Heterogenous Regulation of Financial Institutions*

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Abstract

We consider a model where intermediaries specialize in two types of projects: standard projects with modest returns and new projects that are potentially more productive but are subject to an agency problem. There is a common market where intermediaries can trade in response to liquidity shocks. Individual intermediaries fail to hold efficient levels of liquidity in our model due to a liquidation externality. Regulation is sector-interdependent in that tighter regulation in one sector allows for looser regulation in the other sector. Optimally regulation across sectors is heterogeneous and implements lower activity restrictions at intermediaries carrying out new projects. The results have implications for the current discussion on the regulation of the non-bank financial system.

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1 Introduction

A principal lesson from the crisis of 2007-2009 is that seemingly different institutions can ultimately be exposed to the same risks. For example, funding mismatches and runs materialized in various parts of the financial system (investment banks, hedge funds, securitization vehicles, money market funds,...) and not only in the traditional commercial banking sector as the textbook case suggests. Different financial institutions also turned out to be exposed to similar risks on the asset side, for instance because they sourced credit risk through securitization products and credit derivatives.

The regulatory response so far has been to subjecting institutions to more similar regulation. This is based on the simple notion that similar risks should be regulated in the same way. The momentum for more homogenous regulation can be witnessed on several fronts: most investment banks are now also subject to traditional banking regulation, insurance company regulation is becoming more similar to banking regulation and there is a discussion of expanding bank-like regulation to the so-called shadow banking system. A move towards more homogenous regulation can also be justified by the pre-crisis experience, where differences in regulation across different entities led to wide-spread regulatory arbitrage (in the case of securitization activities, regulatory arbitrage was considered a key driver). Another reason for equalizing regulation across sectors is that institutions interact with each other, thus even if a part of the financial sector undertakes activities which – taken on their own – do not require regulation, there may be negative spillovers to another part that undertakes critical activities.

While there is thus a clear rationale behind these initiatives, there also some reasons for caution. To start with, if all entities are regulated in the same way, systemic risk may be amplified. Financial institutions will then all be constrained at the same time and a bank in troubles may not be able to turn to another one for support. Regulating all parts of the financial system similarly may also hinder desirable specialization – after all a key function of the market economy is to allow agents to specialize in their activities. Furthermore, if the increase in the reach of regulation results in a situation where there are no longer pockets left that are fairly lightly regulated, innovation in the economy may be discouraged. A final reason for why homogenous regulation may be undesirable is simply that they are essential differences in the activities undertaken in the financial system, and each activity may require a specific approach to regulation.

In this paper we consider a model of financial intermediation and systemic risk. The model is based on the familiar trade-off between return and liquidity: long-term investment delivers high returns but can turn out to be costly in the event of liquidity shocks. Individual bankers thus trade-off the returns from investing in long-term projects with the benefits from holding liquidity. Their choices, however, are not socially efficient because of a systemic liquidation externality: liquidation by one banker increases costs for all other bankers who have to liquidate. In an unregulated economy, bankers thus choose insufficient levels of liquidity.

The main innovation is the introduction of two "sectors". There is a traditional sector which runs standard projects. There are no costs to starting these projects and they deliver a fair return. This sector can be interpreted as commercial banking. Then there is a sector running new projects. These projects require a start-up cost but are more productive once operating. The success of these projects, however, is dependent on the incentives of their operators: bankers have to find it worthwhile to exert effort.[1] We can interpret these projects as activities carried out by hedge funds, private equity funds or investment banks. Bankers are free to choose which sector they want to operate in. While each sector is subject to liquidity shocks, systemic risk has an economy-wide dimension as the two sectors interact with each other. First, there can be negative spillovers during crisis as liquidity shortages in one sector that cause liquidations also affect the other sector. Second, sectors can trade with each other, allowing one sector to supply liquidity to another sector in the case of a shortage.

Financial regulation has to address several challenges in this setting. First, it should ensure an efficient provision of liquidity in the economy. Second, it should strive for an efficient allocation of capital across sectors, in the sense that the productivity of capital is equalized and that the new sector can recoup the fixed costs. Third, it has to make sure that the sector running new projects is regulated in a way that does not undermine incentives. Finally, the relative size of the two sectors (that is, the proportion of bankers operating standard and new projects) should be brought in line with the efficient size.

We derive the following results. Regulation that imposes identical limits on investments (or, equivalently, identical liquidity requirements) for all bankers is not efficient. Essen-

[1] One interpretation of this is financial innovation. Intermediaries with the right incentives may come up with products that enhance value for society, but may also produce efficiency-reducing financial instruments.

tially, uniform regulation causes a trade-off. By limiting investment, it can enforce optimal liquidity holdings in the economy and correct the distortion arising from the liquidation externality (which does not differ across projects). However, doing so results in inefficiencies. First, new projects can no longer operated at a higher scale than standard projects, which is undesirable given the productivity differences. Second, uniform regulation reduces rents for all bankers, which may result in new bankers no longer undertaking effort.

We next consider two independent regulators who, maximizing welfare in their sector, each setting a scale limit. While this allows for heterogenous regulation, it does not yield an efficient outcome. One of the reasons for this is that sector-regulators implement the correct amount of liquidity in their sector but not for the economy. In particular, they do not take account how changes in liquidity holdings affect the other sector via the liquidation externality and via the market for liquidity. The resultant liquidity levels can either be too small but also too large. Simply put, as systemic risk has an economy-wide component in our model, regulators focused on a part of the financial system cannot implement an efficient outcome.

In what follows we consider heterogenous regulation by a single regulator, maximizing welfare in the economy. Since project choices are not observable, the regulator has to offer a menu two bankers. We consider a menu where a regulator offers two choices: a bank can either operate under a lenient scale limit, or under a more restrictive regulation accompanied by a lump-sum payment. We find that such regulation can implement efficiency. Bankers intending to operate the new project will self-select into the light option (this option is relatively more attractive for new bankers as they benefit more from undertaking the project at a high scale) and standard bankers select the restrictive menu. Optimal regulation sets the difference in scale limits across sectors to ensure that capital is allocated efficiently across projects (requiring higher limits in the new sector) and to ensure that bankers in the new sector undertake effort (again, requiring higher limits in the new sector). The average scale level will be set such that liquidity holdings in the economy are efficient. Finally, the lump-sum payment is chosen to make it worthwhile for bankers to operate standard projects; its size has to reflect differences in the liquidation externality across sectors, arising from differences in scales.

We note that the optimal outcome has a resemblance to the status-quo in the financial system: a heavily regulated part of the financial system (commercial banks) co-exists with a lightly regulated part (e.g., hedge funds). Plus, tighter restrictions at the activity level in the heavily regulated sector (e.g., capital requirements) are accompanied by subsidies at the institutional level (deposit insurance, bailouts, access to the discount window) – thus creating a balance between different sectors. It should also be noted that under the optimal outcome, similar activities are regulated differently (in our model, each project causes the same external effects, and hence by itself would not require differential regulation), opening the door to regulatory arbitrage.

Our results can also be understood in terms of comparative advantages. In our setting, the new sector has a comparative advantage in carrying out illiquid projects – once the fixed cost has been incurred. Thus, this sector should have a focus on projects and not on holding liquidity. Without adjustments in the standard sector, this would reduce liquidity in the economy below the efficient level. In fact, one can show that relaxing regulation in one sector requires a tightening of regulation in the other sector. Thus in order to allow the new sector to operate at riskier levels, the standard sector has to become safer and hold more liquidity. Loosely speaking, the standard sector acts as a backstop for the risky new sector.

1.1 Literature

An important branch of the rapidly expanding literature on systemic risk has examined the interaction among different financial sectors, and how regulation can affect it. In Allen and Carletti (2006) and Allen and Gale (2005), credit risk transfer between the banking sector and the insurance sector can cause spillbacks to the banking sector when there are failures in the insurance sector. This is because following the transfer of risk, the insurance sector invests in the same assets as the banking sector. When there is a systemic event in the insurance sector, these assets are then liquidated. This depresses their price and can, in turn, cause bankruptcies in the banking sector. Similar interactions, arising because of a common market for liquidity across sectors and liquidation externalities, also appear in our model and are of a two-way nature (that is, risk in the banking sector can also affect other sectors).

Plantin (2015) shows that if shadow banking cannot be perfectly regulated, it may be optimal not to regulate traditional banking system too much because risk is then pushed in shadow banking system. In Ordonez (2013), shadow banking spurs when outside investors believe that capital requirements are not critical to guarantee the quality of banks' assets (reputation concerns discipline bank behavior). However, reputation concerns collapse when bad news about the future arise. Investors stop believing in the self-discipline of banks, moving their funds to a less efficient, but safer, traditional banking. Harris, Opp, and Opp (2014) develop a model in which capital requirements for banks may be counterproductive. Capital requirements reduce the funding capacity of banks. This spurs entry by nonbanks in the business of lending to good borrowers. This induces banks to focus on lending to bad borrowers for which their profits are generated by the government put, rather than by the intrinsic value of the projects that they fund. While these papers identify reasons why tight regulation of banks in the presence of other sectors may not be desirable, in our paper it is precisely the presence of other sectors that increase optimal capital requirements for banks.

Wheras our paper empasizes heterogeneity in regulation, the rapidly expanding literature on systemic risk has touched on other aspects of heterogeneity. For one, it has been shown that herding among banks – which can be seen as lowering diversity – can increase systemic risk (e.g., Acharya and Yorulmazer, 2007). It has also been pointed out that diversification creates a tension with diversity by requiring agents to invest in similar portfolios (Haldane and May (2011), Wagner (2011) and Allen et al (2012)). Excessively similar portfolios may also be the result of recent policies aiming at limiting the credit cycle (Horvath and Wagner (2015)). Farhi and Tirole (2012) show that strategic complementarities on the liability side can also result in excessive risk. In addition, informal arguments have been brought forward that homogenization of risk management systems (Persaud (2000) and Danielsson (2013)) can have detrimental effects, effectively by making agents in the financial system more similar.

Our analysis also relates to part of the banking literature that analyzes outcomes when there are different regulators (for example, because they are different jurisdictions). This literature has demonstrated that this may result in heterogenous outcomes and inefficiencies. Dell'Arricia and Marquez (2006) show that competition between national regulators can lead to lower capital adequacy standards, since national regulators do not take into account the external benefits of higher capital adequacy standards in terms of higher stability in other countries. Acharya (2003), however, shows that coordinating capital adequacy ratios across countries without coordinating on other dimensions of the regulatory framework can have detrimental effects. Holthausen and Ronde (2002) consider cooperation between home and host country supervisor on the intervention decision for a multinational bank. Given that national regulators represent national interests, a misalignment of interests leads to suboptimal exchange of information and distorted intervention decisions. Our paper differs in that the main analysis considers a single regulator who in principle can regulate all entities – but may optimally chooses not to do so.

2 The model

The economy has three dates $(0, 1, 2)$ and a measure one of risk-neutral bankers. Each banker is endowed with two investment opportunities. We assume that a bank's liability side is given: a bank has one unit of funds of which e $(\in (0,1))$ is in equity and $1-e$ in demandable deposits. Deposits are insured and carry an interest rate of zero.

There is a standard (short-term) storage technology, which allows to transfer one unit of goods from one to the next period (the *liquid* technology). In addition, there are two (long-term) investment technologies. The *traditional* technology allows to operate a project which returns $f(y)$ at date 2 for an investment of y $(y > 0)$ at date 0. We assume that $f(0) = 0$, $f'(y) > 0$, $f''(y) < 0$. The *advanced* technology returns $f(y) + by$ $(b > 0)$ at date 2 for an investment of y, but requires a fixed investment cost of $k > 0$ at date 0. We assume that $b > k$, that is, the advanced project dominates the traditional one if operated at a sufficiently large scale. The advanced technology, however, is subject to an incentive problem. At $t = 1.5$, a banker can extract a private benefit B (> 0) from the project in case there was no liquidation of the project at $t = 1$. If the private benefit is extracted (interpreted as the banker not undertaking effort), the technology returns zero at $t = 2$. Bankers can only operate one type of long-term technology (traditional or advanced). We also assume that the choice of the project types (traditional or advanced) is not observable but the project scale y is (this is tantamount to assuming that liquidity holdings can be observable).

At $t = 1$ there is a technology for liquidating projects. The technology allows to turn $1+\gamma$ units of output at date 2 into 1 unit at date 1. The lost output γ can be interpreted as the cost of liquidation. This liquidation cost depends on the total amount of liquidations in the economy, denoted with l. We assume that $\gamma(0) = 0$, $\gamma'(l) > 0$ and $\gamma''(l) > 0$. Individual bankers take γ as given, which creates an externality. This can be thought of as the result of fire-sale externalities or complementarities in production.

The economy is subject to liquidity risk (there is no fundamental risk). At date 1, there are two states of the world. With probability $1 - \pi$ $(\pi \in (0,1))$ the economy enters the "quiet" state and no depositor withdraws. With probability π there is a "crisis" and a mass λ ($\in (0,1)$) of depositors withdraws (we abstract from insolvency problems, hence there are no runs on banks by the entirety of depositors).

At date 1 there is a market where bankers can trade claims to date-2 returns. This market can be used to distribute liquidity from banks with liquidity surplus to banks with shortages.

3 The economy without incentive problems

For solving the model we consider parameters such that:

1. there are no insolvency problems as long as effort is exerted: date-2 output is always sufficient to satisfy the claims of late depositors. This condition can be assured by making equity e high enough.

2. we have interior solutions: i) the economy is invested in both long-term technologies, ii) each banker holds some liquidity, iii) there is a liquidity shortage in the crisis state.

3.1 First best

We first analyze the economy without the incentive problem and start by solving for the first best allocation.

An allocation is generally given by the choices of all individual bankers, consisting of the project undertaken (traditional or advanced), its scale and the amount of liquidity held. Because of concavity of production, it is not optimal that bankers operate the same technology with different scales, i.e., the investment scale for each project type is the same across bankers. We can hence summarize an allocation by the proportion of bankers operating traditional projects n ($n \in [0,1]$), the portfolios of these bankers, consisting of investment levels y_B and liquidity holdings x_B, and the portfolios of bankers operating advanced projects, y_F and x_F.

We first consider the liquidity problem arising in the crisis state. The liquidity shortage in this state is given total withdrawals by depositors, λ, minus the combined liquidity holdings of the two sectors, $nx_B + (1-n)x_F$:

$$l = \lambda - nx_B - (1-n)x_F. \tag{1}$$

When there is a liquidity shortage of l, $(1+\gamma(l))l$ units of date-2 output have to be converted in order to satisfy withdrawals at date 1. It follows that the cost due to liquidations in the economy is $\gamma(l)l$, which in expected terms is $\pi\gamma(l)l$.

Welfare is taken to be the surplus in the economy, which is given by the expected returns in the two sectors net of funding costs. The surplus generated by an individual project can be written as the excess return from investment absent liquidation problems, minus the expected cost due to liquidations. A traditional project generates surplus of $f(y_B) + x_B - \pi\gamma(l)(\lambda - x_B) - 1$, while surplus for an advanced project is $f(y_F) + by_F + x_F - k - \pi\gamma(l)(\lambda - x_F) - 1$. Aggregating gives us total surplus in the economy:

$$S = n(f(y_B) + x_B) + (1-n)(f(y_F) + by_F + x_F - k) - \pi\gamma(l)l - 1. \tag{2}$$

The optimization problem is hence given by

$$\max_{x_B, y_B, x_F, y_F, n} S(x_B, y_B, x_F, y_F, n), \text{ subject to} \tag{3}$$
$$x_B, y_B, x_F, y_F \geq 0,\ n \in [0,1],\ x_B + y_B = 1,\ x_F + y_F = 1,\ l = \lambda - nx_B - (1-n)x_F.$$

Substituting x_B with $1 - y_B$ and x_F with $1 - y_F$ in equation (2) we obtain an equation for surplus that is a function of the two scales, y_B and y_F, and the size of the traditional sector, n:

$$S = n(f(y_B) + 1 - y_B) + (1-n)(f(y_F) + by_F + 1 - y_F - k) - \pi\gamma(l)l - 1. \tag{4}$$

The first-order condition for the traditional project, y_B^*, is given by

$$f'(y_B) - 1 - \pi\gamma = \pi\gamma'(l)l. \tag{5}$$

The left-hand-side of this equation is the project-level gain from scaling up. The first term, $f'(y_B) - 1$, is the excess return from production absent liquidations. The second term, $-\pi\gamma$, arises because the liquidity shortage in a crisis state increases by one unit, and hence γ units of output are lost due to liquidation. The right hand side of the equation is the general equilibrium effect. It arises because the unit liquidation cost γ increases when more needs to be liquidated at $t = 1$, affecting all projects that undergo liquidation.

Similarly, the first-order condition for y_F is given by

$$f'(y_F) + b - 1 - \pi\gamma = \pi\gamma'(l)l. \tag{6}$$

Combining (5) and (6) we obtain $f'(y_B^*) = f'(y_F^*) + b$, implying lower scales in the traditional sector: $y_B^* < y_F^*$. This is because, once the fixed cost is incurred, the advanced project has higher productivity and hence it should be operated at higher scale. Lower scales for traditional projects in turn imply higher liquidity holdings for bankers undertaking these projects: $x_B^* > y_F^*$.

Finally, we have the first-order condition for n:

$$f(y_B) - y_B - (f(y_F) + by_F - y_F - k) + \pi\gamma(l)(y_F - y_B) = -\pi\gamma'(l)l(y_F - y_B). \quad (7)$$

The left hand side of equation (7) is the project-level gain of using the traditional technology as opposed to the advanced technology. This gain will be determined by differences in productivity (higher in the advanced sector), differences in scales (higher in the advanced sector), differences in liquidation costs (higher in the advanced sector because of higher scales) and the presence of the fixed cost in the advanced sector. The right hand side is the economy-wide effect arising because the per-unit liquidation cost changes when a banker switches to the traditional technology. This effect depends on the difference in scales in the two sectors $(y_F - y_B)$ – as scales determine liquidity levels and hence liquidations. Since liquidity holdings are higher in the traditional sector (and hence $y_F^* - y_B^* > 0$), liquidations decline when a banker switches to the traditional technology, and unit liquidation costs γ fall. The right-hand-side is thus negative at the efficient outcome. It follows that the project-level gain (the left-hand side) has to be negative as well. Intuitively, since a banker in the traditional sector causes lower negative external effects (by holding more liquidity), efficiency requires the project-level gains to be lower as well in this sector such that the benefits from carrying out the two technologies are equalized.

Is an interior equilibrium for n feasible? Consider the second derivative of surplus with respect to n:

$$S''(n) = -2\pi\gamma'(l)(y_F - y_B)^2 - \pi\gamma''(l)l(y_F - y_B)^2 < 0. \quad (8)$$

The derivative is negative for the following reason. Bankers in the traditional sector are less affected by the liquidation costs γ as they have lower liquidations $(\lambda - x_B^* < \lambda - x_F^*)$. Thus as n increases and liquidation costs γ fall, the benefit from operating a traditional project as opposed to an advanced project declines. Similarly, as n decreases the marginal liquidation costs γ' decline, again benefitting the operation of traditional project less than advanced projects. The problem is thus concave in n, allowing for an interior solution.

Proposition 1 *In the first best allocation*

(i) the advanced sector has higher scales ($y_F^* > y_B^*$) but lower liquidity is lower in the advanced sector ($x_F^* < x_B^*$),

(ii) productivity is equalized across projects ($f'(y_B^*) = f'(y_F^*) + b$),

(iii) project-level surplus is higher in the advanced sector ($f(y_F^*) + by_F^* + 1 - y_F^* - k - \pi(\lambda - (1 - y_F^*)\gamma > f(y_B^*) + 1 - y_B^* - \pi(\lambda - (1 - y_B^*))\gamma$).

Proof. *(i)-(iii) follow directly from (5)-(7).* ■

The reason behind these results can be summarized as follows. First because of the higher productivity of advanced projects, when operating these projects it is optimal to scale them up more. This implies that bankers operating advanced technologies should hold less liquidity; traditional bankers thus have to hold more. Put differently: the advanced sector has an advantage in investing, resulting in the traditional sector having a comparative advantage in holding liquidity. Note, however, that even though the per-banker liquidity holdings are lower in the advanced sector ($x_F^* < x_B^*$), this does not mean that total liquidity held by this sector is less than liquidity in the traditional sector ($(1 - n^*)x_F^*$ may be smaller or larger than $n^*x_B^*$). If the advanced sector is large relative to the traditional sector (this will for example occur when k is small), it may hold more liquidity overall.

Second, the gains from carrying out projects (i.e., the project-level surpluses) are not equalized across sectors. In principle, there are two offsetting effects on investment productivity. First, for given scale, productivity is always higher in the advanced sector. However, this is offset by the fact that in the advanced sector scales are larger, driving down returns (as the production function is concave). Overall, productivities are not equalized at the efficient outcome because external effects are higher in advanced sector.

While we have analyzed the problem that optimizes allocations in both sectors, it is interesting to also consider a situation where only scales in, say, the traditional sector can be chosen. In this case, it is easy to see that optimal scales (and also thus liquidity holdings) across sectors are interdependent. Consider for example an (exogenous) increase in the investment scale in the advanced sector, y_F. This will lead to an increase in the liquidation cost γ in the economy, and from (5) we can see that this lowers the optimal scale in the traditional sector. Investment levels (or alternatively, liquidity levels) in both sectors are thus substitutes. The reason is that liquidation costs are driven by economy-wide shortages, and not shortages specific to an individual sector.

3.2 Laissez-faire equilibrium

We now solve for the equilibrium. At date 1, the interbank market opens. In the quiet state, no depositor withdraws and there is an excess of liquidity at the aggregate level. The price of liquidity (expressed in terms of date-2 output) is then determined by the return on storage – which is one. There is hence no cost to a liquidity shortage (which may occur at an individual bank), nor a benefit to having spare liquidity. In the crisis state, there has to be an (aggregate) liquidity shortage (otherwise liquidity holders never obtain excess returns, making holding liquidity inefficient, see Allen and Gale, 2000). Arbitrage then equalizes the price of liquidity to the cost of liquidation $(1+\gamma)$.

A banker's overall return is given by the return on his portfolio absent liquidations, less any cost due to liquidations, and less repayment to depositors. In expected terms the liquidations costs are $\pi\gamma(\lambda-(1-y_s))$ ($s \in \{B, F\}$) (in case a banker has chosen a sufficiently high level of liquidity, this expression can also be negative). Using $x_s = 1 - y_s$, we thus have for the expected return for a banker in the traditional and in the advanced sector:

$$v_B = f(y_B) + 1 - y_B - \pi\gamma(\lambda - (1-y_B)) - (1-e), \tag{9}$$

$$v_F = f(y_F) + by_F + 1 - y_F - k - \pi\gamma(\lambda - (1-y_F)) - (1-e). \tag{10}$$

An equilibrium can be characterized by the variables $(\widetilde{n}, \widetilde{x}_B, \widetilde{y}_B, \widetilde{x}_F, \widetilde{y}_F)$ such that no banker can improve his expected return by either switching technology, or by adjusting his portfolio mix (changing the project scale).

Definition 1 *An equilibrium consists of a quintuple* $(\widetilde{x}_B, \widetilde{y}_B, \widetilde{x}_F, \widetilde{y}_F, \widetilde{n})$ *with*

(i) $v_B(\widetilde{y}_B) \geq v_B(y)$ *for all* $y \in [0,1]$,

(ii) $v_F(\widetilde{y}_F) \geq v_F(y)$ *for all* $y \in [0,1]$,

(iii) $v_B(\widetilde{y}_B) \geq v_F(\widetilde{y}_F)$ *if* $\widetilde{n} > 0$ *and* $v_B(\widetilde{y}_B) \leq v_F(\widetilde{y}_F)$ *if* $\widetilde{n} < 1$,

(iv) $\widetilde{x}_B, \widetilde{y}_B, \widetilde{x}_F, \widetilde{y}_F \geq 0$, $\widetilde{n} \in [0,1]$, $\widetilde{x}_B + \widetilde{y}_B = 1$, $\widetilde{x}_F + \widetilde{y}_F = 1$.

The first order conditions for the two scales are

$$f'(y_B) - 1 - \pi\gamma = 0, \tag{11}$$

$$f'(y_F) + b - 1 - \pi\gamma = 0. \tag{12}$$

These conditions are identical to the conditions for efficiency, (5) and (6), except that the term on the right-hand-side is missing. We hence have that $f'(\widetilde{y}_s) < f'(y_s^*)$ and thus

$\widetilde{y}_s > y_s^*$, that is, in equilibrium, all bankers invest more in projects (and hold less liquidity) than in the first best. The reason is the liquidation cost externality (an individual banker ignores the impact of investment on the unit-liquidation costs γ). From (11) and (12) it also follows that we have $f'(\widetilde{y}_F) + b = f'(\widetilde{y}_B)$ (the same condition than under efficiency) and hence that $\widetilde{y}_F > \widetilde{y}_B$ and $\widetilde{x}_B < \widetilde{x}_F$. Thus advanced bankers still scale up more than traditional bankers.

In an interior equilibrium, individual bankers have to be indifferent between operating the advanced and the traditional technology, that is $v_B(\widetilde{y}_B) = v_F(\widetilde{y}_F)$. This condition writes

$$f(\widetilde{y}_B) - \widetilde{y}_B - (f(\widetilde{y}_F) + b\widetilde{y}_F - \widetilde{y}_F - k) + \pi\gamma(\widetilde{y}_B - \widetilde{y}_F) = 0. \tag{13}$$

The left hand side of this equation is identical to the condition for n^*, equation (7). However, the right-hand-side of equation (7), $(-\pi\gamma'(l)l(y_F - y_B))$, which is the effect arising through a change in the liquidation cost γ, is missing again. As traditional projects are operated with lower scales (and higher liquidity holdings), this term is negative $(-\pi\gamma'(l)l(\widetilde{y}_F - \widetilde{y}_B) < 0)$: a banker turning from the advanced to the traditional technology increases the net supply of liquidity and lowers liquidation costs. This effect is ignored by individual bankers and hence the mass of bankers operating traditional projects will be below the efficient amount.

Proposition 2 *In equilibrium we have that*

(i) the aggregate amount of liquidity is inefficiently low ($\widetilde{x} < x^*$),

(ii) the advanced sector is inefficiently large ($\widetilde{n} > n^*$),

(iii) the productivity of projects is equalized ($f'(y_B) = f'(y_F) + b$).

Proof. *Follows from comparing (11)-(13) with (5)-(7).* ■

3.3 Economy with regulation

Proposition 2 shows that the equilibrium is inefficient, hence there is scope for policy. In this section we analyze several types of policies.

3.3.1 Uniform scale limits

We first consider a policy that limits risk-taking by putting a cap on the amount bankers can invest in the long-term project. This cap is identical for both sectors. Note that in our model this policy is equivalent to a (single) liquidity requirement.

We denote the limit on project scales with $\overline{y}$. Following the announcement of the policy $\overline{y}$, bankers choose again the project to operate and its scale. Compared to the laissez-faire, an equilibrium now has to fulfill the additional condition that scales satisfy $\widetilde{y}_B, \widetilde{y}_F \leq \overline{y}$.

Proposition 3 *A single scale limit cannot achieve the first best.*

Proof. *Proof by contradiction. The first best requires to implement y_B^* for traditional projects. From (5) and (9) we have that $v_B'(y_B^*) > 0$, that is, at the efficient scale for traditional projects (y_B^*) a banker operating the traditional technology would like to invest more. Efficiency hence requires to set the scale limit to $\overline{y} = y_B^*$. It follows that a banker with an advanced project has to choose $y_F \leq \overline{y} = y_B^*$, which is below the efficient amount for this project because of $y_B^* < y_F^*$, thus contradicting efficiency.* ■

The explanation for this policy failure is simple. Bankers would like to choose a scale that exceeds the efficient one for their project. Thus (binding) scale restrictions are needed at both projects to obtain efficiency. But since optimal scales differs across sectors, there is no scale that can implement efficient levels simultaneously.

3.3.2 Two regulators

We now allow for heterogenous regulation, chosen by two independent regulators. Each regulator is responsible for bankers undertaking projects of a given type (this can be interpreted as different sectors of the financial system being regulated by their own regulator). Regulators maximize surplus for their sector, taking regulation in the other sector as given. We also assume that regulators take the relative size of sectors (that is, n) as given.[2]

The regulator in the traditional sector thus sets $\overline{y}_B$ to maximize

$$S_B|_{n=\overline{n}, y_F=\overline{y}_F} = n(f(y_B) + x_B - \pi\gamma(\lambda - x_B) - 1), \tag{14}$$

while the regulator in the advanced sector sets $\overline{y}_F$ to maximize

$$S_F|_{n=\overline{n}, y_B=\overline{y}_B} = (1-n)(f(y_F) + by_F + x_F - \pi\gamma(\lambda - x_F) - 1). \tag{15}$$

[2] Otherwise the problem arises that a regulator's action will also affect surplus by changing the size of his sector. This is will add a new element to the optimization problem: for given per-bank surplus regulators will then want to undertake actions that make their sector larger (which may or may not be a plausible assumption).

Proposition 4 *Scale restrictions set by two regulators result in an inefficient allocation.*

Proof. *The first-order conditions for the regulator in the traditional and advanced sector are given by*

$$f'(y_B) - 1 - \pi\gamma = \pi\gamma'(l)l_B, \tag{16}$$

$$f'(y_F) + b - 1 - \pi\gamma = \pi\gamma'(l)l_F, \tag{17}$$

where $l_B = n(\lambda - x_B)$ *and* $l_F = (1-n)(\lambda - x_F)$ *are the total liquidity shortages arising for bankers undertaking traditional and advanced projects, respectively. Comparing to (11) and (12), equations (16) and (17) only coincide with efficiency if* $l_B = l_F = l$*, which can only be the case when aggregate liquidity shortages are* 0*, contradicting our assumption of positive aggregate liquidity shortages.* ■

The reason why an economy with two regulators is inefficient is the following. Even though a regulator takes into account that higher scale for his projects increases costs in his sector due to higher γ, he does not take into account that higher cost of liquidation also have an effect on the other sector. He thus only partially internalizes the liquidation externality. Interestingly, this does not necessarily lead to excessive risk-taking in each sector. Consider that there is a liquidity surplus in the traditional sector ($l_B < 0$) in the crisis state. We then have that the liquidity shortage in the advanced sector exceeds the aggregate shortage ($l_F > l$). Equation (17) shows that the regulator in the advanced sector then perceives higher liquidation costs than present in the overall economy ($\pi\gamma'(l)l_F > \pi\gamma'(l)l$). Efficitively, since there is a liquidity surplus in the traditional sector, higher liquidation costs put a *positive* externality on the traditional sector since bankers in this sector can then lend out their surplus liquidity at higher rates.

3.3.3 Menu

We now study heterogenous regulation implemented by a single regulator. Specifically, we consider a regulator offering two menus to bankers: A light menu and a restrictive menu, associated with respective scaling restrictions $\overline{y}_F$ and $\overline{y}_B$ ($\overline{y}_F \geq \overline{y}_B$). The regulator offers also a lump-sum payment s_B for when a banker chooses the restrictive menu.

The menu $(\overline{y}_F, \overline{y}_B, s_B)$ is announced at the beginning of $t = 0$. Following this, bankers choose which option to take, and then decide upon the project they want to operate, as well as how much they want to scale up. Note that project choices are not observed by the regulator; these choices have to be incentive compatible.

Proposition 5 *A menu consisting of two different activity restrictions ($\overline{y}_F > \overline{y}_B$) and a subsidy for the restrictive choice ($s_B > 0$) can implement the first best.*

Proof. *Consider the menu $\overline{y}_F = y_F^*$ (light choice), $\overline{y}_2 = y_B^*$ (restrictive choice) and a subsidy $s_B = \pi\gamma'(l^*)l^*(y_F^* - y_B^*) > 0$ associated with the restrictive choice. Since the advanced technology has higher productivity ($v_F(y) > v_B(y)$), a banker's utility from choosing the light menu are higher than for the advanced technology ($v_F(y_F^*) - v_F(y_B^*) > v_B(y_F^*) - v_B(y_B^*)$). Thus in an equilibrium in which both menus are chosen, bankers that will operate the advanced technology choose the light menu and other bankers the restrictive menu. It follows that all bankers will choose efficient scales ($\widetilde{y}_B = y_B^*$ and $\widetilde{y}_F = y_F^*$). The condition that a banker is indifferent between the two menus is*

$$f(y_B^*) - y_B^* - (f(y_F^*) + by_F^* - y_F^* - k) - \pi\gamma(y_F^* - y_B^*) = -\pi\gamma'(l^*)l(y_F^* - y_B^*), \tag{18}$$

which is identical to the condition under efficiency (7). The considered menu thus implements the efficient allocation. ■

The gains from operating the advanced project (relative to the traditional project) increase when the scale is higher – this is true both from the banker's perspective but also from the social perspective. The less restrictive menu choice is thus relatively more valuable to bankers that want to operate the advanced technology, and this is at the same time also socially desirable. This explains why the menu can implement the right mapping between scales and project choices in the economy. The subsidy (which needs to be strictly positive) is needed to incentivize bankers to choose the traditional sector – as this sector is more regulated, bankers would otherwise populate only the advanced sector.

The problem of the optimal menu can conceptually be divided into two parts. A regulator can first set the two scales to achieve optimal production in the two sectors. Second, he can set the subsidy in order to affect the relative size of both sectors (a higher subsidy of course leads to a larger traditional sector). In this way he can implement any desired liquidity level as higher subsidies will correspond to more liquidity holdings.

Note that the menu described in Proposition 5 resembles the status quo in regulation. A heavily regulated sector (commercial banks) coexists with lightly regulated sectors (hedge funds, private equity, shadow banking). This seemingly allows for regulatory arbitrage as activities that have the same risk (the two projects) are regulated differently in each sector. At the same time, however, the traditional sector sector benefits from (explicit or implicit) subsidies (e.g., deposit insurance, bank bailouts and access to discount window), making it worthwhile for bankers to undertake activities in this sector as well.

3.3.4 Pigouvian tax

We finish the analysis of regulation by noting that the optimal allocation can also be implemented by means of price regulation (Pigouvian taxation). Compared to quantity restrictions, price regulation is less commonly observed in practice. However, in our setting it is particularly attractive since it can implement heterogeneity with a single tool.

Proposition 6 *A Pigouvian tax can implement the efficient allocation.*

Proof. *Consider a proportional tax* $\tau = \pi\gamma'(l^*)l^*$ *on investment in projects, regardless of project type (or, equivalently, a subsidy of* $\pi l^*\gamma'(l^*)$ *on holding liquidity). The first-order conditions for bankers that have chosen the chosen the traditional and the advanced project, respectively, are then:*

$$\begin{aligned} f'(y_B) - 1 - \pi\gamma - \tau &= f'(y_B) - 1 - \pi\gamma - \pi l\gamma'(l^*) = 0, && (19) \\ f'(y_F) + b - 1 - \pi\gamma - \tau &= f'(y_B) - 1 - \pi\gamma - \pi l\gamma'(l^*) = 0. && (20) \end{aligned}$$

It follows that at the first-best allocation ($y_B = y_B^*$, $y_F = y_F^*$)*, both first-order conditions are fulfilled. Consider next banker's choice of the project. Given that a banker's optimal choice when investing in the traditional and advanced sector (as just shown) is* y_B^* *and* y_F^**, respectively, he has to pay taxes of* $\pi\gamma'(l^*)l^*y_B^*$ *and* $\pi\gamma'(l^*)l^*y_F^*$ *when choosing either project. The indifference condition is then*

$$f(y_B^*) - y_B^* - (f(y_F^*) + by_F^* - y_F^* - k) + \pi\gamma(y_B^* - y_F^*) = -\pi\gamma'(l^*)l(y_F^* - y_B^*), \qquad (21)$$

which is identical to the condition for efficiency (equation (7)). ■

It should be noted that the reason why a single tax can implement the efficient allocation is due to a specificity in our setup: the externality arising from holding illiquid projects does not depend on the project type. If externalities where to differ (for example, liquidation of advanced projects may have a bigger effect on economy-wide liquidation costs), different taxes would be needed to implement efficiency. Menus with scale restrictions allow for implementing heterogeneity directly and are more robust to modifications of the setup.

4 Incentive constraint in the advanced sector

The incentive problem is now assumed to bind – the effort choice at $t = 1.5$ has to be incentive compatible. When a banker does not exert effort, he defaults at $t = 2$. Given limited liability his utility is then equal to the private benefit B. The condition that banker finds it optimal to exert effort at $t = 1.5$ is hence given by

$$f(y_F) + by_F + 1 - y_F - (1 - e) \geq B. \tag{22}$$

We assume that effort is socially desirable

$$f(y_F^*) + by_F^* + 1 - y_F^* \geq B, \tag{23}$$

but that the incentive constraint binds at the first best:

$$f(y_F^*) + by_F^* + 1 - y_F^* - (1 - e) < B. \tag{24}$$

From (22) we can see that increasing scale y_F (up to the private optimum $\widetilde{y}_F$) loosens the incentive constraint (this follows from $v_F'(y_F) > 0$ for $y_F < \widetilde{y}_F$). There can hence exist a unique $\widehat{y}^{IC}$ such that for $y_F < \widehat{y}^{IC}$ the IC is not fulfilled, while for $y_F \in [\widehat{y}^{IC}, \widetilde{y}_F]$ it is fulfilled. Intuitively, the banker needs to be allowed to operate the project at a sufficient scale to make effort worthwhile.

4.1 Second best outcome

We solve for the constrained efficient outcome, that is the efficient outcome given that a social planner has to respect unobserveability of effort. The optimization problem is the same as in Section 3.1, except that the social planner faces the additional constraint (22).

Denote the Lagrange multiplier associated with the incentive constraint

$$f(y_F) + by_F + 1 - y_F - (1 - e) - B = 0 \tag{25}$$

with ϕ. The conditions for efficient scale in the traditional sector and for efficient size of the traditional sector are unchanged (equations (5) and (7) still apply) but the condition for the project scale in the advanced sector becomes:

$$f'(y_F) + b - 1 - \pi\gamma + \phi(f'(y_F) + b - 1) = \pi l \gamma'(l). \tag{26}$$

Comparing to equation (6) we can see that investment in the advanced project has now an additional benefit, arising because higher scale alleviates the incentive constraint.

Proposition 7 *In the constrained-efficient allocation*

(i) scales in the traditional sector are lower than in the first best ($y_B^{*IC} < y_B^*$), while scales in the advanced sector are higher ($y_F^{*IC} > y_F^*$),

(ii) the traditional sector is larger ($n^{*IC} > n^*$).

Proof. *At the constrained-efficient allocation we have that $\phi^{*IC} > 1$, as the incentive constraint is assumed to be binding. It follows that at the first best allocation (Section 3.1) the first-order conditions for n and y_B are fulfilled but not the condition for y_F. Comparing (6) and (26) we can see that welfare is increasing in y_F at the first best allocation ($\frac{\partial S(n,y_B,y_F)}{\partial y_F}\Big|_{n=n^*,y_B=y_B^*,y_F=y_F^*} > 0$). Thus, the optimal scale in the advanced sector will be higher than the one for the first best allocation ($y_F^{*IC} > y_F^*$). Higher scale in the advanced sector will in turn cause second order effects. Consider first the scale in the traditional sector. The higher y_F will increase the liquidity shortfall in the crisis state l, and hence liquidation costs γ. From condition (5) we can see that this reduces the benefit of scale in the traditional sector ($\partial(\frac{\partial S}{\partial y_B})/\partial l < 0$), hence a lower scale becomes optimal ($y_B^{*IC} < y_B^*$). Consider next the relative size of the two sectors. From equation (7) we can see that the social benefit from allocating a banker to the traditional sector has increased (because of $\partial(\frac{\partial S}{\partial n})/\partial y_F > 0$ and $(\partial(\frac{\partial S}{\partial n})/\partial l) > 0$). This is because the incentive constraint results in a less efficient scale in the advanced sector ($y_F^{*IC} > y_F^*$) and because the advanced sector suffers more from the increased liquidation cost, lowering the expected return in this sector. It thus becomes optimal to run a larger traditional sector ($n^{*IC} > n^*$).* ■

The incentive problem thus leads to further specialization in the economy. Liquidity in the advanced sector is now more costly as it reduce economies of scale and worsens incentives. This makes it optimal to have relatively fewer liquidity in the advanced sector (which already had lower liquidity to begin with). Partially, the reduction in liquidity will be compensated by holding more of it in the traditional sector (in order to have liquidations cost going up too much). This results in lower scales in the traditional sector. In addition, operations in the advanced sector become now less valuable as the existence of the incentive constraint does no longer allow to implement the first best scale there. Hence the advanced sector should be reduced and the traditional sector enlarged.

Note that the optimal response to the incentive constraint is to make regulation more lenient, rather than tighter. Tight regulation worsens incentives by lowering scales, which in turn makes it less attractive for the banker to exert in the production process. Loosely speaking, regulation has to offer bankers in the advanced sector sufficient rents in order to ensure that this sector does not invest in inferior projects.

4.2 Equilibrium with regulation

The definition of an equilibrium with effort is identical to Section 3.2, except for the additional incentive constraint.

Definition 2 *An equilibrium with effort consists of a quintuple* $(\widetilde{n}^{IC}, \widetilde{x}_B^{IC}, \widetilde{y}_B^{IC}, \widetilde{x}_F^{IC}, \widetilde{y}_F^{IC})$ *with*

(i) $v_B(\widetilde{y}_B) \geq v_B(y)$ *for all* $y \in [0,1]$,

(ii) $v_F(\widetilde{y}_F) \geq v_F(y)$ *for all* $y \in [0,1]$,

(iii) $v_B(\widetilde{y}_B) \geq v_F(\widetilde{y}_F)$ *if* $\widetilde{n} > 0$ *and* $v_B(\widetilde{y}_B) \leq v_F(\widetilde{y}_F)$ *if* $\widetilde{n} < 1$,

(iv) $\widetilde{y}_F^{IC} \geq \widehat{y}^{IC}$,

(v) $\widetilde{x}_B, \widetilde{y}_B, \widetilde{x}_F, \widetilde{y}_F \geq 0$, $\widetilde{n} \in [0,1]$, $\widetilde{x}_B + \widetilde{y}_B = 1$, $\widetilde{x}_F + \widetilde{y}_F = 1$.

In what follows we focus directly on the question of whether regulation can achieve efficiency.[3] Proposition 8 shows that heterogenous regulation by means of a menu can achieve constrained-efficiency.

Proposition 8 *A menu consisting of two different activity restrictions* ($\overline{y}_F > \overline{y}_B$) *and a subsidy for the restrictive choice* ($s_B > 0$) *can implement the constrained efficient allocation.*

Proof. *Consider a menu with* $\overline{y}_F = y_F^{*IC}$ *and* $\overline{y}_B = y_B^{*IC}$ *and subsidy of* $s_B^{*IC} = \pi\gamma'(l^{*IC})l^{*IC}(y_F^{*IC} - y_B^{*IC})$. *We show that* $(y_B^{*IC}, y_F^{*IC}, n^{*IC})$ *with effort at* $t = 1.5$ *constitutes an equilibrium under this menu. As in the case without the incentive problems, bankers intending to operate the advanced technology will choose the light menu (and other bankers the restrictive menu) as productivity is higher for advanced projects. Recall first that the incentive constraint is fulfilled at the constrained-efficient scale* y_F^{*IC} *and hence an advanced banker that operates at the scale limit* $\overline{y}_F = y_F^{*IC}$ *finds it optimal to undertake effort. Consider, second, an advanced banker deviating from* y_F^{*IC} *by choosing* $y_F < y_F^{*IC}$. *In this case it is also optimal not to exert effort and the banker's pay-off is* B. *By equation (25)* B

[3] The incentive constraint creates an additional role for regulation because in the presence of deposit insurance the banker cannot be made to internalize the cost of default arising when he does not undertake effort. If there is no deposit insurance, it matters whether depositors can condition lending rates on the scale of the project chosen. If not, the same problem as with deposit insurance arises.

is not more than what he obtains from not deviating, hence he has no incentives to deviate. Third, traditional bankers also have no incentives to deviate by choosing a scale below their limit y_B^{*IC}, as y_B^{*IC} is lower than the privately optimal scale of the banker ($\widetilde{y}_B$). Finally, given that traditional bankers find it optimal to choose y_B^{*IC} and advanced bankers to choose y_F^{*IC} (and to exert effort), banker are indifferent among the two sectors:

$$f(y_B^{*IC}) - y_B^{*IC} - (f(y_F^{*IC}) + by_F^{*IC} - y_F^{*IC} - k) - \pi\gamma(y_F^{*IC} - y_B^{*IC}) = -\pi\gamma'(l^{*IC})l^{*IC}(y_F^{*IC} - y_B^{*IC}). \tag{27}$$

■

Compared to the analysis without incentive constraint, heterogeneous regulation has an additional benefit: by allowing to implement different scales across sectors it makes it easier to fulfill the incentive constraint. Regulation which requires a common scale would be very inefficient in this setting. In order to implement effort in the advanced sector, fairly lenient activity restrictions would be needed – but this would result in overall liquidity in the economy being low and the liquidation externality not being addressed.

Last we show that a (single) Pigouvian tax – to be paid at $t = 2$ – cannot implement the first best.

Proposition 9 *A Pigouvian tax cannot implement the first best.*

Proof. *Proof by contradiction. Suppose there exists a tax τ^{*IC} that results in an equilibrium $(y_B^{*IC}, y_F^{*IC}, n^{*IC})$ with effort. From equation (5) we have that in order for a traditional banker not to deviate from y_B^{*IC}, a tax of $\pi\gamma'(l^{*IC})l^{*IC}$ is needed. It follows that at y_F^{*IC} (defined by the condition for constrained-efficiency, $f'(y_F^{*IC}) + b - 1 - \pi\gamma + \phi(f'(y_F^{*IC}) + b - 1) = \pi l\gamma'(l)$), the private marginal benefit from scaling up is negative: $f'(y_F^{*IC}) + b - 1 - \pi\gamma - \pi l^{*IC}\gamma'(l^{*IC}) = -\phi(f'(y_F^{*IC}) + b - 1) < 0$. Thus efficient scale in the advanced sector cannot be implemented.* ■

The reason why a Pigouvian tax fails to reach efficiency is that we now have two independent distortions: the liquidation externality on other banks and the effort externality on depositors. The first distortion requires taxing investment in both sector sectors at the same rate, while the second distortion requires subsidizing investment in the advanced sector only (in order to incentivize bankers to choose a sufficiently high scale that makes effort worthwhile). This is not possible with a single instrument.

5 Conclusions and implications for policy

We have examined a model of systemic risk with two, interacting, financial sectors. A central result of the analysis is that regulation that applies uniformly across sectors can be inefficient by deterring specialization and by undermining rents required for effort or innovation. The optimal outcome can instead be achieved by heterogenous regulation, which offers a menu two bankers. Bankers self-select, resulting in two sectors operating projects at different scales and holding different levels of liquidity. Liquidity holdings in the economy overall, and the relative size of the two sectors, are nonetheless efficient.

The analysis offers useful thoughts for financial regulation:

1. There is a trend – taking place at several levels – to subject more and more financial institutions to the same type of regulation. While such regulation has certainly benefits, our paper suggest that there are also costs to this process.

2. Optimal regulation in our model is seemingly close to the status-quo. Lightly regulated parts of the financial system co-exist alongside a tightly regulated sector, combined with an institutional setting that provides subsidies for the latter. While differences in regulation are often seen as a weakness of the current financial architecture, our analysis shows that such differences can in fact be necessary to achieve an efficient outcome.

3. Differences in regulation of activities on one hand, and differences in subsidies at the institutional level on the other hand, have to be seen in conjunction. Individually, they each create inefficiencies. However, combined they can create a system that offers opportunities for specialization, while at the same time preserving incentives to also invest in liquid activities.

4. Regulation has to take place at the "meta" system level. Historically, different parts of the system were under the responsibility of independent regulators who were tasked with the objective of safeguarding the sector under their supervision. As systemic risk is not confined to individual sectors, this does not lead to efficient outcomes. Sector-focused regulation will ignore external effects on other parts of the financial system. This can result in both too lenient and too strict regulation.

5. Regulation across sectors is interdependent. Lighter regulation in one sector requires to be accompanied by stricter regulation in other sectors. This allows the creation of pockets of activities in the financial system that are fairly unregulated, if there is at the same time a “back-stop”, a heavily regulated sector.

6. Regulation should be based on comparative advantages. Some sectors have an advantage in carrying out risky activities, while others may have an advantage in holding and supplying liquidity. Regulators should focus on identifying these advantages, and design regulation to reflects them.

References

[1] Acharya, Viral (2003), Is the international convergence of capital adequacy regulation desirable?, Journal of Finance 58, 2745–2781.

[2] Acharya, Viral (2009). "A theory of systemic risk and design of prudential bank regulation," Journal of Financial Stability, 5, pages 224-255.

[3] Allen, Franklin and Elena Carletti (2006), 'Credit Risk Transfer and Contagion'. Journal of Monetary Economics 53, 89—111.

[4] Allen, Franklin and Douglas Gale (2005), 'Systemic Risk and Regulation'. In: M. Carey and R. Stulz (eds.): The Risks of Financial Institutions. Chicago University Press.

[5] Dell'Ariccia, Giovanni and Robert Marquez (2006): Competition Among Regulators and Credit Market Integration, Journal of Financial Economics 79, 401-30.

[6] Danielson, Jon (2013), "Towards a more procyclical financial system", VoxEU column 6 March 2013.

[7] Farhi, Emmanuel and Tirole, Jean (2012). "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts," American Economic Review, vol. 102, pages 60-93.

[8] Goodhart, Charles and Wolf Wagner, (2012). "Regulators should encourage more diversity in the financial system". VoxEU.

[9] Haldane Andrew and Robert M. May (2011). Systemic risk in banking ecosystems. Nature 469, 351–355.

[10] Harris, M., C. Opp, and M. Opp. 2014. Higher capital requirem ents, safer banks?, working paper.

[11] Horvath, Balint and Wolf Wagner (2015), "The Disturbing Interaction between Countercyclical Capital Requirements and Systemic Risk", mimeo Tilburg University

[12] Holthausen, Cornelia and Thomas Ronde (2002), Cooperation in International Banking Supervision: A Political Economy Approach, ECB Working Paper 315, European Central Bank.

[13] Ordonez Guillermo, 2015. "Sustainable Shadow Banking," NBER Working Papers 19022

[14] Persaud, Avinash (2000). “Sending the herd off the cliff edge: the disturbing interaction between herding and market-sensitive risk management models,” Jacques de Larosiere Prize Essay, Institute of International Finance.

[15] Plantin, Guillaume (2015), "Shadow Banking and Bank Capital Regulation", forthcoming Review of Financial Studies

[16] Wagner, Wolf (2011). Systemic Liquidation Risk and the Diversity-Diversification Trade-Off, Journal of Finance, 2011, Vol. 66, p. 1141-1175