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Self-Regulation and Stock Listing Decision of Banks

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Self-Regulation and Stock Listing Decision of Banks*

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March, 2017

Abstract

This paper studies the banks' decisions to self-regulate their activities and their selection of the financial markets where they raise their capital. We show that in an economy with a single financial market, self-regulation increases investors' demand for banks' stocks while weaker bank concentration reduces incentives to self-regulate. In addition, in an economy with separate financial markets, banks preferably raise capital in financial markets hosting larger number of investors. However, when self-regulation costs vary across financial places, banks may list their stocks in the country with the smaller number of investors.

Keywords: Endogenous quality, self-regulation, economic geography, banks, financial markets, macroprudential effort.

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1 Introduction

Since the 2007 financial crisis, academics and policymakers have attached a lot of importance on failures in banking regulation and their possible remedies. According to Bernanke et al. (2008), Brunnermeier et al. (2009) and French et al. (2010), banking regulatory frameworks (e.g. Basel I and II) were defective because they focused on the financial risks of individual institutions in isolation and rather than on their systemic risks. "Macroprudential" regulatory approaches are now proposed to safeguard the financial system against common shock on banks' operations. Macroprudential tools encompass time-varying capital and higher-quality capital requirements (Hanson et al., 2010).[1] Ng and Rusticus (2011) advocate for improvement in financial reporting transparency because it is the lack of transparency that weakened trust and amplified the 2007 financial crisis.

This paper discusses the banks' choices to self-regulate their activities and their choice of the financial markets where to issue their stocks. A bank self-regulates when it applies costly macroprudential restrictions on its operations without being forced by a regulator. Our main question is whether self-regulation is more likely and more profitable in the financial markets hosting larger numbers of investors.

We first study a closed economy where banks raise funds to finance internal projects by issuing stocks on a single financial market. Banks simultaneously issue their stocks, set their stocks listing prices and macroprudential effort levels. Risk averse investors buy the banks' stocks in the financial market. Banks' dividends are uncertain and have the same shock structure as in Acemoglu and Zilibotti (1997). Given those risks, investors hold diversified portfolios of banks' stocks. We observe that the impact of macroprudential effort on demand for stocks is similar to the impact of quality investment on demand for commodities in the industrial economic and trade literature

[1] Time-varying capital requirements impose that banks maintain higher capital-to-asset ratios in good times than in bad times. Higher-quality capital requirements constrain banks' balance between common and preferred stocks. Common stocks are recognized to have higher quality than preferred stocks as they are more friendly to recapitalization processes (Hanson et al., 2010).

(Tirole, 1988; Feenstra, 1994; Picard, 2015). The difference here is that a bank's macroprudential effort affects the demand for other banks' stocks. Self-regulation contributes to protect the whole banking sector and generates a positive externality for other banks. This is consistent with the findings of Asgharian et al. (2014) who find that institutional quality has a significant effect on trust and consequently on stock market participation.

Secondly, we consider an open economy model with two countries and two financial markets and discuss the relationship between the banks' self-regulation decisions and incentives to raise their capital in one or another markets. The new economic geography literature with trade costs predicts a concentration of firms in the country with greater domestic demand (Martin and Rogers, 1995). Similarly, in this paper, banks have incentives to list their stocks in the country with the greater mass of investors. The impact of macroprudential choice on banks' stock listing decision is less clear. We finally compare the equilibrium outcomes with the first best and the second best choices of macroprudential regulation and financial market places in the closed and open economies.

When the economy hosts a single financial place, we show that each bank decides either to completely self-regulate or to not self-regulate at all. This dichotomous decision outcome is the same for all banks. Self-regulation incentives decrease with a smaller concentration of banks because macroprudential effort is a public good for the banking sector. A larger number of banks fosters free-riding issues and therefore raises systemic risks. This contrasts with the standard too-big-to-fail argument according to which a larger number of banks shall decrease systemic risks. We also show that self-regulation has a positive impact on the demands and prices of banks' stocks, and, thus on their profits.

In the open economy model with two countries and two financial market places, we find that macroprudential effort decisions are independent of the proportion of investors and number of banks operating in each country. They are only a function of the total number of banks in the economy. Second, when both countries have the same costs of macroprudential efforts, all banks have incentives to raise their capital in the market with the larger number of investors. At the equilibrium, the smaller market becomes empty. This result is consistent with the literature of new economic geography and Martin and Rey (2004)'s empirical evidence suggesting that a bank's stock price increases when it issues its stock in a larger financial market. In contrast, banks may list their stocks in the smaller country when it has a sufficiently low macroprudential cost there. Therefore, this result may explain the existence (or survival) of smaller financial markets (Switzerland, Luxembourg, etc,...). Hence, an important contribution of this paper is to explain the impact of institutional quality on stock listing equilibrium of banks.

Finally, in the first and second best analysis, we show that a benevolent regulator is more likely to impose regulation when the number of banks is large. This contrasts with the equilibrium where banks are more likely to self-regulate when they are few. In such case, banks internalize a larger share of the global effect of a systemic crisis.

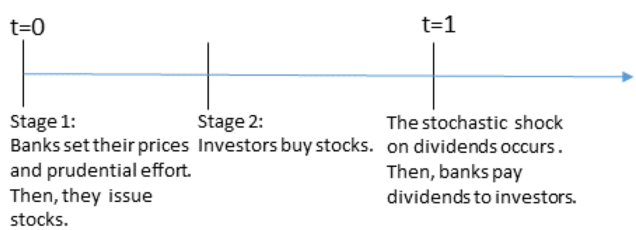
The paper is structured as follows. The next section presents the closed economy model and discusses the demand and supply of bank stocks. Section 3 analyzes the equilibrium properties of banks' stocks prices and self-regulation decisions. Section 4 discusses the first and second best decisions. Section 5 presents the open economy and its banks' stock listing equilibrium. Section 6 analyzes the optimal decision by a regulator maximizing the welfare of two countries. Section 7 concludes.

2 Closed economy

In the baseline model, we consider one country where $N \geq 2$ banks compete in the financial market and investors choose among financial opportunities. There are two periods, $t = 0, 1$. In the initial period (period 0), banks raise funds to finance internal projects by issuing stocks on the financial market. Then, investors buy stocks from the financial market. In the second period (period 1), banks pay dividends (return) to investors. The amount of dividend is uncertain, this is due to negative shocks between period 0 and 1. Two alternative negative shocks can occur: either a *macroeconomic* or an *idiosyncratic shock*. The macroeconomic shock impacts negatively all banks' dividends in the same proportion, while the idiosyncratic shock reduces the dividend of only one particular bank. To reduce the negative impact of the macroeconomic shock, banks can exert *macroprudential effort*. Macroprudential effort is a set of tools that seek to safeguard the financial system when a common shock hits banks (Hanson et al., 2010). The intuition is that increasing the quality of the financial market leads investors to trust the financial market more, and thus increase demand.

The timeline of the game is as follows. In the first stage, banks maximize the amount of funds raised by choosing simultaneously prices and macroprudential effort. In the second stage, investors buy stocks issued by banks by maximizing their expected utility. The equilibrium concept is subgame perfect Nash equilibrium, which is solved by backward induction. Thus, first, we analyze the investor problem and second, the bank problem. Figure 1 summarizes the timing.

Figure 1: Timeline of the model



2.1 Demand side

Investors

We consider identical investors who live for two periods. In the first period, each investor receives the same individual income w. He invests in the financial market by buying a quantity q_k of each stock issued by banks k, $k \in \{1, ...N\}$ at a price p_k and consume x_0. In the second period, he retires, receives dividends D_k and consumes x_1. Thus, in the second period, the investor's portfolio has a value of $x_1 = \sum_{k=1}^{N} D_k q_k$.

We assume that all investors have identical preferences represented by the following quadratic utility function (Markowitz, 1952; Tobin, 1958):

$$U = x_0 + x_1(1 - rx_1),$$

where U is the utility function, x_0 and x_1 are, respectively, the consumption in period 0 and 1. The coefficient r captures the risk aversion. Therefore, given the budget constraint, each investor chooses the portfolio of shares $\{q_k\}_{k=1,\ldots,N}$ that maximizes his expected utility:

$$\underset{\{x_0, x_1, q_k\}_{k=1,\ldots,N}}{\text{Max}} \mathbb{E}U = x_0 + \mathbb{E}\left[x_1\left(1 - rx_1\right)\right], \tag{1}$$

subject to

$$x_1 = \sum_{k=1}^{N} D_k q_k, \tag{2}$$

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{3}$$

For simplicity, the coefficient of risk aversion r is normalized to $\frac{1}{2}$. Equation (3) represents the budget constraint. Without loss of generality, the price of the first period good and the discount rate between time periods are normalized to one. We assume that the wage is large enough for investors to purchase all stocks $q_k > 0$. In order to solve the investor problem, dividends should be explicitly defined. For exposition purposes, the next subsection focuses on the analysis of dividends.

Dividends

We assume that dividends are independent and identically distributed random variables (i.i.d). The shock structure on dividends is defined as in Acemoglu and Zilibotti (1997). For simplicity, banks pay a unit dividend in the absence of shocks. As mentioned above, there are two alternative types of shock: idiosyncratic shocks and a macroeconomic (correlated) shock. The idiosyncratic shock only impacts a particular bank, while the macroeconomic shock impacts all banks identically. There are $N+1$ states of nature. In state of nature $\omega = 0$, the shock on dividends is a negative macroeconomic shock. In this case, all banks simultaneously pay the same dividend $D_k = 1 - \gamma$ to investors where $\gamma \in (0, 1]$. State $\omega = 0$ takes place with probability ϕ. In state of nature $\omega = k, k \in \{1, .., N\}$, an idiosyncratic shock occurs for bank k. All banks pay the maximum dividend except bank $k = \omega$, which pays a lower dividend $D_k = 1 - \beta$, $\beta \in (0, 1]$. The probability of each idiosyncratic shock is equal to ψ. Finally, probabilities add up to one such that

$$\phi + N\psi = 1. \tag{4}$$

This excludes a state of nature in which no shocks happen.
The consumption in period 1 is summarized as follows:

$$x_1 = \begin{cases} Q(1-\gamma) & \text{at prob}(\omega = 0) = \phi, \\ Q - \beta q_k & \text{at prob}(\omega = k,\ k \in \{1, .., N\}\ ) = \psi. \end{cases} \tag{5}$$

Stock demand

We are now able to solve the investor's problem. Replacing (5) in the maximization problem given by (1), (2) and (3), we get

$$\underset{\{q_k\}_{k=1,\dots,N}}{\text{Max}} \quad \mathbb{E}U = x_0 + \phi(1-\gamma)Q[1 - \frac{1}{2}(1-\gamma)Q] + \sum_{k=1}^{N} \psi(Q - \beta q_k)\left[1 - \frac{1}{2}(Q - \beta q_k)\right], \tag{6}$$

subject to

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{7}$$

Assuming $q_k > 0$ for all k, the first order condition of the maximization problem described by (6) and (7) with respect to q_k is:

$$\phi(1-\gamma)[1 - (1-\gamma)Q] - \psi Q(N - 2\beta) + \psi(N - \beta) - \beta^2 q_k \psi - p_k = 0. \tag{8}$$

In Appendix A, we show that the second order condition for a maximum is verified. Aggregating over all stocks yields:

$$N\phi(1-\gamma)[1-(1-\gamma)Q]-\psi Q(N-2\beta)N-\beta^2 Q\psi+\psi(N-\beta)N-P=0. \quad (9)$$

where $P=\sum_{k=1}^{N} p_k$ is a price index. Solving (9) with respect to Q gives:

$$Q=\frac{N\phi(1-\gamma)+\psi(N-\beta)N-P}{N\phi(1-\gamma)^2+\psi(N-\beta)^2}. \quad (10)$$

Finally, plugging (10) in (8) and solving for q_k yields:

$$q_k=\alpha-bp_k+\chi P, \quad (11)$$

where

$$\alpha\equiv\frac{[(1-\gamma)\phi+(N-\beta)\psi]}{[N\phi(1-\gamma)^2+\psi(N-\beta)^2]},$$
$$b\equiv\frac{1}{\beta^2\psi},$$

and

$$\chi\equiv\frac{(1-\gamma)^2\phi+\psi(N-2\beta)}{[(1-\gamma)^2 N\phi+(N-\beta)^2\psi]\beta^2\psi}.$$

Equation (11) is the typical *demand* function found *for horizontal product differentiation* (Singh and Vives, 1984; Belleflamme et al., 2000; Ottaviano et al., 2002). Parameter α measures the demand shifter for each stock. It can be written as:

$$\alpha=\frac{\mathbb{E}(d_k|\omega=0,...,N)}{\frac{N}{(1-\phi)}Var(d_k|\omega=0)+\frac{1}{(1-\psi)}Var(d_k|\omega=1,...,N)}.$$

The demand shifter α increases with the expected return of dividends (numerator) and falls with a larger variance of dividends in the case of the idiosyncratic or the macroeconomic shock (denominator is proportional to the variance). Parameter b measures the price sensitivity of stocks. The coefficient β is the stochastic element which impacts negatively the dividend of a particular bank. Thus, $\beta^2\psi$ is proportional to the variance of the stochastic element of dividends. It increases the price sensitivity of stocks, meaning that investors pay less for more uncertain returns. The parameter χ measures the degree of substitutability. In particular, when $\chi \to 0$ stocks are perfectly differentiated, while they become perfect substitutes when $\chi \to \infty$. Note that when $N \to \infty$, χ is equal to 0.

2.2 Supply side

We consider an oligopoly with N banks who compete to raise funds by issuing stocks in the primary financial market.[2] In the first period, each bank k issues a quantity q_k of stocks at price p_k, $k \in \{1, ..., N\}$. In the second period, bank k pays dividends to investors. Since dividends are uncertain and independent and identically distributed (i.i.d), stocks are differentiated products, as in Martin and Rey (2004). We assume that the amplitude of the macroeconomic shock can be reduced by the banking sector's *macroprudential effort* E such that

$$\gamma = 1 - \eta E,$$

where η is *a macroprudential effort efficiency parameter*. In what follows, we focus on the case in which the amplitude of the macroeconomic shock is high and close to one. We can write the Taylor expansion of the demand parameters about $\gamma = 1$ as:

$$\alpha \simeq a + dE,$$
$$\chi \simeq c,$$

where

$$a = \frac{1}{N - \beta}, \quad d = \frac{\eta\phi}{\psi(N-\beta)^2} \quad \text{and} \quad c = \frac{(N - 2\beta)}{(N-\beta)^2\psi\beta^2}. \tag{12}$$

[2]Note that if we consider monopolistic competition, price index and the sector's prudential effort are given. Then, there is no incentive for bank k to exert prudential effort (free-rider problem).

are the values of $\alpha, \mathrm{d}\alpha/\mathrm{d}\gamma$ and χ at $\gamma = 1$. Note that $\mathrm{d}b/\mathrm{d}\gamma = \mathrm{d}^2 b/\mathrm{d}\gamma^2 = \ldots = 0$ and $\mathrm{d}\chi/\mathrm{d}\gamma = 0$ at $\gamma = 1$. As a result, the demand function is equal to

$$q_k = a - bp_k + cP + dE. \tag{13}$$

We assume that each bank k may contribute to the total macroprudential effort by an individual *macroprudential effort* e_k. We consider diminishing return in effort such that $e_k \in [0, e_0]$ where e_0 is the individual *macroprudential effort upper bound*. Indeed, above e_0, bank's macroprudential effort does not reduce the amplitude of the macroeconomic shock. The *banking sector's total macroprudential effort* is then given by $\sum_{k=1}^{N} e_k$. Thus, $E \in [0, Ne_0]$. In the above approximation, one can see that macroprudential effort neither impacts the price sensitivity nor the substitution effect. The parameter a is the demand shifter for stock k when sector's macroprudential effort and prices are nil. It decreases with high number of banks. The parameter d represents the *demand sensitivity to macroprudence*. It increases with the probability of a macroeconomic shock ϕ and the macroprudential effort efficiency η. In contrast, it decreases with the probability of idiosyncratic shock and the number of banks.

Each bank k faces two different costs. First, a same marginal cost n on internal projects. This cost may occur when banks invest in new branches, for example. Second, a macroprudence cost which increases with macroprudential effort. For example, it can represent the cost of bank's reporting. It increases with the number of issued shares. We define macroprudence cost for bank k as me_k where m is the macroprudence marginal cost of bank k. Using the optimal demand from (13), the profit of bank k is:

$$\pi_k = (p_k - n - me_k)(a - bp_k + cP + dE).$$

Under oligopolistic competition, each bank takes prices and macroprudential effort of others banks as given and chooses simultaneously its best stock share price and macroprudential effort. The equilibrium is defined such that bank $k \in \mathcal{N}$ maximizes its profit from issuing stocks:

$$\max_{p_k \geq 0, e_k \in [0, e_0]} \quad \pi_k = (p_k - n - m e_k)(a - b p_k + cP + dE), \tag{14}$$

where $E = e_k + \sum_{k' \neq k} e^*_{k'}$, $P = p_k + \sum_{k' \neq k} p^*_{k'}$ and where $e^*_{k'}$ and $p^*_{k'}$ are taken as given.

3 Price and self-regulation equilibrium

In this section, we discuss equilibrium prices and macroprudential effort chosen by banks.

For convenience, we define $m(b-c)$ as the *self-regulation loss* of each bank. It is a function of macroprudence marginal cost m, price sensitivity b and degree of substitution c. In Appendix B, we show that $b > c$.

In Appendix C, we solve for the maximization problem described by (14). Since the problem is convex in e_k, we find two different equilibria: one with self-regulation $e^* = e_0$ and

$$p^* = \frac{a + d e_0 N + (n + m e_0)(b - c)}{2b - c - Nc},$$

the other with no self-regulation, $e^* = 0$ and

$$p^* = \frac{a + n(b - c)}{2b - c - Nc}.$$

The first takes place if $d \geq m(b-c)$ and the second otherwise.[3] This condition is equivalent to

$$\frac{m}{\eta} \leq \frac{\phi \beta^2}{(N - \beta)^2 - (N - 2\beta)}. \tag{15}$$

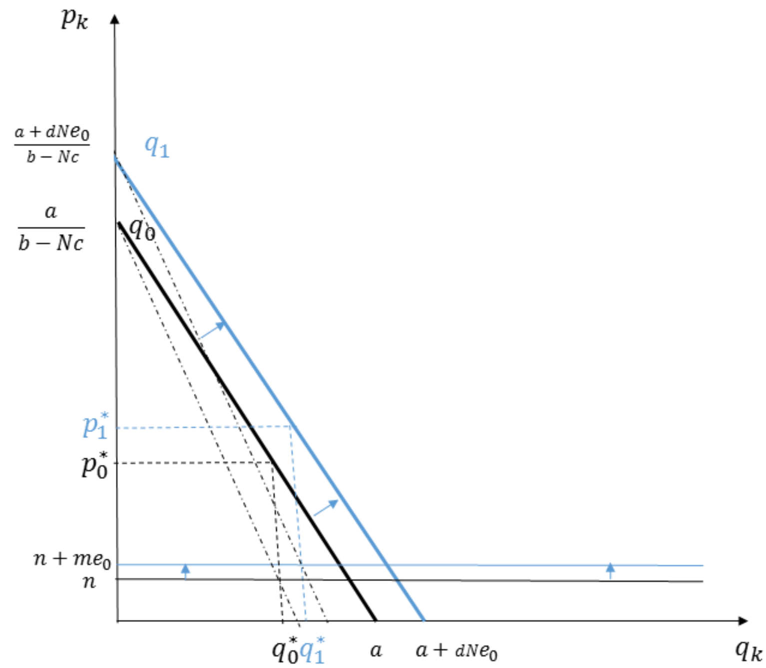
Proposition 1. *If condition (15) holds the banking sector self-regulates. Otherwise, it prefers to not exert self-regulation.*

Figure 2 shows that each bank k self-regulates when its profit given (q^*_1, p^*_1) is higher than its profit with (q^*_0, p^*_0). This is verified when condition

[3] Note that results are robust in the absence of the Taylor approximation.

(15) holds.

Figure 2: Effect of self-regulation on equilibrium



The impact of macroprudential effort on demand for stocks is similar to the impact of quality on demand for commodities (Tirole, 1988; Feenstra, 1994; Picard, 2015). Thus, bank k self-regulates as long as its cost of self-regulation is lower than its gain from the demand increase. The left-hand side of (15) is the self-regulation cost over efficiency and the right-hand side represents the self-regulation gain. In what follows, to analyze the comparative statics, we consider that an increase in the number of banks N or in the probability of macroeconomic shock ϕ reduces the probability of the idiosyncratic shock ψ for bank k such that equation (4) can be written as

$$\psi = \frac{(1-\phi)}{N}. \tag{16}$$

Indeed, a higher number of banks raises the number of possible states of nature. This reduces the probability of a particular bank to be hit by an idiosyncratic shock. Therefore, from condition (15) we show that the number of banks N has a negative impact on each bank self-regulation gain and then on banks' decisions to self-regulate.[4] The intuition is that when a bank increases its macroprudential effort, all banks' demands shifter are positively impacted. Macroprudential effort can be considered as a public good. Thus, a larger number of banks amplifies the free-rider problem and then, systemic risks. This contrasts with the standard too-big-to-fail argument according to which a larger number of banks shall decrease systemic risks. The intuition is that banks know that the planner will not let them fail and thus, take more risk. Note also that the incentive to self-regulate increases with macroprudential effort efficiency on macroeconomic shock η and macroeconomic shock's probability ϕ.

From condition $d \geq m(b-c)$, one can see that large demand sensitivity to macroprudence d and large degree of substitution c increase the incentive to self-regulate for banks. The intuition is that a higher degree of substitution raises demand and thus, reduces the self-regulation loss. In opposite, price sensitivity b reduces self-regulation. Indeed, for stocks with high price sensitivity, increasing the price by self-regulating reduces the demand.

In the self-regulation equilibrium ($e^* = e_0$), equilibrium prices rise with demand sensitivity to macroprudence d and self-regulation loss $m(b-c)$. This implies that macroprudence is partially paid by investors. Equilibrium quantities and profits are:

$$q^* = \left[\frac{a + dNe_0 - (n + me_0)(b - Nc)}{2b - c - Nc}\right](b - c),$$

and

$$\pi^* = \left[\frac{a + dNe_0 - (n + me_0)(b - Nc)}{2b - c - Nc}\right]^2 (b - c).$$

Since $d \geq m(b-c)$ and $Nd > m(b-cN)$, the choice of effort impacts positively equilibrium quantities q^* and profits π^*. The first condition presented above comes from the individual self-regulation decision of banks, while the second results from the aggregate self-regulation decision. In Appendix C, we show that profits under self-regulation are always positive.

[4] Proof is presented in Appendix D

In the no self-regulation equilibrium ($e^* = 0$), equilibrium prices increase with demand shifter a, substitution effect c and high number of banks N. In contrast, they decrease with price sensitivity b. Equilibrium quantities and profits are:

$$q^* = \left[\frac{a - n(b - Nc)}{2b - c - Nc}\right](b - c) \text{ and } \pi^* = \left[\frac{a - n(b - Nc)}{2b - c - Nc}\right]^2 (b - c). \quad (17)$$

4 Regulator's maximization problem

In this section, we investigate the case of a welfare-maximizing regulator. Social welfare W is represented by the sum of banks' profits Π and investors surplus IS:

$$W = \Pi + IS. \quad (18)$$

Combining (6), (7), (8) and (13) investors surplus IS is given by

$$IS = \sum_{k=1}^{N}(a - bp_k + cP + dE)^2 \left[\frac{\psi}{2}(N - \beta)^2\right]. \quad (19)$$

We distinguish two different cases. The first best where the regulator sets optimal macroprudential effort and prices and the second best where the regulator sets only optimal macroprudential effort, and then banks choose their optimal prices.

4.1 First best

In the first best, the regulator maximizes social welfare by choosing the optimal effort e_k and price p_k of bank k.

The regulator problem is defined by

$$\underset{p_k \geq 0, e_k \in [0, e_0]}{\text{Max}} W = \Pi + IS.$$

Solving for the maximization problem described by (18) and (19), the first best gives us two different solutions where prices are equal to marginal cost. The first with regulation $e^{FB} = e_0$ and

$$p^{FB} = n + me_0,$$

the second without regulation, $e^{FB} = 0$ and

$$p^{FB} = n.$$

Note that the price with no self-regulation is equal to the marginal cost on banks' internal projects n.

The first takes place if $dN \geq m(b - Nc)$ and the second otherwise. This condition is equivalent to

$$\frac{m}{\eta} \leq \phi N. \tag{20}$$

The regulator imposes a regulation when the cost of regulation is lower than the gain of mitigating macroeconomic shock losses. Compared to the self-regulation equilibrium, the condition under which the regulator enforces regulation is satisfied for a larger set of economic parameters. Since ϕ is a parameter (see equation (16)), it is straightforward that the incentive to enforce banking regulation increases with a higher number of banks. Indeed, a larger number of banks increases the gain from the regulation. The idiosyncratic shock β do not impact the regulator's decision.

Proposition 2. *If condition (20) holds, the regulator's first best is to regulate. Compared to the self-regulation equilibrium, condition (20) is less difficult to satisfy and the gain from imposing macroprudential effort increases with a larger number of banks.*

4.2 Second best

The second best is characterized as follows. First, the regulator, as for example the Basel Committee or the European Banking Authority, maximizes social welfare by choosing the optimal macroprudential effort e_k. Then, banks set optimal prices p_k. The second best problem can be solved by backward induction.

The bank problem is defined as follows

$$\underset{p_k \geq 0}{\text{Max}} \quad \pi_k = (p_k - n - me_k^{SB})(a - bp_k + cP + dE^{SB}),$$

where $P = p_k + \sum_{k' \neq k} p_{k'}^{SB}$ and where e_k^{SB}, E^{SB} and $p_{k'}^{SB}$ are taken as given. Solving the bank problem gives us the optimal price of bank k:

$$p_k^{SB} = \frac{a + de^{SB}N + (n + me^{SB})(b - c)}{2b - c - Nc}.$$

The regulator problem is defined by

$$\underset{e_k \in [0, e_0]}{\text{Max}} W = \Pi + IS.$$

The regulator optimization problem yields to two solutions: one with regulation $e^{SB} = e_0$ and the other with no regulation, $e^{SB} = 0$. The regulator imposes regulation on banks for $d \geq m\frac{(b-Nc)}{[1+(b-Nc)(b-c)]}$. This condition is equivalent to

$$\frac{m}{\eta} \leq \phi N \left[1 + \frac{(N - \beta)^2 - (N - 2\beta)}{(N - \beta)^4 (\frac{1-\phi}{N})^2 \beta^2} \right]. \tag{21}$$

Compared to the self-regulation equilibrium and the first best, the condition under which the regulator enforces regulation is less difficult to satisfy. Moreover, the number of banks has a relatively higher positive impact on the incentive to enforce banking regulation than in the first best. Intuitively, optimum quantities and profits are an increasing function of the regulation. Thus, the condition to impose self-regulation is even less restrictive than in the first best.

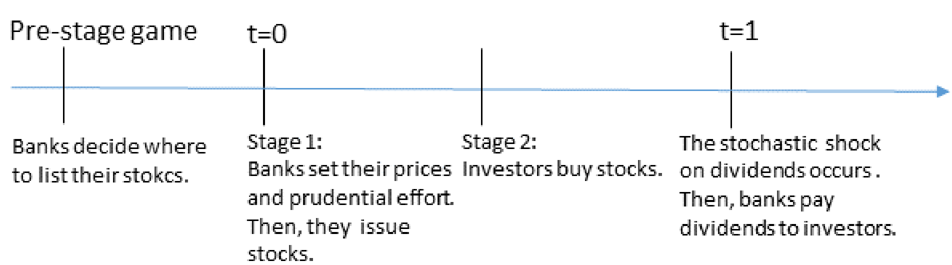
Proposition 3. *If condition (21) holds, the regulator imposes a regulation. Compared to the self-regulation equilibrium and the first best, condition (21) is less difficult to satisfy. The number of banks has even more a positive impact on the incentive to enforce banking regulation than in the first best.*

5 Open economy

In this section, we extend our baseline model by allowing banks to choose where to list their stocks across two geographically separated financial markets in country i and j. In equilibrium, $\mathcal{N}_i$ and $\mathcal{N}_j$ are the sets of banks in financial market i and j, with $N_i + N_j = N$, where N is the total number of banks in the economy. A proportion θ_i (resp. θ_j) of investors are in country i (resp. j), so that $\theta_i + \theta_j = 1$. Investors are immobile, and choose among domestic and foreign financial opportunities.

Compared to the baseline model, there is a pre-stage game where banks choose their best stock listing. The rest of the game does not change. As in the baseline model, in the first stage, banks compete by issuing stocks with the aim of raising funds. Then, investors buy stocks from domestic and foreign financial markets. Note that the macroeconomic shock impacts all banks in both countries by an equivalent amount. Figure 3 summarizes the timing of the open economy model.

Figure 3: Timeline of the open economy model



5.1 Demand side

In the open economy, each investor buys an amount of all domestic and foreign stocks to protect his investments against shocks (gain from diversification). In addition to the price, an investor faces an inter-market transaction cost t per-stock for buying foreign stocks. This cost captures banking commission and variable fees, exchange rate transaction costs and possibly information costs. For example, Adjaouté (2000) shows that cross-border financial transactions inside Europe cost 10-20 times more than domestic ones: from 1 to 5 euros for domestic transactions as opposed to 10 to 50 euros for cross-border trades between European markets. Similarly, a study of the European Central Bank (1999) estimates that fees charged to customers for cross-border transactions inside the euro-area vary between 3.5 to 26 euros for small amounts and between 31 and 400 euros for higher amounts. This results from the fact that cross-border payments and securities settlements are more expensive and complicated than domestic ones. Hence, demand for stock of bank $k \in \mathcal{N}_i$ becomes:

$$q_k = \theta_i q_{ki} + \theta_j q_{kj}, \tag{22}$$

where q_{ki} is stock demand for bank k by investors in i (home investors) and q_{kj} is stock demand for bank k by investors in j (foreign investors) where $k \in \mathcal{N}_i$, $j \neq i$. Equation (22) can be rewritten as follows.

$$q_k = \theta_i(a - bp_k + cP_i + dE) + \theta_j(a - b(p_k + t) + cP_j + dE).$$

The inter-market cost is denoted t, and it is assumed to be low enough to allow stock purchase from any market ($q_{ki} > 0, q_{kj} > 0$). Price indices in each country are given by P_i and P_j, $j \neq i$, while $E = \sum_{k \in \mathcal{N}_i} e_k + \sum_{k \in \mathcal{N}_j} e_k$ is the global macroprudential effort. We define $P_i \equiv \sum_{k \in \mathcal{N}_i} p_k + \sum_{k \in \mathcal{N}_j} (p_k + t) = P + tN_j, j \neq i$. The global price index is defined as $P = \sum_{k \in \mathcal{N}_i} p_k + \sum_{k \in \mathcal{N}_j} p_k$. Note that we assume the bank $k \in \mathcal{N}_i$ sells its stock at the same price in both countries. It does not discriminate in prices. As in (13), the parameter a measures the demand shifter for stocks, b is the price sensitivity of stocks, c is the degree of substitution and d is the demand sensitivity to macroprudence. Values of these parameters are the same as in section 2.2.

Home bias

From the stock demand for bank k, $k \in \mathcal{N}_i$, by investors in i and j, we observe the existence of a *home bias* according to which home investors demand more domestic rather than foreign stocks (Kenneth R. French, 1991; Cooper and Kaplanis, 1994).[5] The home bias for country i, for a given price p_k, is given by:[6]

$$\begin{aligned} q_{ki} - q_{kj} &= bt + c\left(P_i - P_j\right) \\ &= t\left[b + c\left(N_j - N_i\right)\right]. \end{aligned}$$

We show in Appendix F that $P_i - P_j = t(N_j - N_i)$. For a symmetric distribution of banks ($N_j = N_i$), home bias corresponds to transaction cost t times price sensitivity. For an asymmetric distribution of banks, the demand for stock of bank k by investors in i diminishes if the price index P_i falls. For a large number of banks N_i in i, competition is more intensive, which provides a lower price index and lower home bias. This discussion can be summarized as follows.

Proposition 4. *Comparable size stock markets are characterized by a home bias, which falls with market integration, i.e lower inter-market cost, and with the difference in the number of banks listed on each stock market.*

5.2 Supply side

As in the closed economy, we consider an oligopoly where $N = N_i + N_j$ banks compete to raise funds by issuing stocks in both financial markets (i and j). Banks also face a macroprudential cost. We assume that all banks in the same country have the same macroprudence marginal cost. We define macroprudence cost for bank k, $k \in \mathcal{N}_i$ as $m^i e_k$ where m^i is the macroprudence marginal cost of bank k in i. Note that the marginal cost on internal projects n are the same for all banks in both countries. Under oligopolistic competition, bank k, $k \in \mathcal{N}_i$ takes prices and macroprudential effort of

[5]This is also referred as a financial home market effect (Helpman and Krugman, 1985).

[6]See Appendix E for computation details.

others as given and chooses its best share price p_k and its macroprudential effort e_k simultaneously. Using (22), profit of bank k, $k \in \mathcal{N}_i$ is given by:

$$\pi_k = (p_k - n - m^i e_k)[\theta_i(a - bp_k + cP_i + dE) + \theta_j(a - b(p_k + t) + cP_j + dE)],$$

where π_k is the profit of the bank k listed in i. The equilibrium is defined such that bank $k \in \mathcal{N}_i$ maximizes its profit from raising funds in the primary financial market.

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \quad \pi_k = (p_k - n - m^i e_k)[\theta_i(a - bp_k + cP_i + dE) + \theta_j(a - b(p_k + t) + cP_j + dE)], \tag{23}$$

where

$$E = e_k + \sum_{k' \neq k, k' \in \mathcal{N}_i} e^*_{k'} + \sum_{k \in \mathcal{N}_j} e^*_k, \tag{24}$$

$$P_i = p_k + \sum_{k' \neq k, k' \in \mathcal{N}_i} p^*_{k'} + \sum_{k \in \mathcal{N}_j} (p^*_k + t), \tag{25}$$

and

$$P_j = (p_k + t) + \sum_{k' \neq k, k' \in \mathcal{N}_i} (p^*_{k'} + t) + \sum_{k \in \mathcal{N}_j} p^*_k, \tag{26}$$

while $e^*_{k'}$, $p^*_{k'}$ for $k' \in \mathcal{N}_i$ are taken as given as well as e^*_k and p^*_k, for $k \in \mathcal{N}_j$.

5.3 Price and self-regulation equilibrium (second stage)

In this section, we discuss equilibrium prices and macroprudential effort chosen by banks in both countries.
Define respectively $m^i(b - c)$ and $m^j(b - c)$ as the *self-regulation loss* of banks in i (for all $k \in \mathcal{N}_i$) and j (for all $k \in \mathcal{N}_j$).

Solving for the maximization problem described by (23), (24), (25) and (26), we find four different equilibria: the first with *global self-regulation* $e^*_k = e_0$ for $k \in \{\mathcal{N}_i, \mathcal{N}_j\}$ and

$$\begin{aligned} p^*_k &= \frac{a + de_0 N}{2b - c - Nc} + \frac{(n + m^i e_0)(b - c) - \theta_j bt}{2b - c} \\ &\quad + \frac{c(b - c)\left[nN + e_0(m^i N_i + m^j N_j) + t(\theta_i N_j + \theta_j N_i)\right]}{(2b - c)(2b - c - Nc)}, \end{aligned} \tag{27}$$

for $k \in \mathcal{N}_i$. The second with *no self-regulation*, $e_k^* = 0$ for $k \in \{\mathcal{N}_i, \mathcal{N}_j\}$ and

$$p_k^* = \frac{a}{2b - c - Nc} + \frac{n(b-c) - \theta_j bt}{2b - c} + \frac{c(b-c)[nN + t(\theta_i N_j + \theta_j N_i)]}{(2b-c)(2b-c-Nc)}, \quad (28)$$

for $k \in \mathcal{N}_i$. The third with *partial self-regulation* $e_k^* = e_0$ for $k \in \mathcal{N}_i$, $e_k^* = 0$ for $k \in \mathcal{N}_j$ and

$$p_k^* = \frac{a + de_0 N_i}{2b - c - Nc} + \frac{(n + m^i e_0)(b-c) - \theta_j bt}{2b - c} + \frac{c(b-c)\left[nN + e_0 m^i N_i + t(\theta_i N_j + \theta_j N_i)\right]}{(2b-c)(2b-c-Nc)}, \quad (29)$$

for $k \in \mathcal{N}_i$. Note that the fourth equilibrium is symmetric to the partial self-regulation configuration with $e_k^* = 0$ for $k \in \mathcal{N}_i$ and $e_k^* = e_0$ for $k \in \mathcal{N}_j$.

For convenience, we define

$$\overline{m} = \frac{\phi \beta^2 \eta}{(N - \beta)^2 - (N - 2\beta)},$$

as the maximum macroprudence cost under which banks self-regulate. The first equilibrium takes place if $d \geq m^i(b-c)$ and $d \geq m^j(b-c)$ and the second otherwise. These conditions are equivalent to

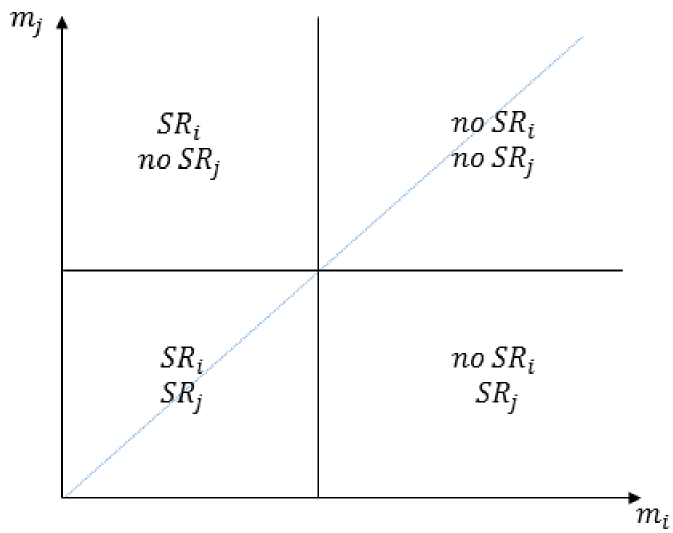
$$m^i \text{ and } m^j \leq \overline{m}. \quad (30)$$

The third occurs if $d \geq m^i(b-c)$ and $d < m^j(b-c)$ which is equivalent to

$$m^i \leq \overline{m} < m^j. \quad (31)$$

Figure 4 summarizes the different possible self-regulation equilibria.

Figure 4: Self-regulation equilibria



Proposition 5. *If condition (30) holds the global banking sector self-regulates. Otherwise, it prefers to not exert self-regulation. If condition (31) holds, only the banking sector in country i self-regulates.*

The proof of proposition 5 is presented in Appendix G.

Proposition 5 shows that self-regulation is an optimal choice for banks in each country when *demand sensitivity to macroprudence* d is high. In contrast, self regulation in each country decreases with large self-regulation loss $m^i(b-c)$ and $m^j(b-c)$. Note that condition (30) for each country is the same as in the closed economy model.

Concerning equilibrium prices, we define $\theta_i N_j + \theta_j N_i$ as the index of co-agglomeration. It decreases when banks and investors co-agglomerate in the same market. Therefore, co-agglomeration of banks and investors in the same market decreases stock prices (Picard, 2015).

5.4 Stock listing equilibrium

In this section, we analyze the properties of the different stock listing equilibria. A stock listing equilibrium is such that banks list their stocks in the most profitable market. Define $\mu_k^i = 1$ if bank k lists its stocks in country i.

Definition 1. *Given* μ_l^{j*}*,* $l \neq k$*, if* $\pi_k^i > \pi_k^j$ *then,* $\mu_k^i = 1$ *and* $\mu_k^j = 0$ *for* $i \neq j$*. If* $\pi_k^i = \pi_k^j$*, then bank* k *has the same probability equal to* $1/2$ *to list its stocks in country* i *or* j*. Note that* π_k^i *is given by (23) with prices (27), (28), (29) depending on the self-regulation equilibrium.*

We, first, consider the case where macroprudence marginal costs are the same in both countries. Second, we analyze the case where banks in one country face lower macroprudence marginal cost.

Same macroprudence marginal costs: $m^i = m^j = m$

Suppose similar macroprudence marginal costs for every bank $k \in \{\mathcal{N}_i, \mathcal{N}_j\}$. Only two different equilibria are possible: one with global self-regulation and the other with no self-regulation (diagonal line in Figure 4).

Proposition 6. *The stock listing equilibrium is at corner points* $N_i = N$ *when* $\theta_i > \theta_j$*, and* $N_i = 0$ *when* $\theta_j > \theta_i$*. Stock prices are larger in the larger market. All banks list their stocks in the largest stock market. The smallest stock market is empty. The banking sector self-regulates if the macroprudence cost* m *in the larger market is lower than* $\overline{m}$*.*

Proof of Proposition 6 is presented in Appendix H. In presence of trade cost t, all banks list themselves in the market with the larger proportion of investors. There is no dispersion force (crowding out) as in new economic geography models (Krugman, 1991), even if banks are competing with each others. Proposition 6 supports the theory of concentration of stocks in large market places. This contrasts with analysis in Pagano (1989) whose discussion hinges on the agglomeration force resulting from market liquidity.

Different macroprudence marginal costs: $m^i < m^j$

Suppose that exerting macroprudential effort is less costly for banks in i such that $m^i < m^j$. For example, banks in i have better knowledge and technologies such that self-regulation is less costly for them compared to banks in country j. Three equilibria are possible: one with global self-regulation, the second with no self-regulation and the last with partial self-regulation.

Since the equilibrium with no self-regulation gives same results with same or different macroprudence marginal costs, we focus on the analysis of the equilibria with global self-regulation and partial self-regulation with $m^i < m^j$. We analyze those equilibria for $\theta_i \geq \theta_j$ and $\theta i < \theta_j$.

Proposition 7. *If $m^i < m^j$ and m^i and $m^j \leq \overline{m}$.*

1. *For $\theta_i \geq \theta_j$. All banks list their stocks in the larger market and self-regulate.*

2. *For $\theta_i < \theta_j$ and $(\theta_i - \theta_j)t > m^i - m^j$, all banks list their stocks in the smaller market and self-regulate. In contrast, for $(\theta_i - \theta_j)t < m^i - m^j$, banks list their stocks in the larger market and self-regulate.*

Proof of Proposition 7: Define $e^*_k \equiv e^{i*}$ and $q^*_k \equiv q^{i*}$, for $k \in \mathcal{N}_i$, while $e^*_k \equiv e^{j*}$ and $q^*_k \equiv q^{j*}$, for $k \in \mathcal{N}_j$. Under global self-regulation ($e^{i*} = e^{j*} = e_0$), optimal stock demand of banks listed in country i is:

$$q^{i*} = \left[\begin{array}{l} \frac{1}{2b-c-Nc}\left[a + dNe_0\right] + \frac{c(b-c)[nN+m^iN_i+m^jN_j+t(\theta_iN_j+\theta_jN_i)]}{(2b-c)(2b-c-Nc)} \\ \\ -b\frac{(n+m^ie_0+\theta_jt)}{2b-c} \end{array} \right](b-c).$$

$$q^{i*} - q^{j*} = (\theta_i - \theta_j)t + (m^j - m^i).$$

We show that demand q^{i*} is larger than q^{j*} at equilibrium, if and only if $(\theta_i - \theta_j)t + (m^j - m^i) > 0$. This condition can hold for a low proportion of investors in i, $\theta i < \theta_j$, when the difference in macroprudence cost efficiency is large enough, $m^i - m^j$. In this case, macroprudence cost efficiency relaxes the advantage of a larger demand. This is consistent with Pieretti et al. (2007) and Han et al. (2013), who argue that small sized countries can attract firms if they regulate more efficiently. Note that this is more likely to occur for small trade costs t. This result explains the existence of financial markets in small countries such as in Luxembourg, Switzerland, inter-alia. Hence, an important contribution of this paper to the new economic geography literature is the impact of macroprudential effort on stock listing equilibrium of banks. Macroprudential effort can therefore modify the stock listing equilibrium and relax the advantage of a larger demand.

Proposition 8. *If* $m^i < m^j$ *and* $m^i \leq \overline{m} < m^j$.

1. *Suppose* $\theta_i \geq \theta_j$. *For* $t(\theta_i - \theta j) > m^i$, *all banks list their stocks in the larger market* i *and self-regulate. In contrast, for* $t(\theta_i - \theta j) < m^i$, *all banks list their stocks in the smaller market* j *and do not self-regulate.*

2. *Suppose* $\theta_i < \theta_j$, *such that* $t(\theta_i - \theta j) < m^i$. *All banks list their stocks in the larger market* j *and do not self-regulate.*

Proof of Proposition 8: Under partial self-regulation ($e^{i*} = e_0$ and $e^{j*} = 0$), the optimal stock demand of banks listed in country i is:

$$q^{i*} = \begin{bmatrix} \frac{1}{2b-c-Nc}(a + dN_i e_0) + \frac{c(b-c)[t(\theta_i N_j + \theta_j N_i) + m^i N_i + nN]}{(2b-c)(2b-c-Nc)} \\ \\ -b\frac{(n+m^i e_0 + \theta_j t)}{2b-c} \end{bmatrix} (b-c).$$

$$q^{i*} - q^{j*} = t(\theta_i - \theta j) - m^i.$$

Therefore, $q^{i*} > q^{j*}$ if and only if $t(\theta_i - \theta j) > m^i$. This condition holds only for large values of θ_i. When it holds, all banks list their stocks in i. Therefore, since $N_i = N$, the partial self-regulation becomes the global self-regulation equilibrium. In contrast, when $t(\theta_i - \theta j) < m^i$, the partial self-regulation becomes the no self-regulation equilibrium. At equivalent proportion of investors in both countries ($\theta_i = \theta_j$), the no-self regulation dominates.

6 International regulator's maximization

In this section, we investigate the case of an international welfare-maximizing regulator. Global social welfare is represented by the sum of banks' profits in i and j (Π^i and Π^j) and investors surplus for investors in both countries IS.

$$\mathbb{W} = \Pi^i + \Pi^j + IS.$$

We show the first best and the second best. In the first best, the international regulator sets optimal stock listing, macroprudential effort and prices. In the second best, banks chooses their stock listing location. Then, the Basel committee maximizes social welfare by choosing the optimal effort, and finally banks set their prices by maximizing their profits.

In the first stage, the regulator decides the optimal stock listing and in the second stage, it maximizes social welfare by choosing the optimal effort e_k and price p_k for bank $k \in \{\mathcal{N}_i, \mathcal{N}_j\}$. Note that we assume the same marginal macroprudence cost for banks in both countries m. Solving by backward induction, the second stage regulator problem is defined as

$$\underset{p_k \geq 0, e_k \in [0, e_0]}{\text{Max}} \mathbb{W} = \Pi^i + \Pi^j + IS. \tag{32}$$

Solving for the maximization problem described by (32), the first best gives us two different equilibria, with prices equal to marginal cost. The first with regulation $e^{FB} = e_0$ and

$$p_k^{FB} = n + me_0,$$

the second without regulation, $e_k^{FB} = 0$ and

$$p_k^{FB} = n.$$

Note that the price with no self-regulation is equal to the marginal cost on internal projects n.

The first takes place if $d \geq \frac{m}{N}(b - Nc)$ and the second otherwise. This condition is equivalent to

$$\frac{m}{\eta} \leq \phi N.$$

This condition is the same as in the first best condition in the closed economy (20). This comes from the fact that banks face the same macroprudence cost, thus the regulator enforces a regulation under the same condition for both countries. For the regulator, the number of banks increases the incentive to enforce banking regulation.

It can be shown that the regulator decides to locate banks in the country with the larger number of investors. Thus, the number of investors who faces transactions costs is minimized and profits of firms is maximized.

Second best

In the first stage, banks chooses their stock listing. In the second stage, the Basel committee maximizes social welfare by choosing the optimal effort, and finally banks set their prices by maximizing their profits.

Solving by backward induction, the bank $k \in \mathcal{N}_i$ problem is defined as follows

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \quad \pi_k = (p_k - n - m^i e_k^{SB})[\theta_i(a - bp_k + cP_i + dE^{SB}) + \theta_j(a - b(p_k + t) + cP_j + dE^{SB})],$$

where

$$P_i = p_k + \sum_{k' \neq k, k' \in \mathcal{N}_i} p_{k'}^{SB} + \sum_{k \in \mathcal{N}_j} (p_k^{SB} + t),$$

and

$$P_j = (p_k + t) + \sum_{k' \neq k, k' \in \mathcal{N}_i} (p_{k'}^{SB} + t) + \sum_{k \in \mathcal{N}_j} p_k^{SB},$$

while e_k^{SB}, $p_{k'}^{SB}$ for $k' \in \mathcal{N}_i$ are taken as given as well as e_k^{SB} and p_k^{SB}, for $k \in \mathcal{N}_j$. Solving for the bank problem gives us the optimal price of bank k $\in \mathcal{N}_i$,:

$$p_k^{SB} = \frac{a + de_k^{SB} N}{2b - c - Nc} + \frac{(n + me_k^{SB})(b - c) - \theta_j bt}{2b - c} + \frac{c(b - c)\left[nN + e_k^{SB} N + t(\theta_i N_j + \theta_j N_i)\right]}{(2b - c)(2b - c - Nc)}.$$

The Basel committee problem is defined by

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \mathbb{W} = \Pi^i + \Pi^j + IS,$$

for bank $k \in \{\mathcal{N}_i, \mathcal{N}_j\}$. The regulator optimization problem yields to two equilibria: one with regulation $e_k^{SB} = e_0$ and the other with no regulation,

$e_k^{SB} = 0$. The regulator imposes regulation on banks for $d \geq m\frac{(b-Nc)}{[1+(b-Nc)(b-c)]}$. This condition is equivalent to

$$\frac{m}{\eta} \leq \phi N \left[1 + \frac{(N-\beta)^2 - (N-2\beta)}{(N-\beta)^4(\frac{1-\phi}{N})^2\beta^2}\right].$$

Here, again the condition for regulation is the same as in the closed economy. It can be shown that banks list their stocks in the larger country.

7 Concluding remarks

The present paper studies banks' choices to voluntarily exert macroprudential efforts and their choices of raising their capital across two separate financial markets. Banks either decide to completely self-regulate or to not. Banks' incentives to self-regulate increase with the probability of macroeconomic shock and the efficiency of self-regulation tools. In contrast, they fall with smaller bank concentration. A larger number of banks therefore raises systemic risks. This contrasts with the too-big-to-fail argument which states that a smaller number of banks increases systemic risks. When there are several financial markets and the cost of macroprudential efforts are the same, all banks raise their capital in the larger country. In contrast, banks may list their stocks in the smaller country when it has a sufficiently low macroprudential cost. Therefore, this result may explain the existence of financial markets in small countries. Finally, in the first and second best, the regulator is more likely to impose regulation for a large number of banks. This contrasts with the equilibrium where banks are more likely to self-regulate when they are few. This implies that for a large number of banks, the regulator has to enforce a macroprudential regulation.

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9 Appendix

Appendix A

We prove that the second order condition of problem (6) for a maximum is verified.

The second order condition of (6) with respect to q_k is:

$$-[\phi(1-\gamma)^2 + \psi(N-2\beta) + \beta^2\psi] < 0. \tag{33}$$

Since $N \geq 2, \beta \in (0,1]$ and $\gamma \in (0,1]$, (33) is always verified.

Appendix B

We show that $b > c, \forall \beta, \psi, \phi$ and $N \geq 2$.
From (12), $b > c$ implies:

$$(N-1)(N-2\beta) + \beta^2 > 0. \tag{34}$$

Since $N \geq 2$, (34) is always positive.

Appendix C

This appendix presents the solution of the maximization problem described by (14). The equilibrium is defined such that bank $k \in \mathcal{N}$ maximizes its profit by issuing stock:

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \quad \pi_k = (p_k - n - me_k)q_k,$$

where the demand is given by $q_k = a + d(e_k + \sum_{k' \neq k} e^*_{k'}) - bp_k + c(p_k + \sum_{k' \neq k} p^*_{k'})$ while $e^*_{k'}$ and $p^*_{k'}$ are taken as given. The marginal profits from a price increase is given by

$$\frac{\partial \pi_k}{\partial p_k} = q_k - (p_k - n - me_k)(b - c). \tag{35}$$

Note that $\partial \pi_k / \partial p_k$ is a decreasing function of p_k, which is positive when $p_k = n + me_k$ and negative for $p_k \to \infty$. So, the price p_k lies between $(n+me_k)$ and ∞ and is given by the unique interior solution of $\partial \pi_k / \partial p_k = 0$. From (35), we have

$$q_k = (p_k - n - me_k)(b - c). \tag{36}$$

Since $b > c$, demand for stock is positive $q_k > 0$ if $p_k > me_k$, which we have assumed.

A marginal increase in effort yields

$$\frac{\partial \pi_k}{\partial e_k} = -mq_k + (p_k - n - me_k)d.$$

By (36), this is equal to

$$\frac{\partial \pi_k}{\partial e_k} = (p_k - n - me_k)\left[d - m\left(b - c\right)\right].$$

Under positive demand, this implies $\frac{\partial \pi_k}{\partial e_k} \lesseqgtr 0$ if and only if $d - m\left(b - c\right) \lesseqgtr 0$. This condition is the same for all banks $k = 1, ..., N$ whatever the price. Thus, optimal macroprudential effort is the same for all banks:

$$e_k^* \equiv e^* = \begin{cases} 0 & \text{if} \quad d < m(b - c), \\ e_0 & \text{if} \quad d \geq m(b - c). \end{cases}$$

This decision is the same for all banks $k = 1, ..., N$ whatever the price. Plugging it into (36) gives

$$(p_k - n - me^*)(b - c) - (a + dNe^* - bp_k) = cP,$$

for all $k = 1, ..., N$. Therefore, $p_k^* \equiv p^*$ and the previous identity gives

$$p^* = \frac{a + dNe^* + (n + me^*)(b - c)}{2b - c - Nc}.$$

The demand can be computed as

$$q_k^* \equiv q^* = \left[\frac{a + dNe^* - (n + me^*)(b - Nc)}{2b - c - Nc}\right](b - c).$$

The profit of bank k is

$$\begin{aligned}\pi_k^* &\equiv \pi^*, \\ &= (p^* - n - me^*)^2(b - c), \\ &= \left[\frac{a + dNe^* - (n + me^*)(b - Nc)}{2b - c - Nc}\right]^2 (b - c) > 0.\end{aligned}$$

We finally prove that demands q^* are positive at the equilibrium. This will imply that equilibrium profits are also positive. Indeed, on the one hand, the denominator of equation (9) is equivalent to $2b > c(N + 1)$. This inequality simplifies to

$$\psi\left[(N - 1)(N - 2\beta) + 2\beta^2\right] > 0.$$

which is always verified for $N \geq 2$. On the other hand, the numerator of equation (17) is positive when $d < m(b - c)$ and therefore $e^* = 0$ because $a > 0$. It is also positive when $d > m(b - c)$ and therefore $e^* = e_0$.

Appendix D

This appendix proves that the number of banks N has a negative impact on each bank self-regulation gain and then, on banks' decision to self-regulate. Calling X the right hand side of condition (15), we get

$$X = \frac{\phi\beta^2}{(N - \beta)^2 - (N - 2\beta)}.$$

Therefore,

$$\frac{\partial X}{\partial N} = \frac{-\phi\beta^2\left[2\left(N - \beta\right) - 1\right]}{\left[(N - \beta)^2 - (N - 2\beta)\right]^2}.$$

Since $N \geq 2$ and $\beta \in (0, 1]$, $[2(N - \beta) - 1]$ is always positive. Therefore, $\frac{\partial X}{\partial N} < 0$. This means that an increase in the number of banks N reduces the gain from self-regulation X.

Appendix E

The home bias is given by $q_{ki}^i - q_{kj}^i = bt + c(P_i - P_j)$. Since,

$$
\begin{aligned}
q_{ki}^i &= a - bp_k^i + cP_i + dE. \\
q_{kj}^i &= a - b(p_k^i + t) + cP_j + dE.
\end{aligned}
$$

Thus, the home bias is given by

$$q_{ki}^i - q_{kj}^i = a - bp_k^i + cP_i + dE - a + b(p_k^i + t) - cP_j - dE = bt + c(P_i - P_j).$$

Appendix F

We show that $P_i - P_j = t(N_j - N_i)$. Price indices are defined as follows:

$$
\begin{aligned}
P_i &\equiv \sum_{k=1}^{N_i} p_k^i + \sum_{k=1}^{N_j} (p_k^j + t). \\
P_j &\equiv \sum_{k=1}^{N_i} p_k^j + \sum_{k=1}^{N_j} (p_k^i + t), \ j \neq i.
\end{aligned}
$$

Thus, we write $P_i - P_j$ as follows.

$$P_i - P_j = \sum_{k=1}^{N_i} p_k^i + \sum_{k=1}^{N_j} (p_k^j + t) - \sum_{k=1}^{N_i} p_k^j - \sum_{k=1}^{N_j} (p_k^i + t) = t(N_j - N_i).$$

Appendix G

We, here, prove Proposition 5. The equilibrium is defined such that bank $k \in N_i$ maximizes its profit from issuing stock:

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \quad \pi_k = (p_k - n - m^i e_k) q_k,$$

where the demand is given by $q_k = \theta_i(a + dE - bp_k^i + cP_i) + \theta_j(a + dE - b(p_k^i + t) + cP_j)$ while $e_{k'}^*$ and $p_{k'}^*$ for $k \in \mathcal{N}_i$ and e_k^* and p_k^* for $k \in \mathcal{N}_j$ are taken as given. The marginal profits for bank $k \in \mathcal{N}_i$ from a price increase is given by

$$\frac{\partial \pi_k}{\partial p_k} = q_k - (p_k - n - m^i e_k)(b - c). \tag{37}$$

Note that $\partial \pi_k / \partial p_k$ is a decreasing function of p_k, which is positive when $p_k = n + m^i e_k$ and negative for $p_k \to \infty$. So, the price p_k lies between $(n+m^i e_k)$ and ∞ and is given by the unique interior solution of $\partial \pi_k / \partial p_k = 0$. From (35), we have

$$q_k = (p_k - n - m^i e_k)(b - c).$$

Since $b > c$, demand for stock is positive $q_k > 0$ if $p_k > me_k$, which we have assumed.

A marginal increase in effort yields

$$\frac{\partial \pi_k}{\partial e_k} = -m^i q_k + (p_k - n - m^i e_k) d.$$

By (37), this is equal to

$$\frac{\partial \pi_k}{\partial e_k} = \left(p_k - n - m^i e_k\right) \left[d - m^i (b - c)\right].$$

Under positive demand, this implies $\frac{\partial \pi_k}{\partial e_k} \lesseqqgtr 0$ if and only if $d - m^i (b - c) \lesseqqgtr 0$. This condition is the same for all banks $k \in \mathcal{N}_i$ whatever the price. Define $e_k^* \equiv e^{i*}$ and $q_k^* \equiv q^{i*}, k \in \mathcal{N}_i$, while $e_k^* \equiv e^{j*}$ and $q_k^* \equiv q^{j*}, k \in \mathcal{N}_j$. Thus, optimal macroprudential effort is the same for all banks $k \in \mathcal{N}_i$:

$$e_k^* \equiv e^{i*} \begin{cases} 0 & \text{if} \quad d < m^i(b-c), \\ e_0 & \text{if} \quad d \geq m^i(b-c). \end{cases}$$

This decision is the same for all banks $k \in \mathcal{N}_i$ whatever the price. Plugging it into (37) gives

$$(p_k - n - m^i e^{i*})(b-c) - \left[a + d\left(N_i e^{i*} + N_j e^{j*}\right) - \theta_j bt\right] = c(\theta_i P_i + \theta_j P_j),$$

for all $k \in N_i$. Therefore, $p_k^* \equiv p^{i*}, k \in N_i$ and since $\theta_i P_i + \theta_j P_j = cP + t(\theta_i N_j + \theta_j N_i)$, the previous identity gives

$$p^{i*} = (n+m^i e^{i*})\frac{(b-c)}{2b-c} + \frac{1}{2b-c}\left[a + d\left(N_i e^{i*} + N_j e^{j*}\right) - \theta_j bt + cP + ct(\theta_i N_j + \theta_j N_i)\right].$$

Aggregating those prices we get:

$$\begin{aligned} P &= N_i p^{i*} + N_j p^{j*} \\ &= \frac{(b-c)}{2b-c}\left(nN + m^i N_i e^{i*} + m^j N_j e^{j*}\right) + \frac{N}{2b-c}\left[a + d\left(N_i e^{i*} + N_j e^{j*}\right)\right] \\ &\quad + \frac{Nc}{2b-c}[P + t(\theta_i N_j + \theta_j N_i)] - \frac{bt}{2b-c}(\theta_i N_j + \theta_j N_i). \end{aligned}$$

Solving for the fixed point yields:

$$\begin{aligned} P &= \frac{(b-c)}{2b-c-Nc}\left(nN + m^i N_i e^{i*} + m^j N_j e^{j*}\right) + \frac{N}{2b-c-Nc}\left[a + d\left(N_i e^{i*} + N_j e^{j*}\right)\right] \\ &\quad - t\frac{(b-Nc)}{2b-c-Nc}(\theta_i N_j + \theta_j N_i). \end{aligned}$$

The equilibrium stock prices for $k \in \mathcal{N}_i$ is given by

$$\begin{aligned} p^{i*} &= \frac{1}{2b-c-Nc}\left[a + d\left(N_i e^{i*} + N_j e^{j*}\right)\right] + \frac{(n+m^i e^{i*})(b-c) - \theta_j bt}{2b-c} \\ &\quad + c\frac{(b-c)}{(2b-c)(2b-c-Nc)}[nN + m^i N_i e^{i*} + m^j N_j e^{j*} + t(\theta_i N_j + \theta_j N_i)]. \end{aligned}$$

The demand for banks $k \in \mathcal{N}_i$ can be computed as

$$\begin{aligned} q^{i*} &= \frac{1}{2b-c-Nc}\left[a+d\left(N_i e^{i*}+N_j e^{j*}\right)\right]-\frac{b(n+m^i e^{i*}+\theta_j t)}{2b-c} \\ &\quad +c\frac{(b-c)}{(2b-c)(2b-c-Nc)}[nN+m^i N_i e^{i*}+m^j N_j e^{j*}+t(\theta_i N_j+\theta_j N_i)](b-c). \end{aligned}$$

and optimal profits for all $k \in \mathcal{N}_i$

$$\pi^{i*} = \left[\begin{array}{c} \frac{1}{2b-c-Nc}\left[a+d\left(N_i e^{i*}+N_j e^{j*}\right)\right]-\frac{b(n+m^i e^{i*}+\theta_j t)}{2b-c} \\ +c\frac{(b-c)}{(2b-c)(2b-c-Nc)}[nN+m^i N_i e^{i*}+m^j N_j e^{j*}+t(\theta_i N_j+\theta_j N_i)] \end{array}\right]^2 (b-c).$$

Appendix H

Appendix H proves Proposition 6.

Define $e_k^* \equiv e^{i*}$ and $q_k^* \equiv q^{i*}$ for $k \in \mathcal{N}_i$, while $e_k^* \equiv e^{j*}$ and $q_k^* \equiv q^{j*}$, for $k \in \mathcal{N}_j$. With global self-regulation ($e^{i*} = e^{j*} = e_0$), we show that demands q^{i*} is larger than q^{j*} at equilibrium, if and only if $\theta_i > \theta_j$. This implies that equilibrium profits are larger in country i. Optimal stocks demand of banks listed in country i is: :

$$q^{i*} = \left[\begin{array}{l} \frac{1}{2b-c-Nc}\left(a+dNe_0\right)+\frac{c(b-c)[t(\theta_i N_j+\theta_j N_i)+m^i N e_0+nN]}{(2b-c)(2b-c-Nc)} \\ \\ -\frac{b(n+m^i e_0+\theta_j t)}{2b-c} \end{array}\right](b-c).$$

Then, $q^{i*} - q^{j*}$ is given by

$$q^{i*} - q^{j*} = \theta_i - \theta_j.$$

Therefore, only the difference in investors proportion affects the stock listing equilibrium. At no self-regulation equilibrium, stocks demand for banks in i is written as

$$q^{i*} = \left[\frac{a}{(2b - c - Nc)} + \frac{ct(\theta_i N_j + \theta_j N_i)(b - c)}{(2b - c)(2b - c - Nc)} - \frac{b(n + \theta_j t)}{2b - c} \right] (b - c).$$

$$q^{i*} - q^{j*} = \frac{bt}{2b - c}[\theta_i - \theta_j].$$

Therefore, $q^{i*} > q^{j*}$, and as a consequence $\pi^{i*} > \pi^{j*}$ if and only if $\theta_i > \theta_j$.