omega}} = 1 - q - R + \frac{qR}{p} + \left[\underbrace{\frac{R}{p}qx^{S}_{\omega} - (1-q)x^{D}_{\omega}}_{>0}\right]\frac{\partial p}{\partial L}\omega.$$

The bracket is positive. To see this notice that:

$$\frac{R}{p}qx_{\omega}^{S}-(1-q)x_{\omega}^{D}\overset{EQ}{=}\frac{R}{p}q\frac{c-l_{\omega}^{NP}}{p}-q\frac{c-L^{NP}}{p}=q\frac{R}{p}\left[\frac{c-l_{\omega}^{NP}}{p}-\frac{c-L^{NP}}{R}\right].$$

In an interior solution the best response function implies:

$$\underbrace{p^{CE}\left[1+\frac{\partial p}{\partial L}\omega\left[\frac{c-l_{\omega}^{NP}}{p^{NP}}-\frac{c-L^{NP}}{R}\right]\right]}_{p^{NP}}.$$

Because $p^{NP}>p^{CE}$ it follows that $\frac{R}{p}qx_{\omega}^{S}-(1-q)x_{\omega}^{D}>0$. Therefore, $\frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}}>\frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}}$ when $\omega>0.5$. Since the objective function is strictly concave, it follows that $l_{\omega}^{NP}>l_{1-\omega}^{NP}$. This result also mechanically holds in a corner solution (Lemma B2). ■

Lemma C1 *Liquidity is a public good. If one planner decides to enhance regulation, the other planner has less incentives to regulate, hence* $\frac{\partial l_{\omega}^{NP}}{\partial l_{1-\omega}^{NP}}<0$.

Proof of Lemma C1: The objective functions of both planners in an interior equilibrium are strictly concave. The condition $\frac{\partial l_{\omega}^{NP}}{\partial l_{1-\omega}^{NP}}<0$ therefore holds if $\frac{\partial^2 W_{\omega}^{\mathrm{NP}}}{\partial l_{\omega}\partial l_{1-\omega}}<0$ and $\frac{\partial^2 W_{1-\omega}^{\mathrm{NP}}}{\partial l_{1-\omega}\partial l_{\omega}}<0$.

The first derivative of the ω-planner with respect to bank-specific short assets is:

$$\frac{\partial W_{\omega}^{\mathrm{NP}}}{\partial l_{\omega}}=\frac{\partial W_{\omega}^{\mathrm{NP}}}{\partial L_{\omega}}\frac{\partial L_{\omega}}{\partial l_{\omega}}=\frac{\partial W_{\omega}^{\mathrm{NP}}}{\partial L_{\omega}}\omega.$$

Therefore:

$$\frac{\partial^2 W_{\omega}^{\mathrm{NP}}}{\partial l_{\omega}\partial l_{1-\omega}}=\frac{\partial^2 W_{\omega}^{\mathrm{NP}}}{\partial L_{\omega}\partial L_{1-\omega}}\frac{\partial L_{1-\omega}}{\partial l_{1-\omega}}\omega=\underbrace{\frac{\partial W_{\omega}^{\mathrm{NP}}}{\partial L_{\omega}\partial L_{1-\omega}}}_{<0}\omega(1-\omega)<0.$$

The cross derivative of the objective function of the ω-planner is negative as derived in the National Planner Equilibrium. It immediately follows that $\frac{\partial l_{\omega}^{NP}}{\partial l_{1-\omega}^{NP}}<0$. The same steps apply to the 1-ω-planner. ■

Proof of Proposition 3: If ω=0.5, then $l_{\omega}^{NP}=l_{1-\omega}^{NP}$ and by definition $W_{\omega}^{NP}=W_{1-\omega}^{NP}=W^{NP}$. Period 2 consumption with a global planner equals W^{GP} and is based on the joint maximization over both jurisdictions. The global planner's allocation deviates from national planners, since $L^{GP}>L^{NP}$. Thus by revealed preferences, $W^{GP}>W_{\omega}^{NP}+W_{1-\omega}^{NP}=2W^{NP}$. Therefore $\triangle_{\omega}=0.5W^{GP}-W_{\omega}^{NP}>0$ and $\triangle_{1-\omega}=0.5W^{GP}-W_{1-\omega}^{NP}>$

0. Because gains from cooperation are continuous, there must be a γ close but unequal to zero, such that $\triangle_{\omega} > 0$ and $\triangle_{1-\omega} > 0$ if $\omega = 0.5 + \gamma$.

Next, I show that the 1-ω-planner is unwilling to cooperate when ω approaches 1. As $\omega \to 1$, $l_{\omega}^{NP} \to l^{GP}$. Further, $l_{1-\omega}^{NP} = 0$ based on Lemma B2. Joint regulation would force the 1-ω-planner to allocate l^{GP} to each bank, while the ω-planner would provide the same liquidity as before. The 1-ω-jurisdiction has no effect on aggregate quantities. Aggregate liquidity or the equilibrium asset price hence do not change. Expected period 2 consumption with free-riding is:

$$W_{1-\omega}^{FR} = q\left[R\left[e - \frac{c}{p^{GP}}\right]\right] + (1-q)\left[R\left[e + \phi(x_{1-\omega}^{D})\right] - p^{GP}x_{1-\omega}^{D}\right].$$

With cooperation, one obtains:

$$W_{1-\omega}^{CO} = q\left[R\left[e - l^{GP} - \frac{c - l^{GP}}{p^{GP}}\right]\right] + (1-q)\left[R\left[e - l^{GP} + \phi(x_{1-\omega}^{D})\right] + l^{GP} - p^{GP}x_{1-\omega}^{D}\right].$$

It is straightforward to verify that:

$$W_{1-\omega}^{FR} > W_{1-\omega}^{CO} \iff p^{GP} > \frac{qR}{R-1+q} = p^{CE},$$

which is always true. Therefore, $\triangle_{1-\omega} < 0$ when $\omega \to 1$. Further, due to continuity, there must be a $\epsilon > 0$, such that for $\overline{\overline{\omega}} = 1 - \epsilon < 1$, $\triangle_{1-\overline{\overline{\omega}}} = 0$. The region defined by $\omega > \overline{\overline{\omega}} > 0.5$ is associated with $\triangle_{1-\omega} < 0$. The same reasoning can be reversed. There must be a threshold $\underline{\underline{\omega}} = 1 - \overline{\overline{\omega}}$ which characterizes a region below any $\omega < \underline{\underline{\omega}} < 0.5$ results in $\triangle_{\omega} < 0$. ■

D. Appendix: Section 4

Proof of Proposition 4: A feasible contract $\{l_{\omega}^{p}, l_{1-\omega}^{p}\}$ satisfies the following conditions up to a first order approximation:

$$\begin{aligned}
\triangle_{\omega}^{p} &\approx \frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}}\Delta l_{\omega}^{p} + \frac{\partial W_{\omega}^{NP}}{\partial l_{1-\omega}}\Delta l_{1-\omega}^{p} > 0\\
\triangle_{1-\omega}^{p} &\approx \frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}}\Delta l_{1-\omega}^{p} + \frac{\partial W_{1-\omega}^{NP}}{\partial l_{\omega}}\Delta l_{\omega}^{p} > 0.
\end{aligned}$$

The Envelope Theorem implies $\frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}} = \frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}} = 0$ as both planners optimize with respect to the liquid/illiquid asset mix. Further, foreign liquidity affects domestic welfare only through the equilibrium asset price. Therefore, the two conditions can be equivalently expressed as:

$$\frac{\partial W_{\omega}^{NP}}{\partial p}\frac{\partial p}{\partial l_{1-\omega}}\Delta l_{1-\omega}^{p} > 0, \quad \text{and} \quad \frac{\partial W_{1-\omega}^{NP}}{\partial p}\frac{\partial p}{\partial l_{\omega}}\Delta l_{\omega}^{p} > 0.$$

Next notice that $\frac{\partial p}{\partial l_{\omega}} \propto \frac{\partial p}{\partial L}$ and that $\frac{\partial p}{\partial L} > 0$ according to Lemma 1. Further:

$$\frac{\partial W_{\omega}^{NP}}{\partial p} = \omega \left\{ \underbrace{\left(\frac{R}{p}qx_{\omega}^{S} - (1-q)x_{\omega}^{D}\right)}_{>0} + (1-q)\underbrace{\left(R\phi'(\cdot) - p\right)}_{=0}\frac{\partial x_{\omega}^{D}}{\partial p} \right\} > 0.$$

The first inner bracket is positive (Proof of Proposition 2), and $R\phi'(\cdot) = p$ in equilibrium. Therefore:

$$\underbrace{\frac{\partial W_{\omega}^{NP}}{\partial p}\frac{\partial p}{\partial l_{1-\omega}}}_{>0}\Delta l_{1-\omega}^{p} > 0, \quad \text{and} \quad \underbrace{\frac{\partial W_{1-\omega}^{NP}}{\partial p}\frac{\partial p}{\partial l_{\omega}}}_{>0}\Delta l_{\omega}^{p} > 0.$$

Hence it must be that $\Delta l_{1-\omega}^{p} > 0$ and $\Delta l_{\omega}^{p} > 0$. If $\Delta \to 0$, the approximation for the feasible contract holds exactly. A partial agreement therefore always exists, which proves part (i) of the proposition.

For part (ii) notice that when $\omega > 0.5$, $\frac{\partial p}{\partial l_{\omega}} > \frac{\partial p}{\partial l_{1-\omega}}$. Further:

$$\frac{\partial (W_{1-\omega}^{NP}/(1-\omega))}{\partial p} = \left(\frac{R}{p}qx_{1-\omega}^{S} - (1-q)x_{1-\omega}^{D}\right) > \left(\frac{R}{p}qx_{\omega}^{S} - (1-q)x_{\omega}^{D}\right) = \frac{\partial (W_{\omega}^{NP}/\omega)}{\partial p}.$$

The inequality emerges as $x_{1-\omega}^{D} = x_{\omega}^{D}$ and $x_{1-\omega}^{S} > x_{\omega}^{S}$. Therefore:

$$\frac{\partial (W_{1-\omega}^{NP}/(1-\omega))}{\partial p}\frac{\partial p}{\partial l_{\omega}} > \frac{\partial (W_{\omega}^{NP}/\omega)}{\partial p}\frac{\partial p}{\partial l_{1-\omega}},$$

which immediately translates into $\triangle_{\omega}^{p}/\omega < \triangle_{1-\omega}^{p}/(1-\omega)$ if $\Delta l_{\omega}^{p} = \Delta l_{1-\omega}^{p}$. ■

Proof of Proposition 5: After substituting the resource constraint, the first order condition of the constrained 1-ω-planner satisfies:

$$\frac{\partial W_{1-\omega}^{NP}}{\partial l_{1-\omega}} + \lambda_{1-\omega} = 0.$$

$\lambda_{1-\omega}$ represents the Lagrange multiplier of the non-negativity constraint on liquid assets. Thus, if $l_{1-\omega}^{NP} = 0$, then $\lambda_{1-\omega} > 0$. Because $\frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}} = 0$, a feasible contract is described by:

$$\underbrace{\frac{\partial W_{\omega}^{NP}}{\partial l_{1-\omega}}}_{>0} \Delta l_{1-\omega}^{p} > 0, \quad \text{and} \quad -\lambda_{1-\omega} \Delta l_{1-\omega}^{p} + \underbrace{\frac{\partial W_{1-\omega}^{NP}}{\partial l_{\omega}}}_{>0} \Delta l_{\omega}^{p} > 0.$$

The derivatives are positive (see derivation of Proposition 4). Any feasible contract therefore requires $\Delta l_{\omega}^{p} > 0$ and $\Delta l_{1-\omega}^{p} > 0$. Further, the second condition implies an increase in Δl_{ω}^{p} for a given $\Delta l_{1-\omega}^{p}$ as $\lambda_{1-\omega}$ increases. The derivation assumed that $\frac{\partial W_{\omega}^{NP}}{\partial l_{\omega}} = 0$, which only holds exactly if $\Delta l_{\omega}^{p} \to 0$. Because $\Delta l_{\omega}^{p} > 0$ to compensate $\lambda_{1-\omega}$, the first order condition at l_{ω}^{p} may no longer be equal to zero, and welfare can decrease for the ω-jurisdiction. ■

Many Country Framework: I consider a setup in which aggregate liquidity exceeds the liquidity in the competitive equilibrium, while the 1-ω jurisdictions free-ride ($l^{FR} = 0$). I subsequently show that such an equilibrium exists if $\omega > \omega^*$.

The first order condition of the ω-planner is identical to the national planner setup:

$$p = p^{CE} \left[1 + \frac{q}{1-q} \omega \left[\frac{c - l_{\omega}}{p} - \frac{c - L}{R} \right] \right].$$

If $p > p^{CE}$, every small open economy chooses zero liquidity (see derivation competitive equilibrium). Therefore, I need to show that:

$$\frac{q}{1-q} \omega \left[\frac{c - l_{\omega}}{p} - \frac{c - L}{R} \right] > 0,$$

where $L = \omega l_{\omega}$. Asset market clearing implies:

$$p = R - \frac{q}{1-q}(c - L) = 0.$$

We can solve this condition for l_{ω} and plug the equation in the above inequality to obtain the following:

$$\frac{q}{1-q}(\omega c - c) > (R - p) \left(\omega \frac{R}{p} - 1 \right).$$

If ω=1, the inequality boils down to $0 > (R - p)(p/R - 1)$, which is satisfied as $p < R$. I therefore define ω^* as the largest ω such that the above inequality still holds.

Proof of Proposition 6: If $\omega \geq \overline{\omega}$ (and $\omega \geq \omega^*$), the 1-ω-jurisdiction (union of free-riders) would continue to provide zero liquidity. All allocations remain the same and hence welfare is unchanged. If $\omega < \overline{\omega}$, the 1-$\omega$-jurisdiction provides a positive amount of liquidity. Since, zero liquidity provision is in the choice set, but not selected, revealed preferences imply a strictly higher welfare. This proves part (i) of the proposition.

For part (ii), notice that $\frac{\partial l_{\omega}^{NP}}{\partial l_{1-\omega}^{NP}} < 0$ (Lemma C1). Thus, if $\omega < \overline{\omega}$, the ω-jurisdiction reduces liquidity in response to regulation in the 1-ω-jurisdiction. A necessary condition for a global agreement is $l_{\omega} < l^{GP}$ and $l_{1-\omega} < l^{GP}$ (Lemma 4). Therefore, if $l_{\omega} > l^{GP}$ prior to the formation of a union and $l_{\omega} < l^{GP}$ afterwards, a global agreement becomes feasible.

A national planner internalizes part of the equilibrium effect of liquidity on the asset price relative to a small open economy (individual bank) and therefore has more incentives to invest in the liquid asset. This decreases the Lagrange multiplier (λ) associated with the non-negativity constraint on liquidity. If the union of free-riders leads to an interior solution then λ=0, and a partial agreement is always possible (Proposition 4). Otherwise, the decline in the Lagrange multiplier reduces the required compensation by the ω-jurisdiction (Δl_{ω}^{p}), making a partial agreement feasible for a larger range of ω (Proposition 5). ■

Proof of Proposition 7: Any transfer T that satisfies $\triangle_{\omega} - T \geq 0$ and $\triangle_{1-\omega} + T \geq 0$ leads to a cooperative solution. If $\triangle_{\omega} \geq 0$ and $\triangle_{1-\omega} \geq 0$ transfers are not necessary and $T = 0$ provides an admissible solution. Without loss of generality I assume $\triangle_{1-\omega} < 0$. This necessarily implies that $\triangle_{\omega} > 0$ since $\triangle_{\omega} + \triangle_{1-\omega} > 0 \;\forall\; \omega$. Suppose that $T = \underline{T}$ with $\triangle_{1-\omega} + \underline{T} = 0$. Because $\triangle_{\omega} - \underline{T} + \triangle_{1-\omega} + \underline{T} > 0 \;\forall\; \omega$ one obtains $\triangle_{\omega} - \underline{T} > 0$. The promised transfer $\underline{T}$ leads to a cooperative solution. ■

Proof of Proposition 8: The asset price in the ω-jurisdiction with autarky is denoted as p_{ω} and depends on L_{ω}. Market clearing with ω-banks only corresponds to:

$$\underbrace{(1-q)\omega\phi'^{-1}\left(\frac{p_{\omega}^{NP}(1+\gamma(\omega))}{R}\right)}_{X_{\omega}^{D}} = \underbrace{q\frac{\omega c - L_{\omega}^{NP}}{p_{\omega}^{NP}}}_{X_{\omega}^{S}}.$$

Asset market clearing combined with the Implicit Function Theorem implies:

$$\frac{\partial p_{\omega}}{\partial L_{\omega}} = -\frac{\partial X_{\omega}^{S}/\partial L_{\omega}}{\partial X_{\omega}^{S}/\partial p_{\omega} - \partial X_{\omega}^{D}/\partial p_{\omega}}.$$

Following identical steps as in the derivation for Lemma 2 one obtains $\frac{\partial p}{\partial L} = \omega \frac{\partial p_\omega}{\partial L_\omega}$, which proves the part (i) of the proposition.

For part (ii), the asset price in autarky is:

$$p_\omega = \frac{R}{1+\gamma(\eta)} - \frac{q}{1-q}(c - l_\omega^{NP}).$$

In the national planner equilibrium one obtains:

$$p^{NP} = R - \frac{q}{1-q}(c - L^{NP}).$$

Therefore:

$$\Delta p = p_\omega - p^{NP} = \underbrace{\left(\frac{R}{1+\gamma(\omega)} - R\right)}_{<0} + \frac{q}{1-q}\underbrace{\left(l_\omega^{NP} - L^{NP}\right)}_{>0}.$$

The first bracket is negative because $\gamma'(\omega) < 0$, $\gamma(1) = 0$ and $\omega < 1$. The second bracket is positive as demonstrated in Proposition 2. Fire-sales (x_ω^S) are decreasing in the asset price, and therefore inherit the same trade-off as Δp.

Regarding part (iii), the change in welfare (ΔW_ω) is:

$$\Delta W_\omega \approx \underbrace{\frac{\partial W_\omega}{\partial \gamma}}_{<0} \Delta\gamma + \underbrace{\frac{\partial W_\omega}{\partial p}}_{>0} \Delta p.$$

The negative sign of the first partial derivative directly follows from the negative wealth effect from limited financial market depth. The positive sign of the second partial derivative holds as a higher asset price reduces fire-sales (see derivation of Proposition 4).

Given the different incentives to regulate in autarky (part (i)), the regulator will choose a different l_ω than in the national planer equilibrium. However l_ω^{NP} is still available. A small $\Delta\gamma$ and $\Delta p > 0$ is therefore sufficient. ∎

Proof of Proposition 9: If $\omega > \overline{\overline{\omega}}$, then $W_{1-\omega}^{FR} > W_{1-\omega}^{CO}$ according to Proposition 3. Further, if $\omega \to 1$, then $W_{1-\omega}^{CO} > W_{1-\omega}^{AU}$ based on Lemma B1. Now consider the more general case with $\omega \in (\overline{\overline{\omega}}, 1)$. Suppose that $\gamma = 0$. Without any gains from financial market depth, the Law of Large Numbers, and because the planner internalizes the entire remaining externality in autarky, one can verify that $l_{1-\omega} = l^{GP}$. To see this, notice that when $\gamma = 0$, market clearing and the first order condition in autarky imply:

$$\underbrace{(1-q)(1-\omega)\phi'^{-1}\left(\frac{p_{1-\omega}}{R}\right)}_{X^D_{1-\omega}} = \underbrace{q(1-\omega)\frac{c-l_{1-\omega}}{p_{1-\omega}}}_{X^S_{1-\omega}},$$

and

$$p_{1-\omega} = p^{CE}\left[1+\frac{c-l_{1-\omega}}{R}\frac{\partial p}{\partial L}\left[\frac{1}{\phi'(x^D_{1-\omega})}-1\right]\right].$$

These conditions are equivalent to a global planner, which immediately implies that $l_{1-\omega} = l^{GP}$ and $p_{1-\omega} = p^{GP}$. In other words, the 1-ω-planner would implement the constrained efficient allocation. Therefore:

$$W^{AU}_{1-\omega|\gamma=0} = (1-\omega)W^{GP}.$$

Further:

$$\frac{\partial W^{AU}_{1-\omega}}{\partial\gamma} = \underbrace{\frac{\partial W^{AU}_{1-\omega}}{\partial\gamma}}_{<0} + \underbrace{\frac{\partial W^{AU}_{1-\omega}}{\partial p_{1-\omega}}}_{>0}\underbrace{\frac{\partial p_{1-\omega}}{\partial\gamma}}_{<0} + \left(\underbrace{\frac{\partial W^{AU}_{1-\omega}}{\partial p_{1-\omega}}\frac{\partial p_{1-\omega}}{\partial l_{1-\omega}} + \frac{\partial W^{AU}_{1-\omega}}{\partial l_{1-\omega}}}_{=0}\right)\frac{\partial l_{1-\omega}}{\partial\gamma}.$$

The signs for the first two terms follow from derivations related to Proposition 7. The term in the parenthesis is zero, as it corresponds to the first order condition of a regulator with respect to liquidity in autarky. Therefore, $W^{AU}_{1-\omega|\gamma>0} < (1-\omega)W^{GP}$, which proves $W^{CO}_{1-\omega} > W^{AU}_{1-\omega}$ in the more general case when $\omega \in (\overline{\overline{\omega}}, 1)$. ∎

E. Appendix: Section 5

Variables and Data Sources

Banking Crisis: Binary indicator equal to 1 if a country experienced (at least) one systemic banking crisis since 1990, otherwise 0. (Source: Laeven and Valencia (2018) and author's calculation)

Basel II and III Index: The indices count the number of implemented Basel II and III standards in a given year.[23] The survey reports 5 distinct responses: 1. "Draft regulation not published", 2. "Draft regulation published", 3. "Final rule published", 4. "Final rule in force", 5. "Not applicable". The indices are constructed as the sum of categories with a "Final rule in force". Surveys were conducted in 2004, with follow-ups in 2006, 2008, 2010, 2013 and 2015. The last two surveys also contain information on Basel III. (Source: BIS (2015) and author's calculation)

Capital Controls: The index measures overall restrictions among all asset groups and inflow/outflows. (Source: Fernández et al. (2016))

Concentration: The variable is defined as the asset value from the three largest banks relative to the assets of all commercial banks in %. (Source: Beck et al. (2010))

Credit: Domestic credit to private sector by banks in constant 2010 USD. (Source: World Bank, and author's calculation)

GDP: Series in constant 2010 USD. (Source: World Bank)

Institutional Quality: Index is the sum over all 12 political risk categories from the International Country Risk Guide. (Source: The PRS Group)

Regulatory Governance: Extracted from the Global Indicators of Regulatory Governance. The comprehensive index is measured on a scale from 0 to 5, where 5 means best practices. (Source: World Bank)

ROA: Bank return on assets defined as net income over total assets in %. (Source: Beck et al. (2010))

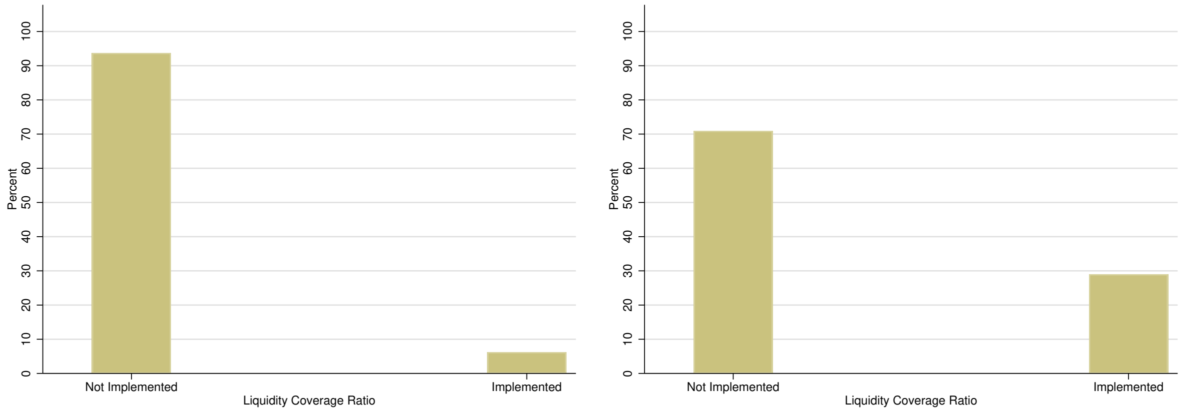
Background on the Basel Agreements: The Basel II Accord was initially published in June 2004 and focused on minimum bank capital requirements related to credit, market, and operational risk (Pillar 1), supervisory oversight (Pillar 2) and policies regarding the public disclosure of important information (Pillar 3). Basel III was agreed upon in 2010, but its implementation was delayed. In 2015, the last year of survey data, non-member countries were still in the process to implement the guidelines (Figure E4). The agreement extends Basel II primarily by countercyclical capital buffers and liquidity regulation.

[23]Basel II has 10 subcomponents. The first eight components are related to Pillar 1: (i) standardized approach to credit risk, (ii) foundation internal ratings-based approach to credit risk, (iii) advanced internal ratings-based approach to credit risk, (iv) basic indicator approach to operational risk, (v) standardized approach to operational risk, (vi) advanced measurement approach to operational risk, (vii) standardized measurement method for market risk, and (viii) internal models approach to market risk. The remaining two components are (ix) Pillar 2 (Supervision), and (x) Pillar 3 (Market Discipline). Basel III is composed of 8 subcomponents: (i) liquidity standard, (ii) definition of capital, (iii) risk coverage, (iv) capital conservation buffer, (v) countercyclical capital buffer, (vi) leverage ration, (vii) domestic systemically important banks, and (viii) global systemically important banks.

Liquidity Coverage Ratio: Figure E1 splits the adherence to the Liquidity Coverage Ratio (Basel III) by countries with large and small financial sectors (proxied by domestic credit). As apparent, the share of countries that implemented the Liquidity Coverage Ratio (vertical axes) is considerably higher among high credit countries compared to low credit countries (29% versus 6%).

Figure E1: *Liquidity Coverage Ratio: Implementation as of 2015*

(a) *Low Credit Countries* ***(b)*** *High Credit Countries*



Notes: *Vertical axes display the share of Basel non-member countries (in %) that implemented/did not implement the Liquidity Coverage Ratio (Basel III). Panel (a) (Panel (b)) considers countries with low (high) domestic credit to the private sector by banks (in constant USD, threshold based on median) as a proxy for the size of the domestic banking sector.*

This difference is further highly statistically significant as Table E1 emphasizes. A two-sample proportions test rejects the Null hypothesis of equal Liquidity Coverage Ratio implementation among high and low credit countries with a p-value of 0.02.

Table E1: *Liquidity Coverage Ratio: Two-sample Proportions Test*

	Difference	SE	z-statistic	p-value
Liquidity Coverage Ratio	-0.23	0.10	-2.38	0.02

Notes: Null hypothesis: Equal likelihood for liquidity regulation among high and low credit countries. The first column displays $p_L - p_H$, where p_i, $i \in \{L, H\}$ denotes the share of countries that implemented liquidity regulation among low and high credit countries. The second column presents the corresponding pooled standard error. The z-statistic is defined as $z = \frac{p_L - p_H}{SE}$.

Additional Tables and Figures

Table E2: *Robustness: Credit versus Credit to GDP Ratio - Basel II*

	(1)	(2)	(3)
Avg. Credit	1.06^{***}		0.67^{**}
	(0.27)		(0.32)
Avg. Credit/GDP		0.04^{***}	0.03^{*}
		(0.01)	(0.01)
Pseudo R^2	0.06	0.06	0.08
Observations	63	63	63

Notes: Ordered Logit Regressions. Dependent variable: Basel II Index as of 2015. The independent variables represent averages (Avg.) over the 2003-2015 period. Credit is standardized. Credit/GDP is measured in %. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

Table E3: *Robustness: Credit versus Credit to GDP Ratio - Basel III*

	(1)	(2)	(3)
Avg. Credit	0.67^{***}		0.56^{**}
	(0.21)		(0.23)
Avg. Credit/GDP		0.02^{**}	0.01
		(0.01)	(0.01)
Pseudo R^2	0.05	0.03	0.05
Observations	63	63	63

Notes: Ordered Logit Regressions. Dependent variable: Basel III Index as of 2015. The independent variables represent averages (Avg.) over the 2003-2015 period. Credit is standardized. Credit/GDP is measured in %. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

Table E4: *Robustness: Basel Implementation, Capital Controls and Banking Sector Size*

	(1)	(2)	(3)
Avg. Capital Controls	0.32	0.54	
	(0.81)	(0.78)	
Avg. Credit			0.01
			(0.05)
Pseudo R^2	0.00	0.00	
Observations	43	43	43

Notes: Column 1: Ordered Logit Regression – Dependent variable is the Basel II Index as of 2015. Column 2: Ordered Logit Regression – Dependent variable is the Basel III Index as of 2015. Column 3: OLS Regression – Dependent variable is the Avg. Capital Control Index over the 2003-2015 period. The independent variables represent averages (Avg.) over the 2003-2015 period. Credit is standardized. Capital Controls vary between 0 and 1, where 1 represents tight controls. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

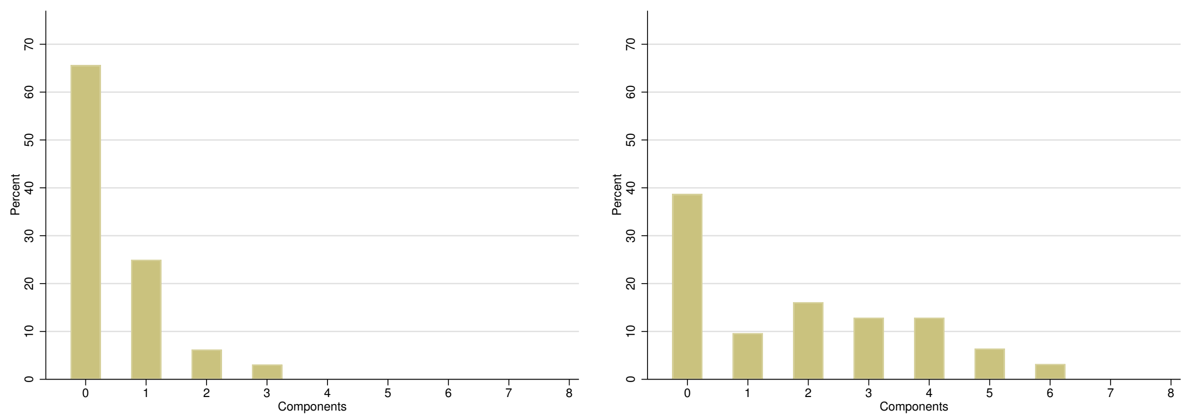
Table E5: *Adherence to Basel II Standards: Pooled Ordered Logit Regression Results*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Credit	0.81***						0.82***	1.02***	0.80***
	(0.09)						(0.09)	(0.12)	(0.14)
Banking Crisis		0.12					0.07	-0.27	0.07
		(0.14)					(0.19)	(0.23)	(0.19)
Inst. Quality			0.14				-0.13	-0.14	-0.12
			(0.09)				(0.10)	(0.13)	(0.11)
ROA				-0.17			-0.10	-0.35***	-0.10
				(0.16)			(0.27)	(0.13)	(0.27)
Concentration					-0.00		0.01**	0.03***	0.01**
					(0.00)		(0.01)	(0.01)	(0.01)
GDP						0.62***			0.02
						(0.09)			(0.12)
Pseudo R^2	0.04	0.00	0.00	0.00	0.00	0.03	0.05	0.12	0.05
Countries	All	All	All	All	All	All	All	Open	All
Observations	749	756	660	740	717	756	630	354	630

Notes: Dependent variable: Basel II Index. The Banking Crisis indicator is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) excludes economies with tight capital controls. Observations are pooled over the period 2004-2015. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

Figure E2: *Basel III Implementation for Non-members as of 2015*

(a) *Low Credit Countries* **(b)** *High Credit Countries*



Notes: *The vertical axes portray the share of countries (in %) that implemented a specific number of Basel III components. Panel (a) (Panel (b)) considers countries with low (high) domestic credit to the private sector by banks (in constant USD, threshold based on median) as a proxy for the size of the domestic banking sector.*

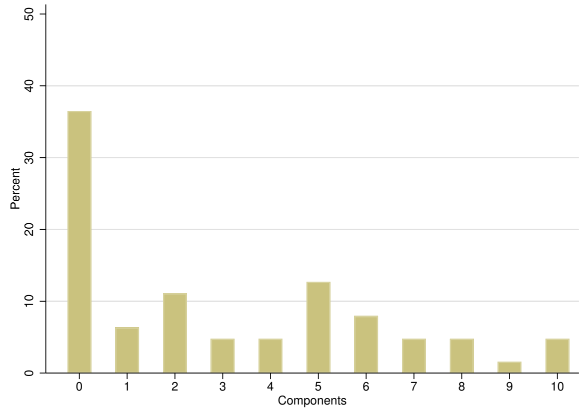
Table E6: *Adherence to Basel III Standards: Pooled Ordered Logit Regression Results*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Credit	0.38***						0.35***	0.35***	0.41**
	(0.09)						(0.10)	(0.10)	(0.19)
Banking Crisis		0.76***					0.47*	0.04	0.46
		(0.25)					(0.29)	(0.39)	(0.28)
Inst. Quality			0.27				0.08	0.13	0.05
			(0.16)				(0.18)	(0.21)	(0.18)
ROA				0.01			0.01	-0.33	0.01
				(0.01)			(0.01)	(0.27)	(0.01)
Concentration					0.01		0.01	0.01	0.01
					(0.01)		(0.01)	(0.01)	(0.01)
GDP						0.30***			-0.08
						(0.10)			(0.22)
Pseudo R^2	0.03	0.02	0.01	0.00	0.00	0.01	0.04	0.06	0.04
Countries	All	All	All	All	All	All	All	Open	All
Observations	374	378	330	372	364	378	320	179	320

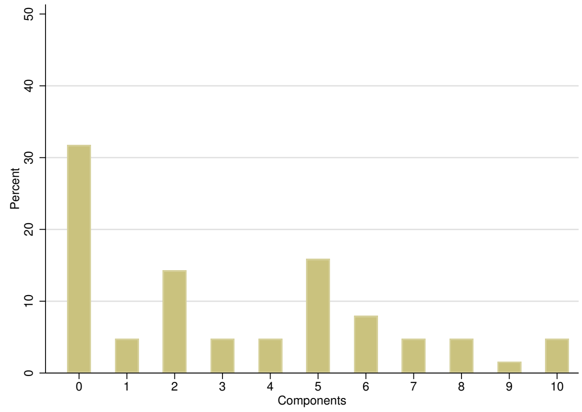
Notes: Dependent variable: Basel III Index. The Banking Crisis indicator is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) excludes economies with tight capital controls. Observations are pooled over the period 20010-2015. Huber-White robust standard errors are reported in parenthesis. Stars indicate significance levels (*10%, **5%, ***1%).

Figure E3: *Basel II Implementation during the Years 2012-2015*

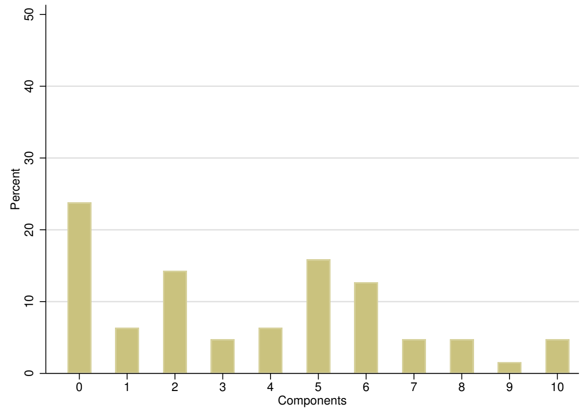
(a) Year 2012



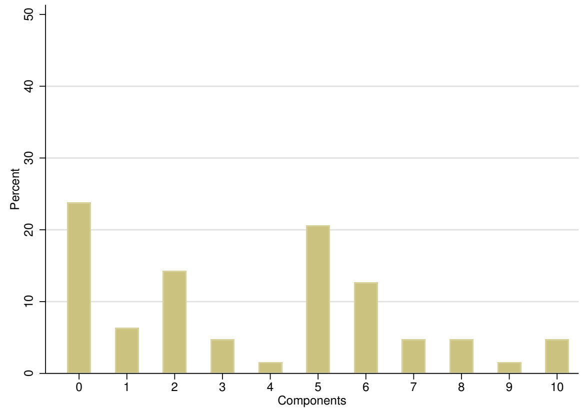
(b) Year 2013



(c) Year 2014



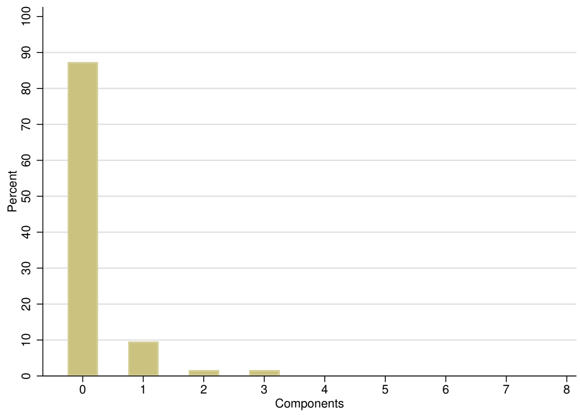
(d) Year 2015



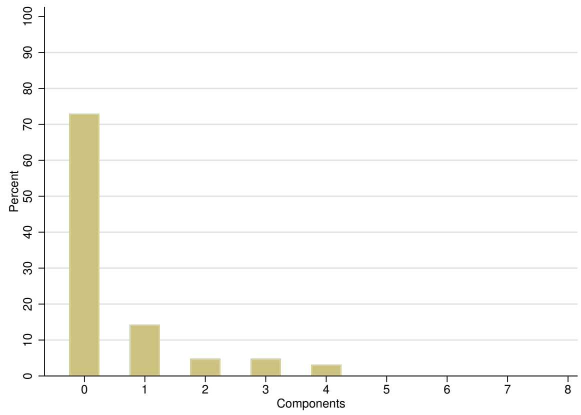
Notes: *The graphs display the cross-sectional distribution of the Basel II Index. The vertical axes portray the share of countries (in %) that implemented a specific number of Basel II components during the years 2012-2015.*

Figure E4: *Basel III Implementation during the Years 2012-2015*

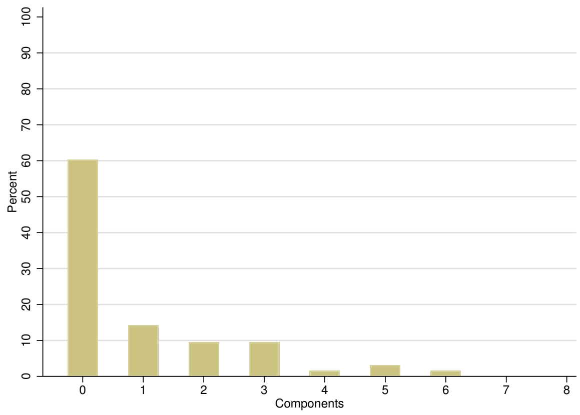
(a) *Year 2012*



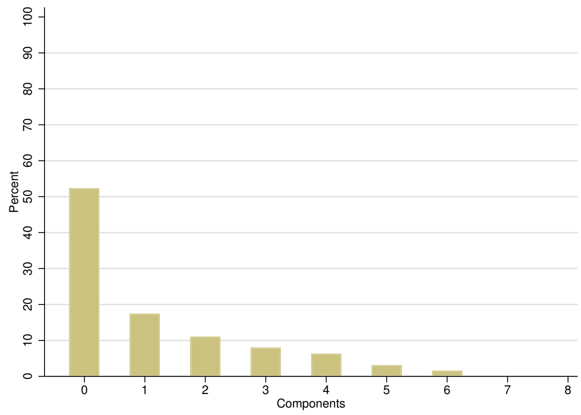
(b) *Year 2013*



(c) *Year 2014*



(d) *Year 2015*



Notes: *The graphs display the cross-sectional distribution of the Basel III Index. The vertical axes portray the share of countries (in %) that implemented a specific number of Basel III components during the years 2012-2015.*

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