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International Financial Regulation: The Role of Banking Sector Sizes

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November 2021; updated July 2024

RWP 21-13

http://doi.org/10.18651/RWP2021-13

This paper supersedes the old version:

"International Spillovers, Macroprudential

Coordination, and Capital Controls"

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International Financial Regulation: The Role of Banking Sector Sizes*

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Working Paper

July 10, 2024

Abstract

This paper presents a simple *N* 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, countries with a smaller banking sector internalize less of the inefficiency and have an incentive to free-ride on foreign regulation. As a consequence, countries cannot agree on common regulatory standards. Further, small countries have a strictly positive marginal cost to regulate, which can also prevent coordination on non-harmonized standards. An empirical section demonstrates that key issues around the implementation of the Basel Agreements are consistent with the implications from the model.

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

JEL: D62, F36, F42 G15, G21

^{*}I thank Paul Begin, Nicolas Caramp, Andrés Carvajal, James Cloyne, Athanasios Geromichalos, Cooper Howes, Òscar Jordà, Anton Korinek, Robert Marquez, Katheryn Russ and Alan M. Taylor for invaluable advice, feedback and comments on the paper. Further, I am grateful to comments by seminar participants at the Bank of England, Bundesbank, Federal Reserve Bank of Kansas City, University of Albany (SUNY), University of Bonn, University of Munich, 57th MVEA conference, 2020 Warwick Economics PhD Conference, 2020 EGSC, and the Virtual International Trade and Macro seminar. The views expressed in this paper are those of the author and do not necessarily represent those of the Federal Reserve Bank of Kansas City or the Federal Reserve System. Declarations of interest: none.

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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

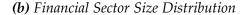
Major banking crises cause significant damage to the domestic economy and result in international spillovers. For this reason, supranational frameworks such as the Basel Initiative set regulatory standards that are meant to increase international financial resilience. Nevertheless, the implementation of the Basel guidelines has been centered around the 28 Basel member countries, even though the World Bank, IMF, and BIS urged non-member countries to adopt 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 sizable portion of the global financial market as I show in this paper. A lack of regulation in these countries could therefore affect global financial stability. 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 Agreement or the European Banking Union, which represents another international regulatory initiative.

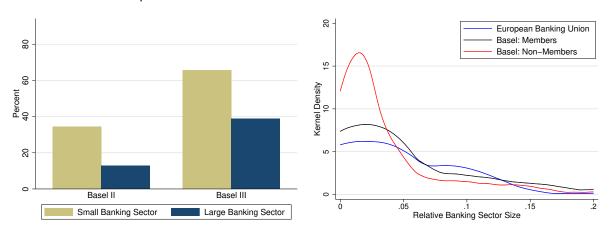
My first contribution is to rationalize why countries with larger, more developed banking sectors are more likely to regulate their financial sector, while countries with a smaller banking sector are unlikely to implement regulatory standards. The idea is that national authorities only internalize their 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 also affects the incentive of a country to coordinate on international standards.

The second contribution of this paper is to analyse the implications of size asymmetry for international regulatory agreements that improve welfare on aggregate. With different regulatory preferences, countries are generally not willing to coordinate on harmonized standards, that is, identical regulatory requirements across jurisdictions

Figure 1: Motivation

(a) Reluctance to Implement Basel Guidelines





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.

(see also Dell'ariccia and Marquez, 2006 and Kara, 2016b). If requirements are set high, countries with a small banking sector, would have to increase regulatory standards by a large amount, crowding out more profitable investments. At the same time, gains from additional regulation are limited, since financial regulation in a small country has little effects on financial stability, which is determined in an international market. Alternatively, if settling on a low regulatory burden, countries with a large banking sector would need to lower standards. This is not in line with their preferences for high regulation and also increases global financial instability. Consequently, also countries with a small banking sector are adversely affected, even though their regulatory costs decrease. Thus, if harmonized standards are lowered, both large and small countries are worse off.

In addition, I show that smaller countries may be reluctant to join a flexible, non-harmonized regulatory agreement. These type of agreements only require all participating jurisdictions to increase regulation by some amount and therefore allow smaller countries to regulate less. The intuition for this finding is as follows: In the model, a regulator sets a liquidity requirement by balancing the stabilizing effect from liquidity with the higher return from illiquid assets. The crucial point is that a small country with a low preference for regulation is not indifferent between these two choices and subject to a binding non-negativity constraint on liquidity. The perturbation argument hence does not apply: a small country has a strictly positive cost

to regulate which can outweigh the benefit from additional foreign regulation if only few foreign countries agree to coordinate. I also show that such a situation can arise due to a coordination failure in which a small country does not join the arrangement if all other small countries do not join as well, even though agreeing would be jointly welfare improving. This highlights that financial regulatory agreements are most effective at the global rather than regional level.

As an alternative to a cooperative solution, I also consider sanctions imposed by regulating countries on free-riders. Sanctions could be implemented via very tight capital controls and reduce negative spillovers from under-regulated countries, while also ensuring that free-riders cannot benefit from financial stability provided by regulating countries. Whether sanctions are welfare improving for the regulating jurisdiction depends on whether the aforementioned gains outweigh costs from reduced financial market depth. However I show that, if credible, non-cooperating countries would start to regulate in order to maintain access to international financial markets.

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. In particular, I uncover the following stylized facts: First, many Basel non-members only partially implement the Basel II and III guidelines and many countries do not follow the guidelines at all. Second, non-member countries with a larger banking sector are more likely to implement the Basel Agreements. Third, non-member countries that implement fewer policies also exert less due diligence on regulatory policies that are implemented. Fourth, a sizable share of the global financial sector is only partially regulated. The first two observations are matched in the model, the third observation is consistent with the lower incentives to regulate, while the fourth observation speaks to the relevance of financial sector size asymmetry in practice.

I evaluate coordination in a tractable multi-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 one jurisdiction affect the required fire-sales in the other jurisdictions 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 regulatory standards. As the main departure, however, I extend this literature by analyzing harmonized/non-harmonized international regulatory arrangements that do not impose the same constrained efficient level of regulation across jurisdictions. Importantly, with an international externality, but without region specific asymmetries, coordination is strictly welfare improving for national regulators. 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.

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 this paper.

On the empirical side, Jones and Zeitz (2017) also analyze the adherence to the Basel standards among non-member countries. They identify the complexity of standards and gaps in local financial market infrastructure as obstacles for a wider adoption.

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

²Empirical support for international asset fire-sales during financial crises has been articulated in, for example, 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).

In complementary work, Kara (2016a) focuses on the stringency of capital regulation – an important part of the Basel Agreements – 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. Barth et al. (2006) attribute the cross-country variation in broader bank supervisory and regulatory practices to differences in the political system.

I structure the remaining paper as follows: Section 2 lays out the model and highlights the inefficiency related to the competitive equilibrium. Section 3 characterizes the behaviour of national regulators. Section 4 discusses harmonized regulatory standards and Section 5 flexible regulatory arrangements. Section 6 analyzes sanctions. Section 7 provides empirical support for key implications from the model based on the Basel Agreements. Section 8 concludes. All derivations and additional empirical results are delegated to the online appendix.

Framework

2.1. Environment

The model features three periods t = 0, 1, 2, two assets, and two actors: investors and banks, each of measure one. Each investor is linked to one local bank. A share $\omega_i > 0$ of investors/banks resides in region i with $i \in \{1, ..., N\}$. Banks invest on behalf of investors into a short and long asset, and participate in two financial markets: a sport market for assets 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 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:

$$h'(c_{i1}) \gg 1$$
 if $c_{i1} \leq c$

$$0 < h'(c_{j1}) < 1$$
 if $c_{j1} > c$,

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 online appendix, I introduce a production technology which provides a real investment opportunity to investors in the first period. This is helpful to distinguish the size of the domestic banking sector from the size of the economy.

Initial portfolio allocation

Distressed banks

Long assets materialize
Early consumption

Lagrange Loan Market

Long assets materialize
Consumption

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 themselves ex-ante against the liquidity shock, which is a standard assumption in the literature (see, for example, Holmström and Tirole, 1998). 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 how much to invest in 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

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

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 There is no risk in these spot transactions. 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}_i) . 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 may not have enough liquidity to purchase long assets from distressed banks, despite sufficient aggregate liquidity. This scenario can arise in the national planner equilibrium where t=0portfolios are generally heterogeneous across jurisdictions. When some intact banks become constrained, aggregate demand for long assets exhibits a kink which gives rise to distinctive aggregate demand schedules, while also possibly leading to multiple equilibria. The loan market ensures that all intact banks are unconstrained regardless of the initial portfolio as long as there is enough aggregate liquidity, which is assumed throughout the paper. As a consequence, there will always be enough supply of funds on the loan market. The gross interest rate (R) on loans therefore 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. As I show later, the market is inconsequential in the sense that the competitive equilibrium is inefficient even in the presence of the loan market. Specifics on the functioning of this market, in particular how the equilibrium is determined ($\tilde{R} = 1$), are available in the online appendix.

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

⁴If $p \ge 1$, long assets provide at least the same return as short assets in t = 1. Consequently, there would be no incentive to hold short assets and the equilibrium would not exist.

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 make the following assumption about ϕ :

$$\phi(x_i^D) = ln(1 + x_i^D).$$

This specific functional form 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 pay a fee $\gamma(\eta)$ for each 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 and hence motivates the global nature of the asset market. 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 to $\gamma(1)=0$.

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

⁶Interbank 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 as follows:

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

subject to a cash-in-the-market constraint:

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

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 $l_j + \tilde{l}_j - (1 + \gamma(\eta))px_j^D$ minus loan repayments $\tilde{R}\tilde{l}_j$ 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 $\mu_j = 0 \ \forall \ j$ (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 subject to the withdrawal request. The optimization problem is summarized as:

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

subject to:

$$px_i^S + l_i \ge c \tag{2}$$

$$x_i^{\mathcal{S}} \le k_j. \tag{3}$$

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 $l_j + px_j^S - c$. 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 long assets are sold at a discount and because self-insurance is not rational, equation (2) binds. The supply of illiquid assets is hence characterized by:

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

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:

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

The variable L denotes aggregate liquidity ($\int_0^1 l_j dj$). The equilibrium is portrayed in Figure 3 (solid lines). 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. Liquidity therefore limits asset fire-sales and stabilizes the fire-sale price.⁷ 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 $\frac{\partial X(L)}{\partial L} < 0$.

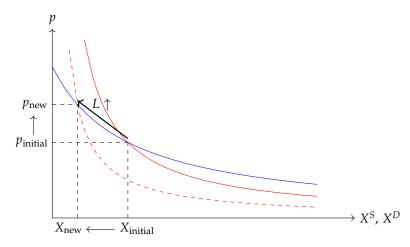


Figure 3: Period 1 Asset Market

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. These restrictions on the parameter space are assumed throughout the paper.

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

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 constrained efficient 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

⁷In an environment without abundant liquidity, asset demand would be constrained by equation (1). In this case, more liquidity would also help constrained intact banks.

best solution by allocating 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 this market. The regulator however internalizes the relationship between the initial portfolio and the equilibrium fire-sale asset price. Relative to the second best global planner allocation, a national regulator disregards the stabilizing effect of liquidity on asset prices for banks in foreign jurisdictions and therefore only partially internalizes the externality.

Competitive Equilibrium

Each bank maximizes:

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

subject to:

$$k_j + l_j = e. (5)$$

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) subject to (1) and (P1:S) subject to (2) and (3). Constraints (1) and (3) are slack in equilibrium. The asset market clears according to (4);
- 2. in period 0, banks optimally determine their portfolio $\{k^{CE}, l^{CE}\}$ according to (Po:CE) subject to (5), taking the asset price as given;
- 3. The aggregate portfolio is $K^{CE} = k^{CE}$ and $L^{CE} = l^{CE}$.

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,

⁸The 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:

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

subject to:

$$K + L = E. (6)$$

Definition: Global Planner Equilibrium

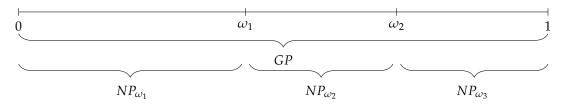
- 1. In period 1, intact and distressed banks optimally choose their demand and supply $\{x_j^D, x_j^S\}$ according to (P1:D) subject to (1) and (P1:S) subject to (2) and (3). Constraints (1) and (3) are slack in equilibrium. The asset market clears according to (4);
- 2. in period 0, the global planner optimally determines the aggregate portfolio $\{K^{GP}, L^{GP}\}$ according to (Po:GP) subject to (6). The planner internalizes the dependency between the asset price and aggregate liquidity;
- 3. 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 oligopoly 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 a national planner setup with three jurisdictions to a single global planner. In terms of notation, the national regulator from jurisdiction i, also simply referred to as jurisdiction i, supervises a share ω_i of banks with $0 < \omega_i < 1$.

Figure 4: Global Planner vs. National Planners



With this in mind, jurisdiction *i* maximizes:

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

subject to:

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

 K_{ω_i} and L_{ω_i} refer to the aggregate amount of long and short assets in jurisdiction i.

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) subject to (1) and (P1:S) subject to (2) and (3). Constraints (1) and (3) are slack in equilibrium. The asset market clears according to (4);
- 2. in period 0, national planners interact in a Cournot oligopoly and determine their aggregate portfolios $\{K_{\omega_i}^{NP}, L_{\omega_i}^{NP}\}$ according to (Po:NP) subject to (7). National planners internalize the dependency between the asset price and domestic aggregate liquidity;
- 3. Each bank in the same jurisdiction receives the same portfolio and the aggregate portfolio is defined by $L^{NP} = \sum_i L^{NP}_{\omega_i} = \sum_i \omega_i l^{NP}_{\omega_i}$ and $K^{NP} = \sum_i K^{NP}_{\omega_i} = \sum_i \omega_i k^{NP}_{\omega_i}$.

Costs and Benefits from Liquidity

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

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

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 from 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

This section describes the portfolio choices of banks and planners respectively. First, I compare aggregate portfolios, which highlight the inefficiency of the national planner and competitive equilibrium. Then, I analyze how the bank-specific liquidity provision of a national planner varies with the banking sector size. The insights from this section underline the incentives of national regulators to agree to international regulatory initiatives, which I discuss in subsequent sections.

Aggregate Liquidity

Proposition 1: (Aggregate Liquidity)

- (i) 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: $L^{GP} > L^{NP} > L^{CE}$.
- (ii) More jurisdictions reduce aggregate liquidity in the national planner equilibrium when all jurisdictions are unconstrained by the non-negativity requirement on liquidity: $L^{NP}(N_1) > L^{NP}(N_2)$ when $N_2 > N_1$ and if $l_{\omega_i}^{NP} > 0 \ \forall i$.

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 and banks invest excessively in the long (illiquid) asset, which reduces the fire-sale price of the asset (Lemma 1). Further, independent domestic regulation is also inefficient in an environment with international spillovers. 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. However, with more jurisdictions, each jurisdiction on average internalizes a smaller share of the externality, hence aggregate liquidity

⁹This 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.

decreases as the number of jurisdiction increases.¹⁰

Bank-Specific Liquidity

How much liquidity do national planners allocate to individual banks and how does that choice depend on the financial sector size? The next proposition summarizes a key insight from this paper.

Proposition 2: (Free-Riding)

Consider two jurisdictions (i,k) with $\omega_i > \omega_k$. Then $l_{\omega_i}^{NP} > l_{\omega_k}^{NP}$ if $l_{\omega_i}^{NP} > 0$.

A jurisdiction with a larger banking sector tilts the bank-specific portfolio towards liquid assets. What drives this result? More influence on international asset markets grants planners more impact on equilibrium prices. By itself this does not justify regulation. However, due to the global aspect of the pecuniary externality, larger jurisdictions internalize more of the inefficiency, which effectively increases the regulator's marginal return on liquid assets. That aside, it is not guaranteed that jurisdictions choose a positive amount of liquidity. Lemma 3 formally establishes the existence of a corner solution which is tied to the non-negativity constraint on liquidity.

Lemma 3 The national planner equilibrium features a corner solution where $l_{\omega_i}^{NP} = 0$ when $\omega_i \leq \overline{\omega}(\{\omega_k\}_{k \neq i}^N)$.

According to Lemma 3 there is a threshold $\overline{\omega}$ below which a jurisdiction has no incentive to provide liquidity. In other words, small jurisdictions provide zero liquidity. The threshold depends on the model specification, that is, the number of jurisdictions, as well as the banking sector size distribution. Intuitively, the willingness of a regulator to provide liquidity is a function of the liquidity provision by *all* other jurisdictions. Aggregate liquidity in turn depends on the number of jurisdictions as well as their size distribution. In order to keep the notation parsimonious, I will simply refer to this threshold as $\overline{\omega}$.

The liquidity provision of national regulators is illustrated in Figure 5 and 6. Figure 5 focuses on a two country variant of the model, while Figure 6 emphasizes how allocations change in a three country version. In more detail, Figure 5 displays bank-specific allocations as the relative banking sector size $\omega_1 = 1 - \omega_2$ varies from 0 to 1. The solid line depicts the amount of liquidity chosen by both national planners for each of their banks $\{l_{\omega_1}^{NP}, l_{\omega_2}^{NP}\}$. The two dots represent the global planner and competitive equilibrium. As mentioned in Proposition 1, a global planner provides

¹⁰This result does not hold in a corner solution. To see this, suppose N=3 and that two jurisdictions provide zero liquidity. If their joint size equals the size of a jurisdiction who provides zero liquidity when N=2, then aggregate liquidity coincides in both scenarios.

on aggregate strictly more liquid assets than national planners, who in turn jointly provide strictly more liquidity than banks in the competitive equilibrium. Looking at the solid line, it becomes apparent that jurisdiction 1 tilts its portfolio towards liquid assets when ω_1 increases. The chart also illustrates the corner region, in which one planner provides zero liquidity. Hence, it can be optimal to fully rely on foreign liquidity provision. Last but not least, a larger planner may provide more bank-specific liquidity than a global planner, though this result depends on the specific calibration of the model. This surprising result can emerge due to the 'public goods property' of liquidity, which implies that domestic and foreign liquidity are substitutes (see Lemma C1 in the online appendix): If constrained by the non-negativity requirement on liquidity, the smaller jurisdiction can no longer substitute away from foreign liquidity. In turn, the large jurisdiction does not have to increasingly subsidize the smaller jurisdiction and is able to reduce bank-specific liquidity. This feature introduces a notion of over-regulation and is illustrated by the section of the red line outside the dashed square.

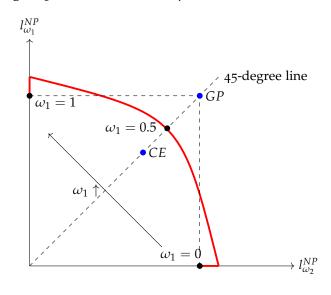


Figure 5: National Planner Equilibria: Two Jurisdictions

Notes: The solid line depicts optimal bank-specific liquidity $\{l_{\omega_1}^{NP}, l_{\omega_2}^{NP}\}$ by national planners as a function of the relative banking sector size $\omega_1 = 1 - \omega_2$ in a two country variant. The competitive (CE) and global planner equilibrium (GP) are marked for comparison. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

Figure 6 displays how the liquidity provision of a jurisdiction – in this case jurisdiction 1 – changes as a third country is added to the model. The solid red line portrays bank-specific liquidity in a two country equilibrium, while the dashed red line presents the same variable in a three country variant. The size of jurisdiction 3 is set to 0.2 in the three country illustration, at which it provides a positive, though limited amount of liquidity. The horizontal axis portrays the banking sector size of

jurisdiction 1. As before, a larger jurisdiction 1 coincides with a smaller jurisdiction 2.

Starting with bank-specific liquidity in the two country model, the solid red line in Figure 6 mirrors the red line from Figure 5: When ω_1 is close to zero, the liquidity constraint binds, after which jurisdiction 1 increases bank-specific liquidity. As jurisdiction 2 becomes constrained, jurisdiction 1 is able to reduce bank-specific liquidity. Relative to this benchmark, jurisdiction 1 in a three country variant provides weakly more liquidity per-bank for the same level of ω_1 . This is because the remaining two jurisdictions provide *less* liquidity on aggregate relative to one foreign jurisdiction of size $\omega_2 + \omega_3$, which increases the marginal benefit from liquidity for jurisdiction 1. Aggregate liquidity across all jurisdictions however remains lower in the three country model in line with Proposition 1. Further, when $\omega_1 = 1 - \omega_3$, the dashed red line intersects the solid red line and the framework collapses to a two country framework.

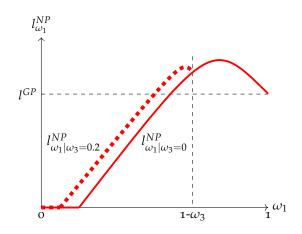


Figure 6: Liquidity Provision with Two or Three Jurisdictions

Notes: The chart portrays the bank-specific liquidity provision of jurisdiction 1 as a function of the relative financial sector size ω_1 . The chart plots liquidity in a two (solid line; $\omega_3 = 0$) and three country model (dashed line; $\omega_3 = 0.2$). Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

Implementation of Regulatory Standards

The distinctive valuation of liquidity 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 period 0, that is, prior to the liquidity crisis, and address systemic risk in financial markets. Because I focus on characterizing 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.

4. Coordination on Harmonized Standards

The last section highlighted the importance of domestic banking sector sizes. In particular, countries with a smaller banking sector prefer lower regulatory standards since they have less exposure to a fire-sale externality that operates through an international financial market. However, because domestic financial markets are interlinked with foreign markets, the analysis also emphasized that financial stability increases with a wholistic global approach to regulation.

This section builds on the previous analysis and evaluates whether *all* national regulators would be willing to agree on harmonized, that is, common standards across jurisdictions. I relax this restrictive assumption in Section 5.

Definition: Harmonized standards represent identical regulatory standards imposed on each bank in each participating jurisdiction.

I first consider a harmonized standard that mandates the constrained efficient global planner level of liquidity l^{GP} for each bank in each jurisdiction, which is a natural benchmark for coordination. The conclusion is that smaller jurisdictions are not willing to coordinate on this benchmark and prefer to free-ride. Towards the end of this section, I analyze less restrictive harmonized standards. However, even though such standards impose a lower burden on smaller jurisdictions, both larger *and* smaller jurisdictions are worse off.

It is a well-known fact that each national planner has an incentive to deviate from cooperation. In other words, such agreements are not a Nash equilibrium. For this reason, I assume the existence of a commitment mechanism which ensures that national planners cannot deviate once they 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.

I define gains from cooperation for an individual bank in jurisdiction i as \triangle_{ω_i} . Gains from cooperation on the global planner benchmark for a bank in jurisdiction i therefore correspond to:

$$\triangle_{\omega_i}^{GP} = W^{GP*} - W_{\omega_i}^{NP*} / \omega_i.$$

The star symbol (*) indicates that W^{GP} and W^{NP} are evaluated at its optimized value l^{GP} and $l_{\omega_i}^{NP}$ respectively. With this specific contract, welfare gains (or losses) for a

bank correspond to the difference between welfare in the global planner and the national planner equilibrium appropriately scaled to the size of an individual bank. Cooperation is only feasible if $\Delta_{\omega_i}^{GP}>0$ \forall *i*. It is worth stressing that aggregate gains from coordinating on the constrained efficient global planner benchmark are by construction positive, that is, $\sum_i \omega_i \Delta_{\omega_i}^{GP}>0$. However as I show in the following proposition, the benefits from an agreement are disproportionately distributed, which may ultimately prevent coordination on this harmonized standard.

Proposition 3 (Coordination on Constrained Efficient Harmonized Standard)

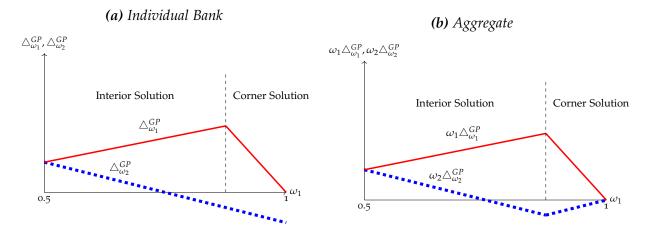
- (i) Jurisdictions of similar size are willing to coordinate on l^{GP} , that is, if $\omega_i \in [\frac{1}{N} \epsilon; \frac{1}{N} + \epsilon]$ with $\overline{\epsilon} > \epsilon > 0$, then $\triangle_{\omega_i}^{GP} > 0 \ \forall i$.
- (ii) Banking sector size asymmetry prevents an agreements on l^{GP} , as small jurisdictions prefer to free-ride. Thus, if $\omega_i > \underline{\omega}(\{\omega_k\}_{k \neq i}^N)$, then $\triangle_{\omega_k}^{GP} < 0 \ \forall \ k \neq i$.

The first part of the proposition states that all jurisdictions would be willing to coordinate if they are of similar size: Jurisdictions of similar size have similar preferences in the absence of other asymmetries. Because the global planner solution is constrained efficient, all jurisdictions gain a similar amount from coordination. The second part emphasizes that if jurisdictions are of different size, small jurisdictions have no incentive to introduce regulatory requirements consistent with the constrained efficient benchmark. Intuitively, a smaller jurisdiction would be required to increasingly scale up less profitable liquid investments relative to the national planner equilibrium, while the jurisdiction has an increasingly smaller impact on the equilibrium asset price and hence overall financial stability.¹¹

I subsequently illustrate the proposition in a two country variant of the model. Figure 7, Panel (a) displays welfare gains for individual banks within each jurisdiction $\{\triangle^{GP}_{\omega_1}, \triangle^{GP}_{\omega_2}\}$ as ω_1 expands from 0.5 (symmetry) to 1, while Panel (b) displays aggregate welfare gains for each jurisdiction $\{\omega_1 \triangle^{GP}_{\omega_1}, \omega_2 \triangle^{GP}_{\omega_2}\}$. If both banking sectors are of similar size, both jurisdictions gain a similar amount by coordinating their regulatory efforts, that is, $\Delta^{GP}_{\omega_1}>0$ and $\Delta^{GP}_{\omega_2}>0$. A country with a small financial sector is less willing to adopt global standards. 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 (b)). This effect is purely driven by the aggregation of an increasingly smaller share of banks in jurisdiction 2.

¹¹The threshold $\underline{\omega}$ depends on the number of countries and their size distribution. Both factors determine aggregate liquidity, which affects the incentive of a jurisdiction to invest into liquid assets/regulate.

Figure 7: Two Countries: Coordination on Global Planner Benchmark



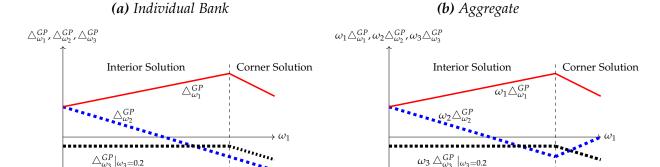
Notes: Panel (a) shows gains from cooperation for individual banks of each jurisdiction $\{\triangle_{\omega_1}^{GP}, \triangle_{\omega_2}^{GP}\}$ as a function of the relative financial sector size ω_1 . ω_1 varies from 0.5 (symmetry) to 1. Panel (b) displays gains from cooperation for jurisdictions $\{\omega_1 \triangle_{\omega_1}^{GP}, \omega_2 \triangle_{\omega_2}^{GP}\}$. The solid (dashed) line refers to jurisdiction 1 (2). The corner region corresponds to equilibria where $l_{\omega_2}^{NP} = 0$. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

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 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. 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_1 approaches 1, the Cournot solution of the large national planner converges to the solution of a single global planner and gains from cooperation vanish.

Figure 7, Panel (b) 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. However, this conclusion does not generalize to multiple free-riding countries with a small financial sector which combined aggregate to a non-trivial financial sector.

Figure 8 illustrates the welfare effects from agreeing on the global planner benchmark in a three country model. Similar to the previous chart, I vary the size of jurisdiction 1, in this case from $(1 - \omega_3)/2$ to $1 - \omega_3$. The size of jurisdiction 3 is held constant at 0.2 at which it provides a positive but small amount of liquidity. There are

Figure 8: Three Countries: Coordination on Global Planner Benchmark



Notes: Panel (a) shows gains from cooperation for individual banks of each jurisdiction $\{\triangle_{\omega_i}^{GP}\}_{i=1}^3$ as ω_1 varies from $(1-\omega_3)/2$ to $1-\omega_3$. ω_3 is held constant throughout the exercise at 0.2. Panel (b) displays aggregate gains from cooperation for jurisdictions $\{\omega_i \triangle_{\omega_i}^{GP}\}_{i=1}^3$. The corner region corresponds to equilibria where $l_{\omega_2}^{NP} = 0$. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

hence two free-riders. As before, Panel (a) displays welfare gains for each bank in a jurisdiction, while Panel (b) portrays aggregate welfare effects for each jurisdiction. The charts provide two takeaways: First, there is no ω_1 that would make all three jurisdictions better off with coordination. The reason for this outcome is the relatively small size of jurisdiction 3 which would always want to free-ride. Second and also in contrast to the two country variant, aggregate welfare gains do not converge to zero as ω_1 increases. This is because there is always a critical mass of free-riders ($\omega_2 + \omega_3 > 0$). In Section 7, I will argue that this is the empirically relevant case.¹²

Less Stringent Harmonized Standards

The harmonized standard previously discussed required all jurisdictions to implement the constrained efficient level of regulation. This maximizes aggregate welfare, but small jurisdictions have no incentive to adhere to such an agreement. They would have to increase regulation substantially, while benefits in terms of global financial stability are limited. I now consider harmonized standards more generally. In terms of notation, I define l^h as the particular harmonized standard that is implemented in every jurisdiction. l^h satisfies $l^{CE} < l^h \le l^{GP}$. Further, $W^h_{\omega_i}$ refers to welfare in jurisdiction i when l^h is implemented and $\Delta^h_{\omega_i}$ measures the change in welfare for a bank in jurisdiction i relative to no cooperation, that is:

Tagains from cooperation for jurisdiction 3 decrease when $l_{\omega_2}^{NP} = 0$. This feature emerges because the increase in $L_{\omega_1}^{NP}$ is no longer offset by a reduction in $L_{\omega_2}^{NP}$, which increases overall liquidity outside jurisdiction 3. In turn, $l_{\omega_3}^{NP}$ and the incentive to cooperate decline.

 $^{^{13}}$ The lower bound guarantees sufficient liquidity, which is necessary for the functioning of the asset market (Lemma 2). The upper bound is without loss of generality: a small jurisdiction refuses to coordinate on l^{GP} (Proposition 3) and has no incentive to impose even tighter standards.

$$\triangle_{\omega_i}^h = \left(W_{\omega_i}^h - W_{\omega_i}^{NP*}\right)/\omega_i.$$

The next Lemma highlights that less stringent harmonized standards are generally worse than a harmonized standard that implements the constrained efficient level of regulation.

Proposition 4 (Less Stringent Harmonized Standards)

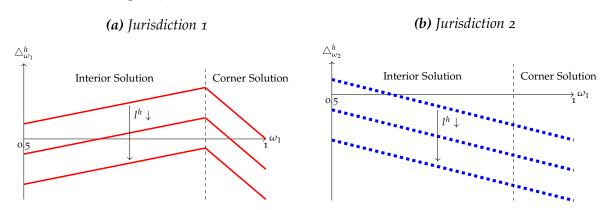
- (i) Aggregate welfare increases with more stringent harmonized standards: $\frac{\partial \sum_i \omega_i W_{\omega_i}^h}{\partial l^h} > 0$ if $l^h < l^{GP}$.
- (ii) Small and large jurisdictions do not want to cooperate: If $\omega_i > \underline{\underline{\omega}}(l^h, \{\omega_k\}_{k \neq i}^N)$ for one i and if $l^h < l^{GP}$, then $\triangle_{\omega_i}^h < 0 \ \forall \ i$.

The Lemma has several takeaways. First, less stringent harmonized standards reduce aggregate welfare. This naturally limits the scope for welfare gains in each jurisdiction. Importantly, just as with the constrained efficient harmonized standard, there continues to be a asymmetry threshold $\underline{\underline{\omega}}$ beyond which cooperation is no longer desirable for small jurisdictions , but if $l^h < \overline{l^{GP}}$, the contract is also not desirable for large jurisdictions: Less stringent requirements impose a cost for a large jurisdiction, which would want to regulate more. At the same time, financial stability declines relative to the constrained efficient harmonized standard and possibly even relative to no cooperation, which reduces welfare in the small jurisdiction through equilibrium fire-sale price effects. These costs are somewhat offset by the lower regulatory burden. However, as highlighted in Lemma 3, a small jurisdiction would prefer to regulate even less. Hence, on net, welfare for small and large jurisdictions declines relative to no cooperation if asymmetries are pronounced.

The results from Proposition 4 are illustrated in Figure 9. The chart displays welfare gains for individual banks in a two country variant of the model as ω_1 expands from 0.5 (symmetry) to 1. The lines in each panel correspond to different harmonized standards l^h . Clearly, as l^h declines, welfare gains from harmonized standards vanish for jurisdiction 1 (Panel (a)) and jurisdiction 2 (Panel (b)). If l^h is close to l^{CE} neither country would want cooperate regardless of the size asymmetry. In this case, regulation would be below the no cooperation benchmark and – if countries are of similar size – below their preferred level of regulation. As size asymmetry increases, the small country prefers to regulate less than l^{CE} and additional requirements become a burden.

¹⁴The threshold $\underline{\underline{\omega}}$ depends on the number of jurisdictions as well as their size distribution similar to the threshold $\underline{\underline{\omega}}$ related to the constrained efficient harmonized standard. The threshold also varies with l^h . A lower l^h reduces aggregate welfare gains and therefore decreases $\underline{\underline{\omega}}$.

Figure 9: Two Countries: Coordination on Harmonized Standard



Notes: The chart shows gains from cooperation for individual banks in jurisdiction 1 (Panel (a)) or jurisdiction 2 (Panel (b)) as a function of the relative financial sector size ω_1 . ω_1 varies from 0.5 (symmetry) to 1. The solid (dashed) lines in Panel (a) and (b) represent different harmonized standards l^h . The corner region corresponds to equilibria where $l_{\omega_2}^{NP} = 0$. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

5. FLEXIBLE ARRANGEMENTS

The contract in the previous section was quite restrictive: all jurisdictions had to impose the same regulatory standard and were generally not willing to coordinate due to different preferences. This section relaxes these assumptions: jurisdictions are allowed to implement different levels of regulation and only $M \le N$ jurisdictions are required to participate. I refer to this contract as a flexible arrangement and explore key features in Section 5.1. In Section 5.2 I show that jurisdictions with a smaller banking sector may not join a flexible arrangement among a subgroup of countries. Section 5.3 characterizes 'optimal' flexible arrangements to illustrate how flexible arrangements compare to the global planner benchmark.

5.1. Overview

Gains from a flexible arrangement for a bank in jurisdiction *i* correspond to:

$$\triangle_{\omega_i}^f = \left(W_{\omega_i}^f - W_{\omega_i}^{NP*}\right)/\omega_i,$$

which resembles the difference in welfare from the flexible arrangement $(W_{\omega_i}^f)$ relative to the uncoordinated national planner equilibrium, adjusted for the share of banks in the jurisdiction.

Definition: A flexible arrangement is a contract that specifies the level of regulation $l_{\omega_i}^f$ for each participating jurisdiction i subject to:

1. $\triangle_{\omega_i}^f > 0 \ \forall \ i \ (Participation \ Constraint);$

2.
$$\Delta l_{\omega_i}^f = l_{\omega_i}^f - l_{\omega_i}^{NP} > 0 \ \forall \ i \ (Feasibility \ Constraint).$$

The participation constraint is trivial: a jurisdiction needs to benefit from the agreement, otherwise it would not join. The feasibility constraint is also a necessary requirement. Increasing regulation in one jurisdiction improves welfare in the other jurisdictions, because it stabilizes the fire-sale asset price. Consequently, if jurisdiction i lowered its liquidity provision, welfare in jurisdiction $k \neq i$ would decline. Therefore, jurisdiction k would want to exclude jurisdiction k from the agreement.

Figure 10 illustrates flexible arrangements in a two country variant of the model. The red line displays the national planner equilibria $\{l_{\omega_1}^{NP}, l_{\omega_2}^{NP}\}$ as a function of ω_1 . The blue shaded areas represent two admissible sets for a flexible arrangement. In the first example when $\omega_1=0.5$, the jurisdictions could agree on the constrained efficient global planner equilibrium to maximize welfare. In the second example, liquidity in jurisdiction 2 exceeds the constrained efficient outcome. In this case, the two jurisdictions are no longer able to coordinate on the global planner benchmark, but a flexible arrangement is still possible.

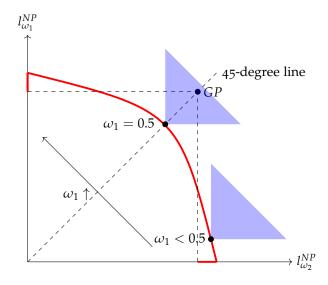


Figure 10: Flexible Arrangements in a Two Country Variant

Notes: The shaded areas illustrate admissible regions for flexible arrangements $\{l_{\omega_1}^f, l_{\omega_2}^f\}$ for two different values of ω_1 . The solid line depicts optimal bank-specific liquidity $\{l_{\omega_1}^{NP}, l_{\omega_2}^{NP}\}$ in the national planner equilibrium as a function of the relative banking sector size $\omega_1 = 1 - \omega_2$. The global planner equilibrium (GP) is marked for comparison. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

5.2. Costs and Benefits

The desirability of a flexible arrangement depends on its costs relative to its benefits. The benefits are tied to additional foreign regulation and thus tighter liquidity requirements abroad. Foreign liquidity enters the objective function only through the asset price, which is at inefficiently low levels due to the fire-sale externality embedded in the model. More foreign liquidity improves welfare at home as it increases the fire-sale price. The costs from the arrangement stem from tighter regulatory standards at home and are tied to the non-negativity constraint on liquidity. For reference, a regulator cannot choose a negative amount of liquidity, which introduces a strictly positive shadow cost for regulation whenever this constraint binds. Absent a binding liquidity constraint, national regulators perfectly arbitrage between illiquid and liquid assets and therefore have a marginal cost of zero to provide the first additional unit of liquidity. Because more foreign liquidity improves welfare at home, jurisdictions that already provide a positive amount of liquidity in the national planner equilibrium always benefit from a flexible arrangement. I subsequently summarize this finding.

Lemma 4

Define $M = \sum_{i=1}^{N} \mathbb{1}(\omega_i > \overline{\omega})$ as the number of jurisdictions with $l_{\omega_i}^{NP} > 0$. Then, a flexible arrangement always exists among these M jurisdictions.

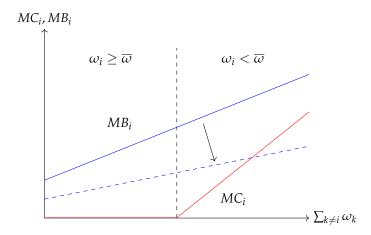
The proposition is illustrated by the area to the left of the dashed vertical line in Figure 11, which portrays the marginal benefit and cost from an increase in foreign and domestic regulation respectively evaluated at the no cooperation national planner equilibrium. In this region, jurisdiction i has no cost to impose additional regulatory requirements at the margin, while it receives a strictly positive welfare gain from additional foreign regulation.

However, a national regulator, who is constrained by the liquidity requirement may not join a flexible arrangement. I explore two scenarios in which this is the case: First, I consider a flexible arrangement among a subset of countries that jointly have a limited impact on the financial market. Then, I analyze a scenario in which small jurisdictions are of sufficient size on aggregate and show that there is an equilibrium in which it is optimal for a small jurisdiction to abstain from the arrangement when all other small jurisdictions abstain as well. Just as in the first scenario, the effect on financial stability from foreign liquidity is muted, which reduces the marginal benefit from the agreement as illustrated by the dashed blue line in Figure 11.

Arrangement among a Subgroup of Jurisdictions

For this subsection, I analyze an arrangement among M < N jurisdictions. The

Figure 11: Incentives for a Flexible Arrangement



Notes: The chart portrays the incentives to enter a flexible arrangement from the perspective of jurisdiction i evaluated at the national planner equilibrium. The blue lines represent the marginal benefit (MB_i) from foreign regulation. The red line the marginal cost (MC_i) from regulating the domestic banking sector. The dashed blue line corresponds to a scenario in which foreign regulation has less impact on domestic banks. The vertical dashed line separates two regimes: to the left (right) of the line, jurisdiction i provides positive (zero) liquidity.

following equation approximates gains from additional foreign regulation as the marginal benefit multiplied by the change in foreign liquidity ($\Delta l_k = \Delta \sum_{k \neq i}^M l_{\omega_k}$):

Benefit_i
$$\approx \frac{\partial W_{\omega_i}^{NP}}{\partial l_k} \Delta l_k \propto \frac{\partial p}{\partial L} \frac{\partial L}{\partial l_k} \Delta l_k = \frac{\partial p}{\partial L} \sum_{k \neq i}^M \omega_k \Delta l_k > 0.$$

The benefit from foreign liquidity is proportional to the sensitivity of the asset price with respect to aggregate liquidity, the change in aggregate liquidity induced by a marginal change in bank-specific liquidity by jurisdictions that participate in the agreement and the overall change in foreign liquidity. Importantly, the effect of foreign liquidity on aggregate liquidity, $\sum_{k\neq i}^{M} \omega_k$, increases with the number of participating jurisdictions and their size. If $\sum_{k\neq i}^{M} \omega_k$ is small and if jurisdiction i has a small financial sector, the costs from increasing regulation at home exceed gains from additional foreign regulation. I summarize this finding below:

Proposition 5 (Non-Existence of Flexible Arrangements: Part 1)

Suppose that $\omega_i < \overline{\omega}$ and that M < N. Then there exists an equilibrium at which jurisdiction i has no incentive to join a regulatory agreement, that is, $\triangle_{\omega_i}^f < 0$, and the participation constraint is violated.

Thus according to Proposition 5, if only few jurisdictions consider an agreement, then there is an equilibrium in which a small jurisdiction does not want to join. This outcome can also emerge when small jurisdictions fail to coordinate.

Coordination Failure

I subsequently show that a small jurisdiction refuses to join a flexible arrangement, if other small jurisdictions also avoid such an agreement and if these jurisdictions jointly cover a non-trivial share of the market. In turn, the decision to not cooperate for each small jurisdiction is validated, and no small jurisdiction would have an incentive to deviate from this decision. Similar to the argument in the previous proposition, financial stability gains are muted and offset by the costs associated with increasing regulation in the small jurisdiction. The next proposition summarizes this result:

Proposition 6 (Non-Existence of Flexible Arrangements: Part 2)

Consider two types of jurisdictions (i,k), with jurisdictions i referring to small jurisdictions with $\omega_i < \overline{\omega} \ \forall i$ and jurisdictions k to a large jurisdictions with $\omega_k > \overline{\omega} \ \forall k$. Then if $\sum_k \omega_k < \widetilde{\omega}$, there exists an equilibrium at which jurisdiction i has no incentive to join a flexible arrangement if all other jurisdictions i do not join, that is, $\Delta_{\omega_i}^f < 0 \ \forall i$, and the participation constraint is violated.

The previous narrative points to possibly two outcomes: One in which a small jurisdiction does not join if all other small jurisdictions also do not join, and an equilibrium in which all small jurisdictions join. In the second case, the additional liquidity increases the benefits from the agreement above the costs for a small jurisdiction, justifying why small jurisdictions participate. The former outcome leads to lower welfare both on aggregate and among free-riders: Aggregate liquidity would be higher if free-riders joined, and free-riders would be better-off if they collectively joined the arrangement. The next Lemma shows that this equilibrium also exists:

Lemma 5 Suppose that $\omega_i < \overline{\omega}$. If $R < \overline{R}$, there exists an equilibrium at which jurisdiction i joins a flexible arrangement if all other jurisdictions also join.

The result in Lemma 5 hinges on the return for long assets. A lower return makes liquid assets more attractive, therefore reducing the costs from providing more liquidity at home. A similar assumption has been imposed to ensure the existence of the asset market (see Lemma 2). Summarizing the previous analysis, the coordination failure – and more generally – cooperation among a subgroup of countries leads to an inefficient outcome. Therefore flexible supranational agreements are more likely to be implemented if administered at a global rather than regional level.

5.3. Optimal Flexible Arrangements

This section characterizes the liquidity provision with flexible arrangements in more detail. As illustrated in Section 5.1, there are many feasible flexible arrangements,

hence I restrict myself to a particular case, which I refer to as an 'optimal' flexible arrangement. The arrangement is optimal in the sense that it maximizes aggregate welfare across all *N* participating jurisdictions, ruling out coordination failures or an agreement among a subset of countries.

Definition: The optimal flexible arrangement is a contract that specifies the level of regulation $l_{\omega_i}^f$ for each jurisdiction $i \in \{1, ..., N\}$ by maximizing:

$$\max_{l_{\omega_i}} \left\{ \sum_{i=1}^{N} W_{\omega_i}^{NP}(e - l_{\omega_i}, l_{\omega_i}; L) \right\},\,$$

subject to $\triangle_{\omega_i}^f > 0$ and $\Delta l_{\omega_i}^f > 0 \ \forall \ i$.

The constraints correspond to the participation constraint and the feasibility constraint outlined in Section 5.1.

Lemma 6 The optimal flexible arrangement is constrained efficient.

The intuition for Lemma 6 is as follows: The optimal contract internalizes the beneficial effect of liquidity on *all* banks irrespectively of the jurisdiction, just like in the global planner equilibrium, that is, the first order condition with respect to l_{ω_i} reads:

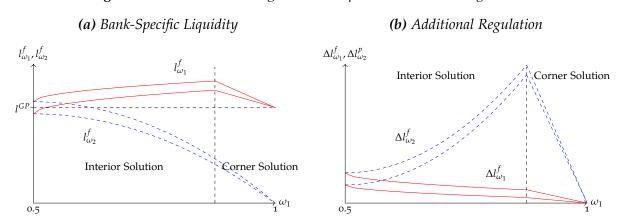
$$\sum_{k}^{N} \frac{\partial W_{\omega_{k}}^{NP}}{\partial l_{\omega_{i}}} = 0 \ \forall \ i.$$

However, as I will illustrate below, this does not imply that each jurisdiction assigns the same level of liquidity per bank, that is, generally $l_{\omega_i}^f \neq l^{GP}$. Nonetheless, because the objective function of each jurisdiction is linear in bank-specific liquidity, welfare across all jurisdictions equals welfare in the constrained efficient global planner solution. In other words, the optimal flexible arrangement adjusts the regulatory burden for each jurisdiction consistent with the feasibility and participation constraint, while retaining aggregate liquidity at the level of the global planner equilibrium. As a side effect from the linearity, the level of liquidity provided by each jurisdiction is not uniquely pinned down.

Figure 12 portrays the liquidity provision with an optimal flexible arrangement. For simplicity, I focus on a case with just two jurisdictions. Panel (a) plots the bank-specific liquidity provided in the arrangement, while Panel (b) emphasizes the change in liquidity relative to the national planner equilibrium. In each case, the dashed blue and solid red lines provide admissible liquidity bands. Based on Panel (a), the smaller jurisdiction continues to provide less liquidity than the larger jurisdiction: The small

jurisdiction has a limited impact on the global asset market and hence a relatively high cost from providing liquidity. Thus, in order to satisfy the participation constraint, additional liquidity provisions cannot be too high. However, as Panel (b) suggests, the additional bank-specific liquidity in the smaller jurisdiction exceeds the increase in bank-specific liquidity of the larger jurisdiction. The gap increases when the small jurisdiction decreases in size, but the gap diminishes again in the corner solution. The former observation is driven by the aggregation of an increasingly smaller banking sector. As such, a jurisdiction needs to impose increasingly stricter regulation for each bank to increase jurisdiction-wide liquidity by the same amount. However, in the corner solution, it becomes increasingly costly for the smaller jurisdiction to provide liquidity; thus, to satisfy the participation constraint the additional bank-specific liquidity provided by the small jurisdiction declines.

Figure 12: Two Countries: Regulation in Optimal Flexible Arrangements



Notes: Panel (a) portrays the range of liquidity provided by banks in each jurisdiction in an optimal partial agreement (area between dashed blue or solid red lines) as a function of the relative financial sector size ω_1 . Panel (b) characterizes the range of additional liquidity provided by each jurisdiction in an optimal partial agreement relative to the national planner equilibrium. In either case, total liquidity across jurisdictions equals L^{GP} . The corner region corresponds to equilibria where $l_{\omega_2}^{NP} = 0$. Calibration: R = 1.01, q = 0.055, e = 10, c = 5.

6. Financial Disintegration

The previous sections highlight that certain international regulatory agreements are not desirable for a small country. This section takes the opposite direction and discusses a ban of free-riders from international financial markets.

The motivation for a ban is intuitive: A free-riding country benefits from foreign liquidity, without making a similar contribution to financial stability. A ban of free-riders has two positive effects on regulating jurisdictions: First, regulating jurisdictions are no longer required to implicitly subsidize free-riders. Second, since

liquidity can no longer flow to free-riders, regulation becomes more targeted. Both factors allow regulating jurisdictions to shift their portfolio towards more profitable long assets, without sacrificing the insurance motive during distress.

These factors are weighted against the cost from excluding free-riders as financial market depth declines. In the model, the costs from diminished financial market depth are summarized by a fee $\gamma(\eta)$ with η referring to the size of the market. This fee is born by intact banks and lowers their demand for illiquid assets on the spot market. Everything else equal, this translates into a lower equilibrium asset price and therefore also harms distressed banks, which would be required to sell more illiquid assets. Because the fee depends on the size of the remaining financial market, the costs for excluding a free-rider increase if the free-rider is large, or equivalently, if the remaining jurisdictions are relatively small. Thus overall, a ban may not improve welfare for the regulating jurisdictions imposing the ban. However, if such a ban is credible, it can force free-riders to follow international regulatory guidelines:¹⁵

Proposition 7 (Autarky versus Coordination)

A jurisdiction prefers to follow the global planner benchmark as a third best outcome when threatened with financial exclusion. Formally: $\omega_i W_{\omega_i}^{GP*} > W_{\omega_i|Autarky}^{NP*}$.

The proposition 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 free-rider i is either a small open economy or a somewhat larger jurisdiction. A small open economy is formally described by $\omega_i \to 0$. Importantly, in this setting, the Law of Large Numbers (LLN) no longer applies and the free-rider can no longer accommodate liquidity shocks on its own. The jurisdiction therefore depends on access to international financial markets during a domestic financial crisis, or alternatively would need to self-insure. Self-insurance is however dominated by an access to financial markets (see Lemma B1 in the online appendix), because the asset market allows banks to hold more profitable long assets. Thus, from the perspective of the free-rider, cooperation would be third best. In the second scenario, the jurisdiction is large enough to accommodate fire-sales on its own due to the continuum of banks in every region, but at a cost due to reduced financial market depth. This friction lowers the equilibrium asset price and distorts

¹⁵The ban of free-riders can be interpret as an extreme form of capital controls. Rebucci and Ma (2019), Erten et al. (2021) and Bianchi and Lorenzoni (2022) provide excellent summaries on the capital control literature. In this 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 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.

the incentives to hold liquidity, which in turn leads to an outcome that is inferior to coordinating on the global planner standard.

7. Empirical Support

This section provides a few stylized facts regarding the adherence to international regulatory standards that are consistent with the previous analysis. Related to the Basel Agreements – the most comprehensive international regulatory framework – I first emphasize that several Basel non-member countries do not or only partially follow the guidelines set forth by the Basel Committee. Second, I highlight that the adherence to the Basel guidelines is closely tied to the size of the domestic banking sector. Third, I document that countries that follow fewer guidelines also exert less due diligence on policies that are implemented. Fourth, I show that partially regulated countries sum up to a significant portion of the global financial sector.¹⁶

Data

The subsequent analysis is based on survey data from the BIS (2015) related to the implementation of the Basel II and III standards. 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). I complement this data with a survey from the World Bank (Johns and Saltane, 2016), which contains particulars about the due diligence related to implemented regulatory policies including the Basel guidelines. 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.

The adherence to the Basel standards can be explored among several dimensions. The most fundamental decision pertains to the extensive margin: Does a country implement certain policies or not? In this section, I examine the binary choice to implement various aspects of the Basel Agreements and capture the adherence 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. Because several countries in the survey have a negligible financial sector

¹⁶The online appendix contains several additional results: I argue that banking sector size asymmetries have more explanatory power than other, complimentary asymmetries explored in the literature. I also show that these effects are more relevant for open, rather than closed economies, and provide several robustness checks including an analysis of the Liquidity Coverage Ratio, which is closely tied to the liquidity regulation in the analytical framework.

which renders financial regulation obsolete, I 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. Most countries are emerging and developing economies, but the sample also includes advanced economies like Israel or Norway.

Observation 1: A partial implementation of the Basel II and III standards is the norm among non-members and many countries do not follow the Basel guidelines.

Figure 13 plots the number of implemented Basel II (Panel (a)) and III guidelines (Panel (b)) for the year 2015. The Basel II framework is split into 10 components, while the Basel III framework is composed of 8 components, hence the specific range on the horizontal axis. Details about the components are provided in the online appendix. Each bar represents the share of non-member countries that incorporated a specific number of policies.

A considerable share of countries did not follow the lead of the Basel Committee on the Basel II and III standards. In more detail, 24 percent of the countries in the sample did not implement any Basel II guidelines. This share increases to 52 percent for Basel III. The high share of countries that did not implement any Basel III guidelines relative to Basel II is not surprising: The data pertains to the year 2015, the last year with available survey data. The Basel III guidelines were however only agreed upon in 2010, and by 2015 many countries – even Basel member countries – were still in the process to implement the rules. This contrasts with the Basel II standards, which were initially published in 2004 and enacted among countries that wished to do so by 2015.¹⁷

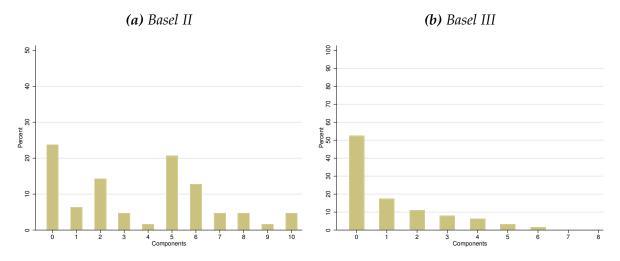
But even among countries that adhere to the Basel II and III framework, most only implement few guidelines. Admittedly, a full implementation would be unrealistic due to the complexity and irrelevance of some rules for smaller emerging markets (see, for example, FSB, IMF and World Bank, 2011 Gottschalk, 2016; Jones and Knaack, 2019). However, this observation is nevertheless striking considering that several guidelines, particularly within the Basel II framework, are relatively easy to implement, and given that the Basel Committee grants countries flexibility to customize specific guidelines to the domestic environment (Cos, 2020).

Observation 2: Non-member countries with a larger banking sector are more likely to implement the Basel Agreements.

Figure 14 provides margins plots from two ordered logit models with the Basel II or III Index as the dependent variable and the size of the domestic banking sector as the

¹⁷The distribution of implemented Basel III guidelines across countries is not stationary as of 2015. In contrast, there is very little time variation for policies related to Basel II. Details are available in the online appendix.

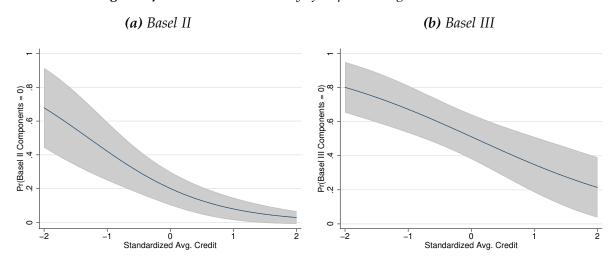
Figure 13: Basel II and III Implementation for Non-members: The Basel Index



Notes: The vertical axes portray the share of countries (in %) that implemented a specific number of Basel components. Panel (a) (Panel (b)) evaluates the Basel II (Basel III) agreement. The data is based on the most recent survey covering the year 2015.

independent variable. The size of the domestic banking sector is proxied by the amount of domestic credit issued by banks to the private sector. For this chart, domestic credit is standardized and averaged over the period 2003-2015. I then compute the probability of adhering to zero (vertical axes) versus at least one Basel II or III policy by the end of 2015.

Figure 14: Conditional Probability of Implementing Zero Basel Policies



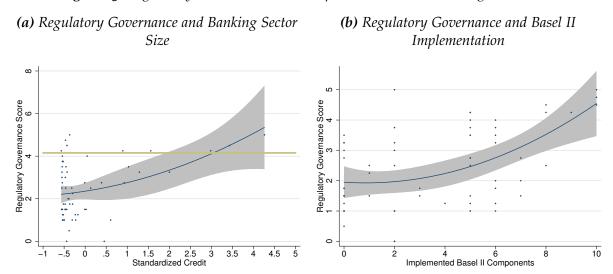
Notes: The vertical axes display the probability of installing zero Basel II (Panel (a)) or III policies (Panel (b)) by the end of the year 2015. The horizontal axes represent the amount of domestic credit (standardized, averaged over the period 2003-2015). Shaded areas indicate 95% confidence intervals.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

The chart reveals a striking 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. This epitomizes the importance of the banking sector size in determining regulatory commitment and is a key observation from the previous analytical framework where this behaviour arises endogenously. The appendix provides the full set of results – including control variables such as the size of the overall economy – and confirms the relationship.

Observation 3: Non-member countries that implement fewer policies also exert less due diligence on implemented regulatory policies.

Figure 15: Regulatory Governance, Basel Implementation, and Banking Sector Size



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.

Figure 15, Panel (a) portrays the relationship between the size of the domestic banking sector (proxied by domestic credit) and the regulatory governance score for Basel non-members from the World Bank (blue dots and line of best fit). Clearly, countries with a smaller banking sector have a lower score as indicated by the regression line. The plot also includes a horizontal line which displays the average score for Basel members, which suggests that most non-members exert less due diligence in monitoring financial regulation than Basel members. Related, Panel (b) 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 do a better job at monitoring and enforcing existing regulation.

Observation 4: A sizable share of the global financial sector is only partially regulated.

Table 1 lists the size of the domestic financial sectors (again proxied by domestic credit) aggregated across Basel non-member countries that implemented less than or equal to N Basel II or III components relative to the banking sector size of the United States. The bottom line from this table is that smaller countries with partially implemented Basel guidelines aggregate to a significant portion of the international financial market. For example, the combined financial sector size of countries that implemented less or equal than half of the Basel II requirements ($N \le 5$) equals 21 percent of the financial sector size of the United States. A lack of regulation in these countries could therefore affect global financial stability.

Table 1: Unregulated/Partially Regulated Financial Sector Size relative to the U.S.

N	О	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).

8. Conclusion

A sizable share of the global banking sector is not or only partially regulated. But what determines the adherence to multinational financial regulatory standards? In this paper I show that countries with a larger financial sector have more incentives to regulate their financial market. Countries with limited influence on international financial markets in contrast benefit from foreign regulation, as markets are interconnected which leads to regulatory spillovers. I then apply the model to the Basel Agreements and show that several non-member countries do not implement the guidelines, even though they have been encouraged to do so. Further, these countries tend to be small, but sum up to a non-trivial portion of the global financial sector. This issue is hence relevant.

I show that countries with a small financial sector have no incentive to adhere to harmonized, that is, common standards across jurisdictions. These countries would have to substantially increase regulation with limited benefits on financial stability, since their share of the global financial sector is small. This finding rationalizes why the Basel Committee proposed a tailored approach with less stringent regulation for economies with less financial market depth. However, I also show that such non-harmonized (or flexible) arrangements can be difficult to administer. Small countries have a strictly positive marginal cost to regulate which can outweigh stability gains through additional foreign regulation when only few countries cooperate. The analysis thus stresses that financial regulatory agreements are most effective when implemented at a global rather than regional level. In light of this result, the paper also discusses sanctions: these would be imposed by regulating jurisdictions on free-riders and would limit their access to international markets. Such restrictions may force 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.¹⁸ Period 2 consumption as a function of t = 1 consumption is:

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

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

¹⁸Banks 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 distressed banks therefore binds.

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

$$p(L)h'(c_{i1}) = R.$$

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:

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

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 the 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:

$$\max_{i_{j}, e_{j}^{\text{bank}}} E_{0}[c_{2j}(i_{j}, e_{j}^{\text{bank}})] = \max_{i_{j}, e_{j}^{\text{bank}}} \{f(i_{j}) + E_{0}[\overline{R}_{j}](1 - \zeta)e_{j}^{\text{bank}}\},$$
(B.2)

subject to:

$$e = i_j + e_j^{\text{bank}}. (B.3)$$

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 $(1 - \zeta)e^{*bank}$.

Details on Loan Market: The loan market allows intact banks to exchange t = 1 consumption goods from matured short assets with 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 jurisdictions. Some intact banks may therefore not have enough funds to finance the desired amount of illiquid assets in the asset market. As a consequence, aggregate demand for long assets would exhibit a kink at the demand level that makes the cash-in-the-market constraint bind, which can lead to multiple equilibria. The loan market ensures that all intact banks are unconstrained regardless of the initial portfolio if there is enough aggregate liquidity, which is assumed throughout the paper.

To further motivate the market, consider the long asset demand for constrained and unconstrained intact banks from Section 2.2. Without loss of generality assume that intact banks from jurisdiction k are financially constrained. Banks from the remaining jurisdictions are not constrained.

Demand for banks in any jurisdiction $i \neq k$ is:

$$p = R\phi'(x_{\omega_i}^D).$$

Demand for each bank in jurisdiction *k* is:

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

It becomes clear that $x_{\omega_i}^D > x_{\omega_k}^D$ as $\mu_{\omega_k} > 0$. Further, by purchasing additional illiquid assets from distressed banks, intact banks in jurisdiction k achieve a higher return than banks in jurisdiction i as $\phi'(x_{\omega_k}^D) > \phi'(x_{\omega_i}^D)$. This naturally motivates a loan market as it is socially optimal for each intact bank to purchase the same amount of illiquid assets. Banks in jurisdiction k have therefore an incentive to expand funding to distressed banks relative to banks in the other jurisdictions 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 intact banks. Demand intersects the vertical axis at $\frac{R\phi'(l_{\omega_k}/p)}{p}$, 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 $px_{\omega_k}^D = l_{\omega_k} + \tilde{l}_{\omega_k}$, which reduces the gross return from loans. Eventually, they obtain enough loans and $\mu_{\omega_k} = 0$. 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 $\mu_{\omega_k} = 0$.

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, all unconstrained intact banks 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 implies that no intact bank is constrained.

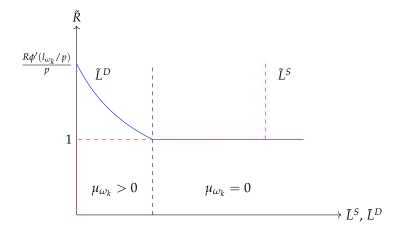


Figure B1: Period 1 Loan Market

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

Proof of Lemma 1: The proof is based on the market clearing condition (4) in conjunction with the Implicit Function Theorem. Consequently:

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

with $X^S = q \frac{c-L}{p}$ and $X^D = (1-q)\phi'^{-1}\left(\frac{p}{R}\right)$. Plugging in the partial derivatives for X^S

and X^D , and exploiting that $X^S = X^D = X$ in equilibrium yields:

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

Because $p = R\phi'$ one obtains:

$$\frac{\partial p}{\partial L} = \frac{-\frac{q}{1-q}\phi''\left(\frac{X}{1-q}\right)}{\frac{X}{1-q}\phi''\left(\frac{X}{1-q}\right) + \phi'\left(\frac{X}{1-q}\right)} = \frac{q}{1-q} > 0.$$
 (B.4)

The second equality follows from the definition of ϕ , which implies that $\phi' = (1 + X/(1-q))^{-1}$ and $\phi'' = -(1 + X/(1-q))^{-2}$.

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:

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

The first equality once again follows from the Implicit Function Theorem. The second equality exploits the partial derivatives and that $p^S = p^D$ in equilibrium. The third equality utilizes the specific functional form of ϕ . Notice that $\phi'' < 0$.

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 $c-L \leq c(1-q)$. From asset market clearing (4), it follows that $1-q=q\frac{c-L}{p}\frac{1}{\phi'^{-1}(\frac{p}{R})}$, which once plugged into the inequality immediately implies $qc \geq \phi'^{-1}\left(\frac{p}{R}\right)p=x_j^Dp$. The term on the left is constant, while the term on the right corresponds to the t=1 long asset expenditure by an intact bank which decreases in p. To see this notice that $\frac{\partial \left(px_j^D(p)\right)}{\partial p}=x_j^D+p\frac{\partial x_j^D}{\partial p}=x_j^D-\frac{R}{1+x_j^D}\frac{(1+x_j^D)^2}{R}<0$ $\forall x_j^D>0$. The second equality follows from the functional form of ϕ . The asset price in the competitive equilibrium equals $p^{CE}=\frac{qR}{R-1+q}$ and 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 $x_j^S = \frac{c-l_j}{p} \le k_j$, or equivalently $\frac{c-l_j}{e-l_j} \le p$ since $e = k_j + l_j$. The fraction on the left decreases in l_j as

 $e > c > l_j$ and is therefore largest when $l_j = 0$ given that liquid assets are non-negative. The term on the right obtains its minimum at $p = p^{CE}$. $\frac{c}{e} \le \frac{qR}{R-1+q}$ is therefore a sufficient condition.

Optimality of Asset Market Equilibrium: Portfolio choices in period 0 are made under the assumption that banks 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 are able to obtain funds from other banks during distress, hence they invest in more profitable long assets. This result rests on two premises: imperfectly correlated liquidity shocks and sufficient aggregate liquidity.¹⁹

Proof of Lemma B1: If not participating in the asset market, it is optimal 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 holds $l_j < c$, 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 $l_i = c$ is:

$$E_0[c_{j2}^{\text{Autarky}}|l_j = c] = qR(e-c) + (1-q)(R(e-c)+c)$$

= $qR(e-c) + (1-q)c(1-R) + (1-q)Re = R(e-c) + (1-q)c$.

Choosing $l_j = c$ further grants a payoff in t = 1 if $s_j = 1$. Expected period 2 consumption in autarky with $l_j = 0$ is:

$$E_0[c_{j2}^{\text{Autarky}}|l_j = 0] = (1 - q)Re.$$

¹⁹In 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.

If $s_j = 1$, the bank defaults and no payoff in either t = 1 or t = 2 is made. Therefore, self insurance dominates no liquidity in autarky if:

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

or equivalently,

$$qR(e-c) + (1-q)c(1-R) \ge 0 \iff \frac{c}{e} \le \frac{qR}{R-1+q}.$$

This condition is satisfied (see Lemma 2).

I next show that the asset market equilibrium provides a higher expected t = 2 payoff than the autarky equilibrium with $l_j = c$, which is a sufficient condition for the payoff dominance of the asset market equilibrium given that both equilibria provide the same payoff in t = 1. The asset market equilibrium leads to the following t = 2 expected consumption:

$$E_{0}[c_{j2}^{\text{Market}}] = q \underbrace{\left[R\left[e - l_{j} - \frac{c - l_{j}}{p}\right]\right]}_{c_{j2}^{s=1}} + (1 - q) \underbrace{\left[R\left[e - l_{j} + \phi\left(x_{j}^{D}\right)\right] + l_{j} - px_{j}^{D}\right]}_{c_{j2}^{s=0}}$$

$$= R(e - l_{j}) - qR\frac{c - l_{j}}{p} + (1 - q)R\underbrace{\left[\phi\left(x_{j}^{D}\right) - \phi'(x_{j}^{D})x_{j}^{D}\right]}_{>0} + (1 - q)l_{j}$$

$$> \underbrace{R(e - c) + (1 - q)c}_{E_{0}[c_{j2}^{\text{Autarky}}|l_{j}=c]} + R(c - l_{j}) - (1 - q)(c - l_{j}) - qR\frac{c - l_{j}}{p}.$$

The second equality follows from asset demand $p = R\phi'$. The inequality in the third row utilizes the functional assumption on ϕ . 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:

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

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

$$R \ge 1 - q + \frac{qR}{p}.$$

The asset price p is an equilibrium object. The equilibrium price of the competitive equilibrium is strictly lower than in the planner's solution (Proposition 1). Therefore, the right hand side is maximized if $p = p^{CE} = \frac{qR}{R-1+q}$. With this substitution, the equation simplifies to $R \ge R$. The inequality therefore always holds and consequently, $E_0[c_{j2}^{\text{Market}}] > E_0[c_{j2}^{\text{Autarky}}|l_j = c]$. The asset market equilibrium is 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:

$$\max_{k_j \ge 0, l_j \ge 0} W_j^{CE}(k_j, l_j; L) = \max_{k_j \ge 0, l_j \ge 0} \left\{ q \left[R \left[k_j - \frac{c - l_j}{p(L)} \right] \right] + (1 - q) \left[R \left[k_j + \phi \left(\phi'^{-1} \left(\frac{p(L)}{R} \right) \right) \right] + l_j - p(L)\phi'^{-1} \left(\frac{p(L)}{R} \right) \right] \right\},$$

subject to:

$$k_i + l_i = e$$
.

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

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

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:

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

subject to:

$$K + L = E$$
.

Substituting K with E-L, optimality requires:

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

The derivative can be simplified since $p^{GP}=R\phi'$. 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:

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

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:

$$p^{GP} = p^{CE} \left[1 + \frac{c - L^{GP}}{R} \frac{\partial p}{\partial L} \left[\frac{1}{\phi'(\cdot)} - 1 \right] \right]. \tag{B.5}$$

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

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

where I made use of the definitions of $X^S(p(L),L) = q \frac{c-L}{p(L)}$ and $X^D(p(L)) = (1-q)\phi'^{-1}\left(\frac{p(L)}{R}\right)$. The second derivative corresponds to:

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

Because $\frac{\partial p}{\partial L} = \frac{q}{1-q}$, $\frac{\partial^2 p}{\partial^2 L} = 0$. I next plug in the partial derivatives of X^S and X^D , which yields:

$$\frac{\partial^2 W^{GP}(E-L,L)}{\partial^2 L} = -q \frac{R}{p^2} \frac{\partial p}{\partial L} + \left[-\frac{R}{p^2} X^S \frac{\partial p}{\partial L} - q \frac{R}{p^2} - \frac{R}{p^2} X^S \frac{\partial p}{\partial L} - (1-q) \frac{1}{R \phi''(\cdot)} \frac{\partial p}{\partial L} \right] \frac{\partial p}{\partial L}.$$

I next exploit that $X^D = X^S = X$ in equilibrium and that $p = R\phi'$. Further utilizing the functional form of ϕ , it follows that $\frac{\partial^2 W^{GP}}{\partial^2 L} < 0$ if:

$$-2\frac{R}{p}X\frac{\partial p}{\partial L} + (1-q)\left(1 + \frac{X}{1-q}\right)\frac{\partial p}{\partial L} < 2q\frac{R}{p}.$$

Rearranging and using that $\frac{\partial p}{\partial L} = \frac{q}{1-q}$ leads to:

$$\underbrace{X\frac{q}{1-q}\left(1-2\frac{R}{p}\right)}_{} < \underbrace{q\left(2\frac{R}{p}-1\right)}_{}.$$

Because R > p the inequality holds. Therefore $\frac{\partial^2 W^{GP}}{\partial^2 L} < 0$. The objective function is strictly concave and the solution is a unique global maximum.

National Planner Equilibrium: I first derive the best response function (first order condition), before I prove the uniqueness of the Cournot equilibrium.

Best Response Function: The optimization problem for jurisdiction i is:

$$\max_{K_{\omega_{i}} \geq 0, L_{\omega_{i}} \geq 0} W_{\omega_{i}}^{NP}(K_{\omega_{i}}, L_{\omega_{i}}; L) = \max_{K_{\omega_{i}} \geq 0, L_{\omega_{i}} \geq 0} \left\{ q \left[R \left[K_{\omega_{i}} - \frac{\omega_{i}c - L_{\omega_{i}}}{p(L)} \right] \right] + (1 - q) \left[R \left[K_{\omega_{i}} + \omega_{i}\phi \left(\phi'^{-1} \left(\frac{p(L)}{R} \right) \right) \right] + L_{\omega_{i}} - \omega_{i}p(L)\phi'^{-1} \left(\frac{p(L)}{R} \right) \right] \right\},$$
(B.6)

subject to:

$$K_{\omega_i} + L_{\omega_i} = \omega_i E$$
.

I substitute K_{ω_i} with $\omega_i E - L_{\omega_i}$. If the non-negativity constraint on liquid assets does not bind, the first order condition satisfies:

$$\frac{\partial W_{\omega_{i}}^{NP}(\omega_{i}E-L_{\omega_{i}},L_{\omega_{i}};L)}{\partial L_{\omega_{i}}} = q \left[R \left[-1 + \frac{1}{p^{NP}} + \frac{\omega_{i}c - L_{\omega_{i}}^{NP}}{[p^{NP}]^{2}} \frac{\partial p}{\partial L} \right] \right] + (1-q) \left[-R + 1 + \left[\left[R\phi'(\cdot) - p^{NP} \right] \frac{1}{R\phi''(\cdot)} - \phi'^{-1} \left(\frac{p^{NP}}{R} \right) \right] \frac{\partial p}{\partial L} \omega_{i} \right] \stackrel{!}{=} 0.$$

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

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

This equation is the best response function. Liquidity from any jurisdiction $k \neq i$ enters the equation through aggregate liquidity in the equilibrium asset price. I can therefore express this equation as $BR_{\omega_i}(L_{\omega_i}(L_k), L_k)) = 0$, where L_k denotes aggregate liquidity of all jurisdictions excluding i, that is, $L_k = \sum_{k \neq i} L_{\omega_k}$.

Rearranging the above first order condition yields:

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

Because $p^{CE} = \frac{qR}{R-1+q}$, the equation can be further simplified to:

$$p^{NP} = p^{CE} \left[1 + \frac{\partial p}{\partial L} \omega_i \left[\frac{c - l_{\omega_i}^{NP}}{p^{NP}} - \frac{c - L^{NP}}{R} \right] \right]. \tag{B.7}$$

Cournot Equilibrium: I next prove the uniqueness of the Cournot Nash equilibrium. The equilibrium is unique if the best response BR_{ω_i} is a contraction. If BR_{ω_i} is a contraction, it must satisfy:

$$\left| \frac{\partial L_{\omega_i}}{\partial L_k} \right| = \left| -\frac{\frac{\partial BR_{\omega_i}}{\partial L_k}}{\frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}}} \right| \stackrel{!}{<} 1 \iff \left| \frac{\partial BR_{\omega_i}}{\partial L_k} \right| \stackrel{!}{<} \left| \frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}} \right|.$$

 $\frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}}$ is the second derivative of the objective function, $\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial^2 L_{\omega_i}}$. $\frac{\partial BR_{\omega_i}}{\partial L_k}$ is the cross derivative, $\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_k}$.

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

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

with $X_{\omega_i}^S(p(L), L_{\omega_i}) = q \frac{\omega_i c - L_{\omega_i}}{p(L)}$ and $X^D(p(L)) = (1 - q)\phi'^{-1}\left(\frac{p(L)}{R}\right)$. The second derivative is:

$$\begin{split} \frac{\partial^{2}W_{\omega_{i}}^{NP}}{\partial^{2}L_{\omega_{i}}} &= -q \frac{R}{p^{2}} \frac{\partial p}{\partial L} + \left[\frac{R}{p} \frac{X_{\omega_{i}}^{S}}{\omega_{i}} - X^{D} \right] \underbrace{\frac{\partial^{2}p}{\partial^{2}L}}_{=0} \omega_{i} \\ &+ \left[-\frac{R}{p^{2}} \frac{X_{\omega_{i}}^{S}}{\omega_{i}} \frac{\partial p}{\partial L} + \frac{R}{p} \frac{\partial X_{\omega_{i}}^{S}}{\partial L_{\omega_{i}}} \frac{1}{\omega_{i}} + \frac{R}{p} \frac{\partial X_{\omega_{i}}^{S}}{\partial p} \frac{\partial p}{\partial L} \frac{1}{\omega_{i}} - \frac{\partial X^{D}}{\partial p} \frac{\partial p}{\partial L} \right] \frac{\partial p}{\partial L} \omega_{i}. \end{split}$$

Because $\frac{\partial p}{\partial L} = \frac{q}{1-q}$, $\frac{\partial^2 p}{\partial^2 L} = 0$. Plugging in the partial derivatives of $X_{\omega_i}^S$ and X^D yields:

$$\frac{\partial^2 W_{\omega_i}^{NP}}{\partial^2 L_{\omega_i}} = -q \frac{R}{p^2} \frac{\partial p}{\partial L} + \left[-\frac{R}{p^2} \frac{X_{\omega_i}^S}{\omega_i} \frac{\partial p}{\partial L} - q \frac{R}{p^2} \frac{1}{\omega_i} - \frac{R}{p^2} \frac{X_{\omega_i}^S}{\omega_i} \frac{\partial p}{\partial L} - (1-q) \frac{1}{R\phi''(\cdot)} \frac{\partial p}{\partial L} \right] \frac{\partial p}{\partial L} \omega_i.$$

I next make use of $p=R\phi'$, the functional form of ϕ and rearrange. It follows that $\frac{\partial^2 W_{\omega_i}^{NP}}{\partial^2 L_{\omega_i}}<0$ if:

$$-2\frac{R}{p}\frac{X_{\omega_i}^S}{\omega_i}\frac{\partial p}{\partial L} < 2q\frac{R}{p}\frac{1}{\omega_i} - (1-q)\left(1 + \frac{X^D}{1-q}\right)\frac{\partial p}{\partial L}.$$

Notice that $\frac{R}{p}=1+X^D/(1-q)$, which follows from the asset demand equation and the assumption about ϕ . Further substituting $\frac{\partial p}{\partial L}$ results in:

$$\underbrace{-2\frac{R}{p}\frac{X_{\omega_i}^S}{\omega_i}\frac{\partial p}{\partial L}}_{-} < \underbrace{q\frac{R}{p}\left(2\frac{1}{\omega_i} - 1\right)}_{\perp}.$$

Because $\omega_i < 1$ the inequality holds. Therefore $\frac{\partial^2 W_{\omega_i}^{NP}}{\partial^2 L_{\omega_i}} = \frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}} < 0$.

I subsequently derive $\frac{\partial BR_{\omega_i}}{\partial L_k}$:

$$\begin{split} \frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_k} &= -q \frac{R}{p^2} \frac{\partial p}{\partial L} + \left[\frac{R}{p} \frac{X_{\omega_i}^S}{\omega_i} - X^D \right] \underbrace{\frac{\partial^2 p}{\partial^2 L}}_{=0} \omega_i \\ &+ \left[-\frac{R}{p^2} \frac{X_{\omega_i}^S}{\omega_i} \frac{\partial p}{\partial L} + \frac{R}{p} \frac{\partial X_{\omega_i}^S}{\partial p} \frac{\partial p}{\partial L} \frac{1}{\omega_i} - \frac{\partial X^D}{\partial p} \frac{\partial p}{\partial L} \right] \frac{\partial p}{\partial L} \omega_i. \end{split}$$

Following the same steps as before for the second derivative one obtains $\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_k} < 0$ if:

$$\underbrace{-2\frac{R}{p}\frac{X_{\omega_i}^S}{\omega_i}\frac{\partial p}{\partial L}}_{} < \underbrace{q\frac{R}{p}\left(\frac{1}{\omega_i} - 1\right)}_{},$$

which is true as $\omega_i < 1$. Thus $\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_k} = \frac{\partial BR_{\omega_i}}{\partial L_k} < 0$. Going back to the definition of a contraction and the formulas for the second and partial derivatives it follows that:

$$\left|\frac{\partial BR_{\omega_i}}{\partial L_k}\right| \stackrel{!}{<} \left|\frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}}\right| \iff \frac{\partial BR_{\omega_i}}{\partial L_k} \stackrel{!}{>} \frac{\partial BR_{\omega_i}}{\partial L_{\omega_i}} \iff 0 \stackrel{!}{>} \frac{R}{p} \frac{\partial X_{\omega_i}^S}{\partial L_{\omega_i}} \frac{\partial p}{\partial L}.$$

Notice that $\frac{\partial X_{\omega_i}^S}{\partial L_{\omega_i}} < 0$ and $\frac{\partial p}{\partial L} > 0$, so this statement is indeed true. The best response function of jurisdiction i is a contraction. The Cournot equilibrium is therefore unique.

C. Appendix: Section 3

Proof of Proposition 1: I first show that $L^{NP} > L^{CE}$. The first order condition of jurisdiction i reads:

$$\frac{\partial W_{\omega_i}^{NP}}{\partial L_{\omega_i}} = \underbrace{1 - q - R + q \frac{R}{p}}_{\text{FOC: CE}} + \underbrace{\left[\frac{R}{p} q x_{\omega_i}^S - (1 - q) x^D\right]}_{(*)} \frac{\partial p}{\partial L} \omega_i,$$

with $x_{\omega_i}^S = \frac{c - l_{\omega_i}}{p}$ and $x^D = \phi'^{-1}(\frac{p}{R})$. The first part of the equation corresponds to the first order condition in the competitive equilibrium. I subsequently show that (*) > 0 when evaluated at the competitive equilibrium:

$$\frac{R}{p}qx_{\omega_i}^S-(1-q)x^D=\frac{R}{p^{CE}}q\frac{c-L^{CE}}{p^{CE}}-(1-q)\left(\frac{R}{p^{CE}}-1\right)=q\frac{c-L^{CE}}{p^{CE}}\left(\frac{R}{p^{CE}}-1\right)>0.$$

The first equality makes use of the definitions for $x_{\omega_i}^S$ and x^D , the functional assumption on ϕ , and that $l^{CE} = L^{CE}$. The second equality exploits the asset market clearing condition (4). Notice that $c > L^{CE}$ and $R > p^{CE}$.

Because (*) > 0, $\frac{\partial p}{\partial L}\omega_i > 0$ and since the objective function $W^{NP}_{\omega_i}$ is strictly concave (see derivation of national planner equilibrium), national regulators have an incentive to invest into additional liquidity when evaluated at the competitive equilibrium. Therefore $L^{NP} > L^{CE}$.

I next show $L^{GP} > L^{NP}$ by contradiction. Throughout the proof I utilize that $\frac{\partial p}{\partial L}$ is constant and positive, which I derived in equation (B.4). Based on the optimality conditions (B.5) and (B.7) for the global and national planners the following condition must hold with equality $\forall i$ with $l_{\omega_i}^{NP} > 0$:

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

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

Note that this equality always holds for at least one national planner by construction, since $L^{NP} > L^{CE} > 0$, that is, at least one regulator provides a positive amount of liquidity. I will subsequently show that the 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. Without loss of generality assume that $l_{\omega_i}^{NP}\geq l_{\omega_k}^{NP} \ \forall \ k\neq i$. It immediately follows that $l_{\omega_i}^{NP}\geq L^{NP}$. Therefore:

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

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 equality in (C.1) implies:

$$\frac{c - L^{GP}}{p^{GP}} - \frac{c - L^{GP}}{R} \stackrel{!}{<} \omega_i \left[\frac{c - l_{\omega_i}^{NP}}{p^{NP}} - \frac{c - L^{NP}}{R} \right].$$

As before, without loss of generality assume that $l_{\omega_i}^{NP} \geq l_{\omega_k}^{NP} \ \forall \ k \neq i$ and therefore $l_{\omega_i}^{NP} \geq L^{NP}$. Then:

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

which contradicts (C.1). $L^{GP} < L^{NP}$ is hence not a solution. I thus proved $L^{GP} > L^{NP}$.

Next, I show that aggregate liquidity decreases in the national planner equilibrium when the number of jurisdictions increases and all jurisdictions choose a positive amount of liquidity. Summing up over the first order condition of each jurisdiction implies:

$$\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}} = \sum_{i}^{N} \left\{ 1 - q - R + q \frac{R}{p^{NP}} + \left[\frac{R}{p^{NP}} q x_{\omega_{i}}^{S}(p^{NP}, l_{\omega_{i}}^{NP}) - (1 - q) x^{D}(p^{NP}) \right] \frac{\partial p}{\partial L} \omega_{i} \right\} = 0.$$

The sum of all partial derivatives is zero, since no jurisdiction is constrained by the non-negativity requirement on liquidity, that is, $\frac{\partial W_{\omega_i}^{NP}}{\partial L_{\omega_i}} = 0 \ \forall \ i$. The equation can be rearranged to:

$$\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}} = N \left[1 - q - R + q \frac{R}{p^{NP}} \right] + \left[\frac{R}{p^{NP}} X^{S}(p^{NP}, L^{NP}) - X^{D}(p^{NP}) \right] \frac{\partial p}{\partial L} = 0.$$

Notice that p^{NP} is only a function of L^{NP} , but not of N. The Implicit Function Theorem implies:

$$\frac{\partial L^{NP}}{\partial N} = -\frac{\partial \left(\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}} \right)}{\partial \left(\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}} \right)}{\partial L^{NP}}.$$

The partial derivative with respect to N is:

$$\frac{\partial \left(\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}}\right)}{\partial N} = 1 - q - R + q \frac{R}{p^{NP}} < 0.$$

The partial derivative is the first order condition in the competitive equilibrium with respect to liquidity and holds with equality when $p = p^{CE}$. The derivative is therefore always negative in a national planner equilibrium as $p^{NP} > p^{CE}$.

The sum of the first order conditions $\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}}$ corresponds to the first order condition of a global planner when N=1. Following identical steps as for the second derivative

in the global planner equilibrium (see p.47/48), the derivative with respect to L^{NP} is negative when:

$$\frac{\partial \left(\sum_{i}^{N} \frac{\partial W_{\omega_{i}}^{NP}}{\partial L_{\omega_{i}}}\right)}{\partial L^{NP}} < 0 \iff \underbrace{X \frac{q}{1-q} \left(1-2\frac{R}{p^{NP}}\right)}_{-} < \underbrace{q \left((1+N)\frac{R}{p^{NP}}-1\right)}_{+},$$

where X is the equilibrium transaction volume of long assets in t=1. The inequality holds because $R>p^{NP}$. In turn this means that $\frac{\partial L^{NP}}{\partial N}<0$.

Proof of Proposition 2: The first order condition for a national planner reads:

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

Based on Proposition 1 and Lemma 1 it follows that $p^{NP} > p^{CE}$, and because $\frac{\partial p}{\partial L} > 0$ it must be that:

$$\omega_i \left[\frac{c - l_{\omega_i}^{NP}}{p^{NP}} - \frac{c - L^{NP}}{R} \right] > 0,$$

for all jurisdictions i for which the non-negativity constraint on liquidity does not bind. Now consider two jurisdictions (i,k) that provide a positive amount of liquidity. Based on the above first order condition one obtains:

$$\omega_i \left[\underbrace{\frac{c - l_{\omega_i}^{NP}}{p^{NP}} - \frac{c - L^{NP}}{R}}_{>0} \right] = \omega_k \left[\underbrace{\frac{c - l_{\omega_k}^{NP}}{p^{NP}} - \frac{c - L^{NP}}{R}}_{>0} \right].$$

The terms in the bracket are positive. Therefore, if $\omega_i > \omega_k > \overline{\omega}$, then $l_{\omega_i}^{NP} > l_{\omega_k}^{NP} > 0$, where $\overline{\omega}$ refers to the size threshold below which a jurisdiction provides zero liquidity (see Lemma 3). Further, by construction if $\omega_i > \overline{\omega} \geq \omega_k$, then $l_{\omega_i}^{NP} > l_{\omega_k}^{NP} = 0$ and if $\overline{\omega} \geq \omega_i > \omega_k$, then $l_{\omega_i}^{NP} = l_{\omega_k}^{NP} = 0$.

Proof of Lemma 3: I show that if $\omega_i \leq \overline{\omega}(\{\omega_k\}_{k\neq i}^N)$, then $l_{\omega_i}^{NP} = 0$. The first order condition of jurisdiction i is:

$$\frac{\partial W_{\omega_i}^{NP}}{\partial L_{\omega_i}} = \underbrace{1 - q - R + q \frac{R}{p^{NP}}}_{\text{FOC: CE}} + \underbrace{\left[\frac{R}{p^{NP}} q x_{\omega_i}^S - (1 - q) x^D\right] \frac{\partial p}{\partial L} \omega_i}_{(*)}.$$

The first component corresponds to the first order condition in the competitive equilibrium. It follows that if $\omega_i \to 0$, then $(*) \to 0$ and since $p^{NP} > p^{CE}$, $\frac{\partial W_{\omega_i}^{NP}}{\partial L_{\omega_i}} < 0$. Therefore, if $\omega_i \to 0$, then $l_{\omega_i}^{NP} = 0$ because $W_{\omega_i}^{NP}$ is strictly concave. Exploiting the continuity of the planners' first order condition, it follows that if $0 < \omega_i \le \overline{\omega}$, jurisdiction i also provides zero liquidity. Notice that the threshold $\overline{\omega}$ depends on $\{\omega_k\}_{k\neq i}^N$, because varying weights across the remaining jurisdictions as well as the total number of jurisdictions affect aggregate liquidity outside jurisdiction i, and in turn, the marginal benefit from liquidity in jurisdiction i through equilibrium price effects.

Lemma C1 Liquidity is a public good. If jurisdiction k decides to enhance regulation, then all other jurisdictions i with $i \neq k$ regulate less. Hence $\frac{\partial l_{\omega_i}^{NP}}{\partial l_{\omega_k}^{NP}} < 0$ if $\omega_i > \overline{\omega}$.

Proof of Lemma C1: The objective function of the national planner is strictly concave. Hence $\frac{\partial l_{\omega_i}^{NP}}{\partial l_{\omega_k}^{NP}} < 0$ if $\frac{\partial^2 W_{\omega_i}^{NP}}{\partial l_{\omega_k}} < 0$.

The first derivative with respect to bank-specific short assets in jurisdiction i is:

$$\frac{\partial W_{\omega_i}^{\text{NP}}}{\partial l_{\omega_i}} = \frac{\partial W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i}} \frac{\partial L_{\omega_i}}{\partial l_{\omega_i}} = \frac{\partial W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i}} \omega_i.$$

This implies that:

$$\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial l_{\omega_i} \partial l_{\omega_k}} = \frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_{\omega_k}} \frac{\partial L_{\omega_k}}{\partial l_{\omega_k}} \omega_i = \underbrace{\frac{\partial^2 W_{\omega_i}^{\text{NP}}}{\partial L_{\omega_i} \partial L_{\omega_k}}}_{<0} \omega_i \omega_k < 0.$$

The cross derivative is negative as shown in the derivation of the national planner equilibrium. Hence $\frac{\partial l_{\omega_i}^{NP}}{\partial l_{\omega_k}^{NP}} < 0$. The proof requires that jurisdiction i operates along the first order condition. Therefore, the Lemma only applies if the non-negativity constraint on liquidity does not bind.

D. Appendix: Section 4

Proof of Proposition 3: If $\omega_i=1/N$, then $l_{\omega_i}^{NP}=l^{NP}\ \forall\ i$ because all jurisdictions are of the same size and consequently $W_{\omega_i}^{NP*}=W^{NP*}$. Period 2 consumption with a global planner equals W^{GP*} and is based on the joint maximization over all jurisdictions. The global planner's allocation deviates from national planners, since $L^{GP}>L^{NP}$ (Proposition 1). Thus by revealed preferences, $W^{GP*}>\sum_i W_{\omega_i}^{NP*}=N$ W^{NP*} . Therefore

 $\triangle_{\omega_i}^{GP} = W^{GP*} - W_{\omega_i}^{NP*} / \omega_i > 0$. Because the planner's objective function is continuous, there must further be a $\overline{\epsilon}$ with $0 < \epsilon < \overline{\epsilon}$ such that $\triangle_{\omega_i}^{GP} > 0 \ \forall \ i \text{ if } \omega_i \in [\frac{1}{N} - \epsilon; \frac{1}{N} + \epsilon]$.

Now suppose that $\omega_i \to 1$. I show that jurisdiction k is unwilling to cooperate. When $\omega_i \to 1$, $l_{\omega_i}^{NP} \to l^{GP}$, $p^{NP} \to p^{GP}$ and $l_{\omega_k}^{NP} = 0$ because $\omega_k < \overline{\omega}$. Consequently, jurisdiction k has no effect on aggregate liquidity or the asset price. Joint regulation would force jurisdiction k to allocate l^{GP} to each bank, while jurisdiction k would provide the same liquidity as before. Without any change in aggregate liquidity and because $l_{\omega_k}^{NP} = 0$ is the best response it immediately follows that $\Delta_{\omega_k}^{GP} = W^{GP*} - W_{\omega_k}^{NP*}/\omega_k < 0$ when $\omega_i \to 1$.

Exploiting the continuity of the planner's objective function it follows that jurisdiction k is also not willing to cooperate when $\underline{\omega} < \omega_i < 1$. The threshold $\underline{\omega}$ depends on $\{\omega_k\}_{k\neq i}^N$, as varying weights across jurisdictions as well as the total number of jurisdictions affect aggregate and jurisdiction specific liquidity in the national planner equilibrium, which in turn determine the incentive to coordinate.

Proof of Proposition 4: I first show that aggregate welfare increases with l^h . Welfare across all jurisdictions is $\sum_i \omega_i W^h_{\omega_i}$, which by construction equals welfare of a global planner when evaluated at l^h . As shown in the derivation of the global planner equilibrium, W^{GP} is strictly concave and optimized at l^{GP} . Therefore:

$$\frac{\sum_{i} \omega_{i} W_{\omega_{i}}^{h}}{\partial l^{h}} = \frac{\partial W^{GP}}{\partial l} > 0 \quad \text{if} \quad l = l^{h} < l^{GP}.$$

Now for the second part of the Lemma suppose that $l^h < l^{GP}$ and $\omega_i \to 1$. When $\omega_i \to 1$, $l_{\omega_i}^{NP} \to l^{GP}$, $p^{NP} \to p^{GP}$ and $l_{\omega_k}^{NP} = 0$ because $\omega_k < \overline{\omega}$. Turning to jurisdiction i, it follows that:

$$\frac{W_{\omega_i}^h}{\partial l^h} = \frac{\partial W^{GP}}{\partial l} > 0 \quad \text{if} \quad l = l^h < l^{GP}.$$

The equality is based on the assumption that $\omega_i \to 1$, which implies that jurisdiction i behaves like a global planner. The objective function of a national/global planner is strictly concave. $\frac{W_{\omega_i}^h}{\partial l^h} > 0$ therefore translates into a welfare loss for jurisdiction i relative to no cooperation: jurisdiction i would prefer l^{GP} and every other jurisdiction $k \neq i$ has no aggregate impact. Therefore $\Delta_{\omega_i}^h < 0$.

A small jurisdiction k also looses welfare from the agreement. This result emerges as cooperation on $l^h < l^{GP}$ when $\omega_i \to 1$ leads to lower financial stability and a higher regulatory burden for jurisdiction k relative to no cooperation. To see the latter notice

that $l_{\omega_k}^{NP} = 0$ without cooperation. Regarding the former, notice that $p < p^{GP}$ when l^h is implemented and that welfare increases with financial stability. More formally, the marginal gains from a higher asset price for a bank in jurisdiction k are:

$$\frac{\partial \left(W_{\omega_k}/\omega_i\right)}{\partial p} = \left[\underbrace{\left(\frac{R}{p}qx_{\omega_k}^S - (1-q)x^D\right)}_{>0} + (1-q)\underbrace{\left(R\phi'\left(\cdot\right) - p\right)}_{=0}\frac{\partial x^D}{\partial p}\right] > 0.$$

The second term is zero, which directly follows from asset demand in the spot market. The first term is greater than zero since R > p and:

$$qx_{\omega_k}^S = q \frac{c}{p} > q \frac{c-L}{p} = (1-q)\phi'^{-1}\left(\frac{p}{R}\right) = (1-q)x^D.$$

The first equality is based on the definition of asset supply, the second equality follows from market clearing and the third equality is the definition of asset demand. Therefore $\triangle_{\omega_k}^h < 0$. Similar to coordination on the constrained efficient benchmark, it then follows from continuity of the planner's objective function that there must be a $\underline{\underline{\omega}}$ such that if $\underline{\underline{\omega}} < \omega_i < 1$, $\triangle_{\omega_i}^h < 0$ and $\triangle_{\omega_k}^h < 0 \ \forall \ k \neq i$.

E. Appendix: Section 5

Proof of Lemma 4: I subsequently demonstrate that a regulator who supplies a positive amount of liquidity in the national planner equilibrium is always willing to join a flexible arrangement. In particular, I show that the national regulator has a cost of zero to marginally increase liquidity relative to the national planner equilibrium. Then I show that the marginal benefit from foreign liquidity is strictly positive. As a consequence, there exists a flexible arrangement among jurisdictions with $\omega_i > \overline{\omega}$ that satisfies the feasibility constraint and the participation constraint.

Regarding the marginal costs, notice that if $l_{\omega_i}^{NP} > 0$:

$$\frac{\partial W_{\omega_i}^{NP*}(e-l_{\omega_i}^{NP},l_{\omega_i}^{NP};L^{NP})}{\partial l_{\omega_i}}=0,$$

which directly follows from the first order condition of a national planner. The regulator has hence a cost of zero to increase liquidity at the margin. The marginal benefit from foreign liquidity $l_k = \sum_{k\neq i}^M l_{\omega_k}$ evaluated at the national planner equilibrium is (see equation (B.6) for the objective function):

$$\frac{\partial W_{\omega_{i}}^{NP*}}{\partial l_{k}} = \omega_{i} \left\{ \left[\underbrace{\left(\frac{R}{p^{NP}} q x_{\omega_{i}}^{S} - (1 - q) x^{D}\right)}_{>0} + (1 - q) \underbrace{\left(R \phi'\left(\cdot\right) - p^{NP}\right)}_{=0} \frac{\partial x^{D}}{\partial p} \right] \frac{\partial p}{\partial L} \sum_{k \neq i}^{M} \omega_{k} \right\} > 0.$$

Asset demand by intact banks implies that $p = R\phi'$. The second term in the parenthesis is therefore zero. The first term is strictly positive. To see this, recall that the first order condition of a national planner when $l_{\omega_i}^{NP} > 0$ reads:

$$\frac{\partial W_{\omega_i}^{NP*}}{\partial l_{\omega_i}} = \omega_i \left\{ \underbrace{1 - q - R + q \frac{R}{p^{NP}}}_{<0} + \underbrace{\left[\frac{R}{p^{NP}} q x_{\omega_i}^S - (1 - q) x^D\right]}_{(*)} \frac{\partial p}{\partial L} \omega_i \right\} = 0.$$

The first term corresponds to the first order condition of a competitive bank and is zero when $p=p^{CE}$. Since $p^{NP}>p^{CE}$, this term must be negative, implying that (*) is positive. This immediately leads to $\frac{\partial W_{\omega_i}^{NP*}}{\partial l_k}>0$ and hence a strictly positive marginal benefit from foreign liquidity.

Proof of Proposition 5: I show that the marginal benefit from foreign regulation for banks in jurisdiction i converges to zero when the size of participating jurisdictions excluding i converges to zero, that is, if $\sum_{k\neq i}^{M}\omega_k\to 0$, then $\frac{\partial (W_{\omega_i}^{NP}/\omega_i)}{\partial l_k}\to 0$. Notice that the former requires M< N, otherwise the term cannot converge to zero as $\omega_i<\overline{\omega}$. Foreign jurisdictions might be willing to increase liquidity by more than a marginal unit. However, jurisdictions can only increase liquidity by a finite amount due to their finite endowment. Hence, if $\frac{\partial W_{\omega_i}^{NP}}{\partial l_k}\to 0$, then by construction $\Delta_{\omega_i}^f<0$ considering that $\omega_i<\overline{\omega}$ and hence strictly positive marginal costs to regulate.

The bank-specific marginal benefit from an arrangement for jurisdiction i is:

$$\frac{\partial \left(W_{\omega_{i}}^{NP}/\omega_{i}\right)}{\partial l_{k}} = \left[\underbrace{\left(\frac{R}{p}qx_{\omega_{i}}^{S} - (1-q)x^{D}\right)}_{>0} + (1-q)\underbrace{\left(R\phi'\left(\cdot\right) - p\right)}_{=0}\frac{\partial x^{D}}{\partial p}\right]\frac{\partial p}{\partial L}\sum_{k\neq i}^{M}\omega_{k} > 0.$$

The marginal benefit is strictly positive (see Proof of Proposition 4) and decreases with smaller participating jurisdictions (smaller ω_k) and with fewer participating jurisdictions (smaller M). Thus, if $\sum_{k\neq i}^M \omega_k \to 0$ then $\frac{\partial (W_{\omega_i}^{NP}/\omega_i)}{\partial l_k} \to 0$. Because $\omega_i < \overline{\omega}$, it follows that $\Delta_{\omega_i}^f < 0$. Further, because the marginal benefit is a continuous function, there must be a $\sum_{k\neq i}^M \omega_k > 0$ satisfying $\Delta_{\omega_i}^f < 0$.

Proof of Proposition 6: For this proof I consider two types of jurisdictions (i,k). I first show that if $\omega_i \to 0 \ \forall i$ and $\int_i \omega_i > \tilde{\omega}$, there exists an equilibrium in which jurisdiction i does not join a regulatory agreement if all other jurisdictions i also do not join. Based on the continuity of the planner's objective function it then follows that there must be a ω_i satisfying $0 < \omega_i < \overline{\omega} \ \forall i$ that leads to the same conclusion.

In terms of housekeeping, notice that all jurisdictions k satisfy $\omega_k > 0$ and at least the largest jurisdiction k also satisfies $\omega_k > \overline{\omega}$, because $L^{NP} > L^{CE}$ (Proposition 1). Without loss of generality I subsequently assume that all jurisdictions k are unconstrained by liquidity, and hence always willing to cooperate (Lemma 4). This maximizes the benefit from an arrangement for a bank in jurisdiction i.

For reference the objective function of jurisdiction i is:

$$\begin{split} W_{\omega_i}^{NP}(e - l_{\omega_i}, l_{\omega_i}; L) = & \omega_i \left\{ q \left[R \left[e - l_{\omega_i} - \frac{c - l_{\omega_i}}{p(L)} \right] \right] \right. \\ & + (1 - q) \left[R \left[e - l_{\omega_i} + \phi \left(\phi'^{-1} \left(\frac{p(L)}{R} \right) \right) \right] + l_{\omega_i} - p(L) \phi'^{-1} \left(\frac{p(L)}{R} \right) \right] \right\}. \end{split}$$

The benefit from the agreement for a bank in jurisdiction i can be expressed as the marginal benefit from additional foreign liquidity times the change in foreign liquidity and an adjustment term that accounts for the non-linearity in the marginal benefit. The latter two components are aggregated into $\Psi(\Delta l_k)$:

$$\mathrm{Benefit}_{i} = \underbrace{\left[\underbrace{\left(\frac{R}{p}qx_{\omega_{i}}^{S} - (1-q)x^{D}\right)}_{>0} + (1-q)\underbrace{\left(R\phi'\left(\cdot\right) - p\right)}_{=0}\frac{\partial x^{D}}{\partial p}\right]\frac{\partial p}{\partial L}\sum_{k}\omega_{k}}_{MB_{i} = \frac{\partial\left(W_{\omega_{i}}^{NP}/\omega_{i}\right)}{\partial l_{k}}}$$

Foreign bank-specific liquidity is defined as $l_k = \sum_k l_{\omega_k}$. For the above equation I assumed that all jurisdictions i do not participate in the agreement, which implies that $\frac{\partial L}{\partial l_k} = \sum_k \omega_k$. The term $\Psi(\Delta l_k) > 0$ accounts for the fact that (i) jurisdictions k might be willing to increase their liquidity by more than a marginal unit, which emerges if there is more than one jurisdiction k and (ii) that the marginal benefit from foreign liquidity changes with Δl_k . The benefits from an agreement are strictly positive (see proof of Proposition 4).

Regarding the costs from regulation, notice that when $\omega_i \to 0$, the first order condition of a bank in jurisdiction *i* corresponds to the first order condition in the competitive

equilibrium, which is independent of domestic liquidity. Therefore, the costs from additional domestic liquidity corresponds to the marginal cost times the change in liquidity:

$$\operatorname{Cost}_{i} = \underbrace{-\left(1 - q - R + q \frac{R}{p}\right)}_{MC_{i} = -\frac{\partial \left(W_{\omega_{i}}^{NP}/\omega_{i}\right)}{\partial l_{\omega_{i}}}} \Delta l_{\omega_{i}}.$$

Because $p > p^{CE}$, the marginal costs are strictly positive regardless of how much additional domestic liquidity is provided. I subsequently show that the marginal costs associated with increasing domestic liquidity exceed the benefits from additional foreign liquidity for a bank in jurisdiction i when $\sum_k \omega_k$ is small, thus preventing cooperation:

$$\left(\frac{R}{p}qx_{\omega_i}^S - (1-q)x^D\right)\frac{\partial p}{\partial L}\sum_k \omega_k \Psi(\Delta l_k) < -\left(1-q-R+q\frac{R}{p}\right).$$

I utilize the following features: (i) the functional form of ϕ for asset demand; (ii) the observation that $l_{\omega_i}^{NP}=0$ since $\omega_i<\overline{\omega}$, which implies that $x_{\omega_i}^S=c/p$; and (iii) the observation that $\frac{\partial p}{\partial L}=\frac{q}{1-q}$. The previous inequality is then equal to:

$$\left(\frac{R}{p}q\frac{c}{p} - (1-q)\left(\frac{R}{p} - 1\right)\right)\frac{q}{1-q}\sum_{k}\omega_{k}\Psi(\Delta l_{k}) < R - 1 + q - q\frac{R}{p}.$$
(E.1)

Both the left and right hand side of the equation are positive. However, the left hand side converges to zero if $\sum_k \omega_k \to 0$. I can therefore define $\tilde{\omega}$ such that:

$$\left(\frac{R}{p^{NP}}q\frac{c}{p^{NP}}-(1-q)\left(\frac{R}{p^{NP}}-1\right)\right)\frac{q}{1-q}\tilde{\omega}\Psi(\Delta l_k)=R-1+q-q\frac{R}{p^{NP}}.$$

Thus if $\omega_i \to 0$ and $\int_i \omega_i > \tilde{\omega}$, or equivalently $\sum_k \omega_k < \tilde{\omega}$, then jurisdiction i has no incentive to join an international regulatory arrangement if all other jurisdictions i also do not join. Building on the continuity of the planner's problem, it follows that there must be a ω_i and ω_k satisfying $0 < \omega_i < \overline{\omega}$ and $\sum_k \omega_k < \tilde{\omega}$ that imply $\triangle_{\omega_i}^f < 0 \ \forall i$.

Proof of Lemma 5: I show that the marginal benefits from a flexible arrangement exceed the marginal costs for a bank in jurisdiction i when evaluated at the national planner equilibrium if: (i) $\omega_i \to 0$, (ii) $R \to 1$ and (iii) all other jurisdictions join. Based on the continuity of the planner's objective function it then follows that there must be a ω_i satisfying $0 < \omega_i < \overline{\omega} \ \forall \ i$ and $R < \overline{R}$ that leads to the same conclusion.

For reference the objective function of jurisdiction i is:

$$W_{\omega_{i}}^{NP}(e-l_{\omega_{i}}, l_{\omega_{i}}; L) = \omega_{i} \left\{ q \left[R \left[e - l_{\omega_{i}} - \frac{c - l_{\omega_{i}}}{p(L)} \right] \right] + (1 - q) \left[R \left[e - l_{\omega_{i}} + \phi \left(\phi'^{-1} \left(\frac{p(L)}{R} \right) \right) \right] + l_{\omega_{i}} - p(L) \phi'^{-1} \left(\frac{p(L)}{R} \right) \right] \right\}.$$

The marginal benefit for a bank in jurisdiction *i* from foreign liquidity is:

$$\frac{\partial \left(W_{\omega_{i}}^{NP}/\omega_{i}\right)}{\partial l_{k}} = \left[\underbrace{\left(\frac{R}{p}qx_{\omega_{i}}^{S} - (1-q)x^{D}\right)}_{>0} + (1-q)\underbrace{\left(R\phi'\left(\cdot\right) - p\right)}_{=0}\frac{\partial x^{D}}{\partial p}\right]\frac{\partial p}{\partial L'}$$

where $l_k = \sum_{k \neq i} l_{\omega_k}$. I made use of the assumption that $\omega_i \to 0$, which implies that $\frac{\partial L}{\partial l_k} = 1$. Further from asset demand it follows that $p = R\phi'$. The first term is strictly positive (see proof of Proposition 4).

The marginal costs from regulation for a bank in jurisdiction i when $\omega_i \to 0$ simply corresponds to the first derivative in the competitive equilibrium multiplied by minus 1:

$$-\frac{\partial \left(W_{\omega_i}^{NP}/\omega_i\right)}{\partial l_{\omega_i}} = -\left(1 - q - R + q\frac{R}{p}\right).$$

The derivative is zero when evaluated at p^{CE} , but since $p > p^{CE}$ in the national planner equilibrium, the marginal costs are positive. It then follows that the marginal benefits exceed the marginal costs if:

$$\left(\frac{R}{p}qx_{\omega_i}^S-(1-q)x^D\right)\frac{\partial p}{\partial L}>-\left(1-q-R+q\frac{R}{p}\right).$$

I subsequently utilize the following features: (i) the functional form of ϕ for asset demand; (ii) the observation that $l_{\omega_i}^{NP}=0$ since $\omega_i<\overline{\omega}$, which implies that $x_{\omega_i}^S=c/p$; and (iii) the observation that $\frac{\partial p}{\partial L}=\frac{q}{1-q}$. The previous inequality is then equal to:

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

Rearranging this equation implies:

$$Rc\frac{q}{1-q} + p^2\frac{1-R}{q} > 0.$$

The inequality holds if $R \to 1$. I subsequently show that $R \to 1$ does not violate the assumptions spelled out in Lemma 2. Otherwise, the asset market would not exist as prescribed. The two conditions in Lemma 2 require that:

$$qc \ge \left(R - \frac{qR}{R - 1 + q}\right)$$

$$\frac{c}{e} \le \frac{qR}{R - 1 + q}.$$

If $R \to 1$, the first constraint simplifies to $qc \ge 0$ and the second to $\frac{c}{e} \le 1$, both of which are always satisfied since 0 < c < e. Thus if $\omega_i \to 0$ and $R \to 1$, jurisdiction i joins an international regulatory arrangement if all other jurisdictions also join. Building on the continuity of the planner's problem, it follows that there must be a ω_i and R satisfying $0 < \omega_i < \overline{\omega}$ and $R < \overline{R}$ with $\Delta_{\omega_i}^f > 0$.

Proof of Lemma 6: I first show that the first order conditions of the optimal flexible arrangement:

$$\sum_{k}^{N} rac{\partial W_{\omega_{k}}^{NP}}{\partial l_{\omega_{i}}} = 0 \ orall \ i,$$

lead to $L^f = L^{GP}$. For reference the objective function of jurisdiction i is:

$$\begin{split} W_{\omega_i}^{NP}(e-l_{\omega_i},l_{\omega_i};L) = & \omega_i \bigg\{ q \left[R \left[e - l_{\omega_i} - \frac{c - l_{\omega_i}}{p(L)} \right] \right] \\ & + (1-q) \left[R \left[e - l_{\omega_i} + \phi \left(\phi'^{-1} \left(\frac{p(L)}{R} \right) \right) \right] + l_{\omega_i} - p(L) \phi'^{-1} \left(\frac{p(L)}{R} \right) \right] \bigg\}. \end{split}$$

The first order conditions of the optimal flexible contract can be decomposed into two parts. The derivative of $W_{\omega_i}^{NP}$ with respect to l_{ω_i} :

$$\frac{\partial W_{\omega_i}^{NP}}{\partial l_{\omega_i}} = \omega_i \left\{ 1 - q - R + q \frac{R}{p} + \left[\frac{R}{p} q x_{\omega_i}^S - (1 - q) x^D \right] \frac{\partial p}{\partial L} \omega_i \right\},\,$$

and the derivative of $W_{\omega_k}^{NP}$ with respect to l_{ω_i} :

$$\frac{\partial W_{\omega_k}^{NP}}{\partial l_{\omega_i}} = \omega_k \left\{ \left[\frac{R}{p} q x_{\omega_k}^S - (1 - q) x^D \right] \frac{\partial p}{\partial L} \omega_i \right\} \ \forall \ k \neq i.$$

The first order conditions of the optimal flexible contract therefore equal:

$$\sum_{k \neq i}^N \omega_k \left\{ \left[\frac{R}{p} q x_{\omega_k}^S - (1-q) x^D \right] \frac{\partial p}{\partial L} \omega_i \right\} + \omega_i \left\{ 1 - q - R + q \frac{R}{p} + \left[\frac{R}{p} q x_{\omega_i}^S - (1-q) x^D \right] \frac{\partial p}{\partial L} \omega_i \right\} = 0 \ \, \forall \ \, i.$$

Rearranging yields:

$$\omega_i \left\{ 1 - q - R + q \frac{R}{p} + \left[\frac{R}{p} q x^S - (1 - q) x^D \right] \frac{\partial p}{\partial L} \right\} = 0 \ \forall \ i,$$

where $x^S = \frac{c - \sum_{k}^{N} \omega_k l_{\omega_k}}{p} = \frac{c - L}{p}$. The first order condition for a global planner is:

$$1 - q - R + q \frac{R}{p} + \left[\frac{R}{p} q x^{S} - (1 - q) x^{D} \right] \frac{\partial p}{\partial L} = 0.$$

Because ω_i is just a constant it immediately follows that $L^f = L^{GP}$. Further notice that the objective function of a jurisdiction is linear in bank-specific liquidity. The specific allocation of $l^f_{\omega_i}$ across jurisdictions hence does not affect aggregate welfare as long as $\sum_i^N \omega_i l^f_{\omega_i} = L^f = L^{GP}$. The optimal flexible arrangement is therefore constrained efficient and achieves the same aggregate welfare as a global planner.

F. Appendix: Section 6

Proof of Proposition 7: I subsequently show that $\omega_i W_{\omega_i}^{GP*} > W_{\omega_i|Autarky}^{NP*}$ when $\omega_i > 0$, that is, the Law of Large Numbers applies. If $\omega_i \to 0$, autarky is dominated by accessing the asset market according to Lemma B1.

First, assume that $\gamma=0$. Without any losses from limited financial market depth, jurisdiction i chooses l^{GP} in autarky. To see this, notice that when $\gamma=0$, asset market clearing in autarky implies:

$$(1-q)\phi'^{-1}\left(\frac{p_{\omega_i}}{R}\right) = q\frac{c - L_{\omega_i}/\omega_i}{p_{\omega_i}},$$

where p_{ω_i} denotes the asset price in autarky. Based on the functional assumption on ϕ one obtains (see also Proof of Lemma 1):

$$\frac{\partial p_{\omega_i}}{\partial L_{\omega_i}} = \frac{q}{1-q} \frac{1}{\omega_i}$$
 and $\frac{\partial p_{\omega_i}}{\partial l_{\omega_i}} = \frac{q}{1-q}$.

Now consider the objective function of jurisdiction i:

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

subject to:

$$K_{\omega_i} + L_{\omega_i} = \omega_i E$$
.

After substituting K_{ω_i} with $\omega_i E - L_{\omega_i}$, the first order condition with respect to L_{ω_i} implies:

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

This first order condition and the asset market clearing condition are equivalent to a global planner once adjusted for size ω_i , which immediately implies that $l_{\omega_i} = l^{GP}$ and $p_{\omega_i} = p^{GP}$. In other words, jurisdiction i would implement the constrained efficient allocation when $\gamma = 0$. Therefore:

$$W_{\omega_i|Autarky_{\gamma=0}}^{NP*} = \omega_i W^{GP*}.$$

I subsequently show that an increase in γ reduces welfare:

$$\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial \gamma} = \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial \gamma}}_{<0} + \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial p_{\omega_{i}}}}_{>0} + \underbrace{\frac{\partial p_{\omega_{i}}}{\partial \gamma}}_{<0} + \underbrace{\left(\underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial p_{\omega_{i}}}}_{\partial p_{\omega_{i}}} + \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial L_{\omega_{i}}}}_{=0} + \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial L_{\omega_{i}}}}_{\partial \gamma} + \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial L_{\omega_{i}}}}_{OC} + \underbrace{\frac{\partial W_{\omega_{i}|Autarky}^{NP*}}{\partial L_{\omega_{i}}}}_{OC$$

The term in the parenthesis is zero, as it corresponds to the first order condition of a regulator with respect to liquidity in autarky. Regarding the first term notice that:

$$\frac{\partial W_{\omega_i|Autarky}^{NP*}}{\partial \gamma} = (1-q)\omega_i \left[\underbrace{\left(R\phi'(\cdot) - (1+\gamma(\omega_i))p_{\omega_i}\right)}_{=0} \frac{\partial x_{\omega_i}^D}{\partial \gamma} - p_{\omega_i} x_{\omega_i}^D \right] < 0.$$

Based on asset demand by intact banks it follows that $(1 + \gamma)p_{\omega_i} = R\phi'(\cdot)$. The first term in the large bracket is therefore zero and the derivative is consequently negative. Regarding the second term in equation (F.1) notice that:

$$\frac{\partial W^{NP*}_{\omega_{i}|Autarky}}{\partial p_{\omega_{i}}} = \omega_{i} \left\{ \underbrace{\left(\frac{R}{p_{\omega_{i}}} q x_{\omega_{i}}^{S} - (1-q)(1+\gamma(\omega_{i})) x_{\omega_{i}}^{D}\right)}_{>0} + (1-q) \underbrace{\left(R \phi'\left(\cdot\right) - (1+\gamma(\omega_{i})) p_{\omega_{i}}\right)}_{=0} \frac{\partial x_{\omega_{i}}^{D}}{\partial p_{\omega_{i}}} \right\} > 0.$$

The second term is zero. I subsequently show that the first term is larger than zero:

$$\frac{R}{p_{\omega_i}}qx_{\omega_i}^S - (1-q)(1+\gamma(\omega_i))x_{\omega_i}^D > 0 \iff \frac{R}{p} > 1+\gamma(\omega_i) \iff \frac{1}{\phi'(\cdot)} > 1.$$

The first transformation uses asset market clearing in autarky which implies that $qx_{\omega_i}^S=(1-q)x_{\omega_i}^D$. The second transformation rests on asset demand $(1+\gamma)p=R\phi'$. Notice that ϕ' is always less than one based on the assumption about ϕ . Therefore, $\frac{\partial W_{\omega_i|Autarky}^{NP*}}{\partial p_{\omega_i}}>0$. Lastly notice that market clearing in autarky with transaction fees implies:

$$p_{\omega_i} = rac{R}{1 + \gamma(\omega_i)} - rac{q}{1 - q}(\omega_i c - L_{\omega_i}^{NP}) rac{1}{\omega_i}.$$

Therefore, $\frac{\partial p_{\omega_i}}{\gamma} < 0$. Turning back to equation (F.1), one obtains $\frac{\partial W_{\omega_i|Autarky}^{NP*}}{\partial \gamma} < 0$, which immediately leads to $\omega_i W^{GP*} > W_{\omega_i|Autarky_{\gamma>0}}^{NP*}$ as $W_{\omega_i|Autarky_{\gamma=0}}^{NP*} = \omega_i W^{GP*}$.

G. Appendix: Section 7

In-depth analysis on the importance of banking sector size effects

This section adds further suggestive evidence on the importance of banking sector size effects by exploiting the implementation of the Basel Agreements among non-members. I first provide descriptive evidence, before turning to a formal regression analysis. I then analyze the liquidity coverage ratio of the Basel III agreement in more detail and show that a larger banking sector also determines liquidity regulation. This ties the empirical exercise more closely to the model.

Descriptive evidence: Figure G1 plots the Basel II Index for the year 2015, the last year of available data. Panel (a) focuses on non-member countries with a small

banking sector (proxied by domestic credit) while Panel (b) provides the distribution for non-members with a large banking sector. The threshold is based on the median. Clearly, many 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. A similar pattern arises for the Basel III agreement. Based on Figure G2, more than 60 percent of the countries with a small banking sector did not implement any Basel III guidelines, and no country with a small banking sector implemented more or equal than half of the components. In contrast, non-member countries with a larger banking sector were more open to the guidelines.

(a) Low Credit Countries

(b) High Credit Countries

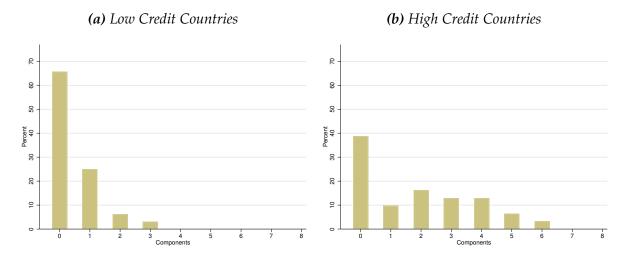
Figure G1: Basel II Implementation for Non-members as of 2015

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 Analysis – Variables: I estimate several ordered logit models with the Basel II or III Index as the dependent variable to assess the robustness of banking sector size effects. The main independent variable is the size of the banking sector which I proxy with the amount of domestic credit towards the private sector by banks in constant USD. I also account for the openness of an economy based on the degree of capital controls. The analytical framework in this paper emphasizes the international interlinkages of the domestic banking sector. As such, the size of the domestic banking sector as a determinant for international regulatory compliance only applies to countries with an internationally integrated financial sector.

I 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

Figure G2: Basel III Implementation for Non-members as of 2015



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.

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 illustrate this point, Israel and Panama 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 2015.²⁰

The literature stresses multiple factors that could determine regulatory stringency: different legal or political systems (Barth et al., 2006), different risk versus return trade-offs (Dell'ariccia and Marquez, 2006), varying profitability of the banking sector (Kara, 2016b), or market concentration (see, for example, Allen and Gale, 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

²⁰More formal evidence on this distinction is available in Tables G₄ and G₅ at the end of this section, 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.

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. This notion is supported by Aizenman (2009) who finds that prolonged periods of financial stability are associated with a lower regulation intensity. 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 whether market concentration affects financial stability and hence the need for regulation.

Regression Analysis – Results: Table G1 provides estimates from several ordered logit models. 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. 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 G7 and G8.²¹ Credit, institutional quality and GDP are further standardized. The concentration and return on asset measures are expressed in %.

Based on Table G1, 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

²¹Fixed 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.

Table G1: 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
O						(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%).

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 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 open jurisdictions. The explanatory power of the banking sector size should therefore primarily apply to open economies.²²

²²Emerging 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 G6. Capital controls are therefore not a substitute for traditional regulation. Domestic credit also does not explain the usage of capital controls.

Table G2: 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
O				(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
1116. 021						(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%).

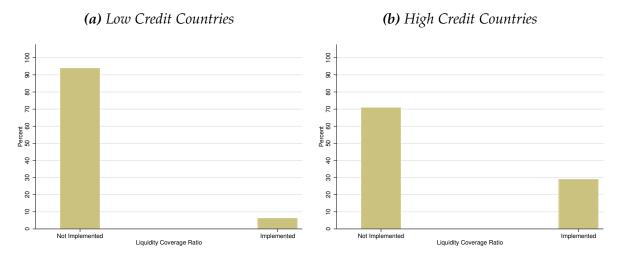
A closely related pattern emerges for Basel III standards. Results are displayed in Table G2. Domestic credit continues to be the dominant factor while proxies capturing alternative explanations in the literature are not able to predict the adoption of Basel III standards. However as column (9) suggests, 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 requirements were just about to be implemented in 2015, generally lower significance levels are somewhat expected.

Liquidity Coverage Ratio: 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 subsequently show that the overall size of the domestic banking sector is also positively associated with cooperation on liquidity regulation.

Figure G₃ splits the adherence to the Liquidity Coverage Ratio 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%).

This difference is further highly statistically significant as Table G₃ 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.

Figure G3: Liquidity Coverage Ratio: Implementation as of 2015



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.

Table G3: 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 $z = \frac{p_L - p_H}{SE}$.

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))

²³Basel 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.

Additional Tables and Figures

Table G4: 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)	(0.01)
Pseudo R ²	0.06	0.01)	0.01)

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 G5: 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 G6: 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	(0.05)
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 G7: 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

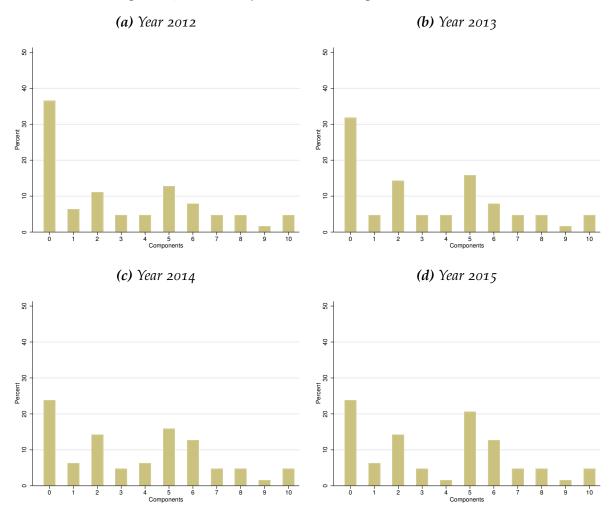
Notes: Dependent variable: Basel II Index. The Banking Crisis indicator is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) excludes economies with tight capital controls. Observations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

Table G8: 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
								-	

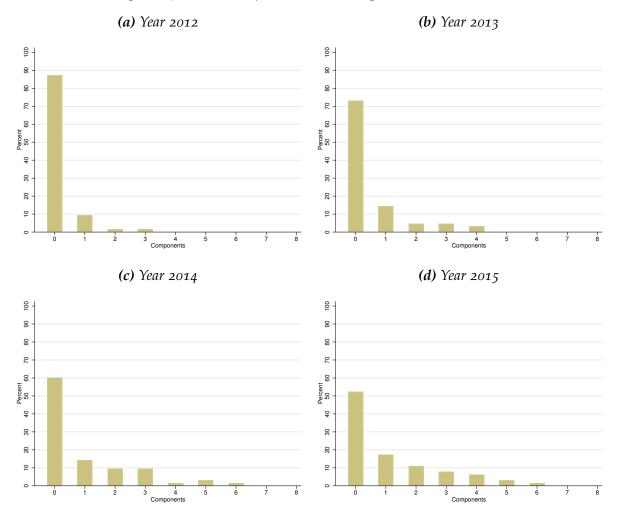
Notes: Dependent variable: Basel III Index. The Banking Crisis indicator is 1, if a country experienced a systemic banking crisis since 1990. Credit, institutional quality and GDP are standardized. Concentration and ROA are measured in %. Column (8) excludes economies with tight capital controls. Observations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

Figure G4: Basel II Implementation during the Years 2012-2015



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 G5: Basel III Implementation during the Years 2012-2015



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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