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ESSAYS ON FINANCIAL MARKETS AND BANKING REGULATION

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Abstract

Financial markets and, in particular, the banking sector are recognized to be a key driver of economies. The recent financial crisis of 2008 has highlighted their important role and the need for regulation. This dissertation focuses on studying the main features of financial markets and the banking sector. It contains the following three chapters.

Self-Regulation and Stock Listing Decision of Banks. This chapter develops a framework to model international banks' assets trade. In particular, we study the endogenous choice of self-regulation and stock listing decision of banks among different financial markets. Investors consider banks' self-regulation as a measure of quality of stocks. First, we explore equilibrium properties of prices and self-regulation in a closed economy. We show that banks self-regulate as long as the cost of self-regulation is lower than its gain from safeguarding the macroeconomic environment. In addition, results suggest that the number of banks has a negative impact on banks' decision to self-regulate. Second, we analyze the equilibrium properties of prices, self-regulation and endogenous stock listing decision in an open economy with two countries. We show that the condition of self-regulation is the same as in the closed economy. Moreover, when both countries have the same cost of self-regulation, the larger region has an advantage of a larger demand. Therefore, all banks list their stocks in the larger financial market. However, when self-regulation' costs are different, banks can decide to list their stocks in the smaller country.

An Empirical Investigation: Institutional Quality, Systemic Shock and Dividends (joint with Chiara Peroni). The present research studies the

impact of countries' institutional quality on firms' performance and on demand for stocks. It also focuses on the effect of institutional quality on firms resilience to systemic shocks. We, first, build a theoretical model where investors buy stocks from the financial market and hold a portfolio of risky investment. We assume that systemic shocks reduce dividends for all firms in the economy and that high institutional quality reduces the negative impact of systemic shocks on dividends. Thus, under our assumptions, we show that institutional quality raises the demand for stocks. Second, we test the two key assumptions of the theoretical model. Our findings show that the two main hypotheses are verified and are robust to different specifications. Moreover, results suggest the existence of a persistence in dividends payout. Therefore, firms that paid large dividends in the previous year are more likely to distribute large dividends in the current year.

Regulations and Rational Banking Bubbles in Infinite Horizon (joint with Claire Océane Chevallier). This chapter develops a dynamic stochastic general equilibrium model in infinite horizon with a regulated banking sector where stochastic banking bubbles may arise endogenously. We analyze the condition under which stochastic bubbles exist and their impact on macroeconomic key variables. We show that when banks face capital requirements based on Value-at-Risk, two different equilibria emerge and can coexist: the bubbleless and the bubbly equilibria. Alternatively, under a regulatory framework where capital requirements are based on credit risk only, as in Basel I, bubbles are explosive and as a consequence cannot exist. The stochastic bubbly equilibrium is characterized by positive or negative bubbles depending on the tightness of capital requirements based on Value-at-Risk. We find a maximum value of capital requirements under which bubbles are positive. Below this threshold, the stochastic bubbly equilibrium provides larger welfare than the bubbleless equilibrium. In particular, our results suggest that a change in banking policies might lead to a crisis without external shocks.

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Introduction

The global financial crisis of 2007-2009 has highlighted the importance of the financial sector in the worldwide economy and its role in the propagation of the economic crisis. This crisis was caused by valuation and liquidity problems in the U.S banking system (Miao and Wang, 2015). Moreover, the globalization of financial markets precipitated the fall of stock markets throughout the world. As an illustration, on September 2008, Lehman Brothers experienced drastic losses in its stock and was filed for Chapter 11 bankruptcy protection on 15th September 2008.[1] This crisis was not limited to the U.S banking sector, with other sectors and other banks hit around the world. For example, the Dow Jones index experienced its biggest daily fall on 29th September 2008, with a drop of 6.98% of its value.[2] In Europe, the Belgian bank Fortis encountered severe problems in October 2008, and was repurchased partially by BNP Paribas.

These events raise awareness among both academics and policymakers of the failure of financial market regulation, and banking regulation in particular. The Basel Committee on Banking Supervision was created in 1973 "to enhance understanding of key supervisory issues and improve the quality of banking supervision worldwide".[3] They released the first Basel Accord called "Basel I" in 1988. Its purpose was to prevent international banks from growing without adequate capital. Therefore, the committee imposes a minimum

[1]Lehman Brothers Holdings Inc. was a global financial services firm founded in 1850.

[2]The Dow Jones Industrial Average is a stock market index which includes the 30 larger publicly owned companies based in the United States. For more details see https://www.djindexes.com.

[3]For more details see The Basel Committee overview, https://www.bis.org/bcbs/.

capital requirement which is calculated using credit risk weight of loans. The idea is that banks holding riskier assets must hold more capital than other banks to remain solvent. This approach has been criticized among researchers and regulatory agencies because it only considers credit risk and does not take market risk into account.[4] Consequently, during "the pre-crisis period", the Basel committee publishes the New Basel Capital Accord (Basel II).[5] This new accord incorporates market risk of the trading book into the banking regulation framework. It allows banks to use an internal model based on Value-at-Risk to quantify their minimum capital requirement. Bernanke (2008), Brunnermeier et al. (2009) and French et al. (2010) show that the regulatory framework for banks prior the global financial crisis was defective. They argue that it was focused on the financial conditions of individual institutions in isolation and forgot to encompass consideration of systemic risks. They propose an alternative regulatory approach called- "macroprudential". To follow this approach, they suggest the development of tools that seek to safeguard the financial system when a common shock hits banks. Therefore, Basel III requires time-varying capital requirements for banks. The idea is that banks face higher capital requirements in good periods, whereas the minimum requirement should be less restrictive in bad periods.[6]

The present thesis investigates the regulation of the banking sector, the effect of countries' institutional quality on agent's behavior and the emergence of banking stock price bubbles.

The first chapter develops a framework to model international banks' assets trade. In particular, it studies the endogenous choice of self-regulation and stock listing of banks among different financial markets. This approach allows to study the implication of self-regulation on demand for stocks, stock prices

[4] For example, Dimson and Marsh (1995) analyze the relationship between economic risk and capital requirements using trading book positions of UK securities firms. They find that the Basel I approach leads only to modest correlation between capital requirements and total risk.

[5] See Basel Committee on Banking Supervision (2004). Implementation started from 2005.

[6] For more details see The Basel Committee Guidelines, July 2015.

and stock listing of banks. We consider endogenous choice of self-regulation as a quality decision for banks such as in competition models with quality choice (Feenstra, 1994; Broda and Weinstein, 2006; Baldwin and Harrigan, 2011). Our results suggest that banks self-regulate as long as the cost of self-regulation is lower than its gain from safeguarding the macroeconomic environment. Martin and Rey (2004) and Shleifer (1986), inter alia, suggest the existence of a demand and size effect in international financial markets. In contrast, the main purpose of this chapter is to understand the emergence of financial markets in countries with a small number of investors. The analysis of this chapter suggests that banks might list their stocks in the smallest financial market when the cost of self-regulation is lower than that in the largest country. Such a behavior is contingent on there being large enough comparative advantage in macroprudence cost and on small trade costs. As a result, macroprudence cost efficiency might modify the stock listing equilibrium and relaxes the advantage of a larger demand.

The second chapter analyzes the impact of countries' institutional quality on firms' performance and on demand for stocks. It also focuses on the effect of institutional quality on firms resilience to systemic shocks. While it is recognized that institutional quality are important to economic development, empirical evidence is scarce. Acemoglu et al. (2005), in a review of the literature on the relationship between institutional quality and growth, argue that good institutions are a fundamental determinant of long-run growth. What is the impact of institutional quality of countries on performance of firms and on demand for stocks? Would greater institutional quality creates the emergence of financial markets in small countries? Would the institutional quality enable firms to become more resilient to systemic shocks? These research questions are addressed theoretically and empirically in that chapter. We use the theoretical model developed in Chapter 1 to model the market for stocks. This framework assumes that better institutional quality reduces the negative impact of systemic shocks on dividends. This implies that institutional quality increases the demand for stocks. An empirical model is developed and used to test the key assumptions of the theoretical model. Empirical results confirm that, effectively, the negative impact of a systemic shock on dividends is mitigated by a favorable institutional setting.

The last chapter focuses on the emergence of stochastic bubbles in a dynamic stochastic general equilibrium (DSGE) model in infinite horizon, with the purpose of providing arguments that could serve as a guidance for policy making. The literature on the existence of bubbles in general equilibrium models with infinitely lived agents is scarce, and is marked with few contributions. Tirole (1982) shows that bubbles under rational expectations with infinitely lived agents cannot exist since bubbles are explosive and cannot satisfy the transversality condition. In contrast, Kocherlakota (1992) demonstrates that bubbles may exist in general equilibrium models with borrowing or wealth constraints. The main findings of this chapter suggest that under a capital requirement based on Value-at-Risk, two different equilibria emerge and can coexist: the bubbleless and the stochastic bubbly equilibria. The capital requirement based on Value-at-Risk allows bubbles to exist. Conversely, under a regulatory framework where capital requirement is based on credit risk (such as in Basel I), bubbles are explosive and as a consequence cannot exist. Moreover, we find a maximum value of capital requirements under which bubbles are positive. Below this threshold, the stochastic bubbly equilibrium provides larger welfare than the bubbleless equilibrium. In particular, our results suggest that a change in banking policies might lead to a crisis without external shocks.

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Chapter 1

Self-Regulation and Stock Listing Decision of Banks

Abstract

This chapter develops a framework to model international banks' assets trade. In particular, we study the endogenous choice of self-regulation of banks and their stock listing decision among different financial markets. Investors consider banks' self-regulation as a measure of quality of stocks. First, we explore equilibrium properties of prices and self-regulation in a closed economy. We show that banks self-regulate as long as the cost of self-regulation is lower than its gain from increasing the demand. In addition, results suggest that the number of banks has a negative impact on banks' decision to self-regulate. Second, we analyze the equilibrium properties of prices, self-regulation and endogenous stock listing decision in an open economy with two countries. We show that the condition of self-regulation is the same as in the closed economy. Moreover, when both countries have the same cost of self-regulation, the larger region has an advantage of a larger demand. Therefore, all banks list their stocks in the larger financial market. However, when self-regulation' costs are different, banks can decide to list their stocks in the smaller country.

Keywords: Endogenous quality, Self-regulation, Economic geography, Banks, Financial markets, Macroprudential effort.

1.1 Introduction

Since the global financial crisis of 2007-2009, there has been a stronger awareness among both academics and policymakers of the failure of banking regulation. Bernanke et al. (2008), Brunnermeier et al. (2009) and French et al. (2010) show that the regulatory framework for banks prior the global financial crisis was defective. They argue that it was focused on the financial conditions of individual institutions in isolation and forgot to encompass consideration of systemic risks. They propose an alternative regulatory approach which is called, "macroprudential". To follow this approach, they suggest the development of tools that seek to safeguard the financial system when a common shock hits banks. Hanson et al. (2010) discuss different types of macroprudential tools such as time-varying capital requirements and higher-quality capital.[1] Furthermore, Ng and Rusticus (2011) also argue that reporting transparency is also an important macroprudential tool. Indeed, they show that the lack of transparency reporting of banks has amplified the financial crisis of 2007-2009 by reducing trust between the different economic agents.

The present chapter develops a framework to model international banks' assets trade. We study the endogenous choice of self-regulation and stock listing of banks among different financial markets. Banks self-regulate if they exert effort applying macroprudential tools without any enforced regulation. This approach allows us to study the implication of self-regulation on demand for stocks, stock prices and stock listing of banks. In particular, this chapter discusses the emergence of financial markets in countries with a small number of investors.

[1] Time-varying capital requirements consist of banks maintaining higher ratios of capital to-assets in good times than in bad times. Concerning, the higher-quality capital requirement, the traditional capital metric for banks is the ratio of Tier 1 capital to risk-weighted assets as defined by the Basel Committee on Banking Supervision. In this metric, capital includes common and preferred stocks. However, common stocks are commonly recognized to be a higher-quality form of capital than preferred. Indeed, in case of macroeconomic shock, they are more friendly to the recapitalization process (Hanson et al., 2010).

In this paper, we first build a model in a closed economy, where banks issue stocks on the financial market with the aim of raising funds to finance internal projects. Banks' stocks are considered as horizontally differentiated products. Banks simultaneously choose optimal stock prices and macroprudential effort levels by maximizing their total amount of raised funds. Then, investors buy stocks from the financial market and as a consequence, hold a portfolio of risky investment. Indeed, the amount of dividends is uncertain. We use the same shock structure as in Acemoglu and Zilibotti (1997) where stocks demand is determined endogenously. We consider macroprudential effort as a quality decision for banks such as in competition models with quality choice (Feenstra, 1994; Broda and Weinstein, 2006; Baldwin and Harrigan, 2011). For horizontally differentiated products, quality is represented by a demand shifter. The main difference here is that a particular bank's quality decision affects the demand shifter for all banks' stocks. This comes from the fact that self-regulation impacts the macroeconomic environment by protecting the whole economy in case of macroeconomic shock. This is consistent with the results of Asgharian et al. (2014) who find that financial market quality has a significant effect on trust, and that trust affects significantly stock market participation.

Secondly, we extend the closed economy model to an open economy model with two countries and study the impact of macroprudential effort decision on the stock listing decision of banks in international financial markets. In the absence of quality, the economic geography literature with trade costs predicts a concentration of banks in the country with greater domestic demand (Krugman, 1991). However, the impact of quality choice on banks' stock listing decision is less clear in this literature.

Finally, we also analyze the first best and the second best optimum of a social-maximizing regulator for both the closed and open economy model.

From the closed economy, we obtain the following results. We show that each bank either decides to completely self-regulate or to not self regulate at all. The decision of exerting macroprudential effort is the same for all banks.

Banks' self-regulation incentive decreases with a larger number of banks in the economy. Indeed, macroprudential effort can be considered as a public good. Therefore, an increase in the number of banks in the economy accentuates the free-riding problem. We also show that macroprudential effort has a positive effect on prices, demand for stock and, then on profits.

From the open economy model, our findings are summarized as follows. First, macroprudential effort decision is independent of the proportion of investors and number of banks in each country. It is only a function of the total number of banks in the economy. Second, when both countries have the same macroprudential effort cost, in the equilibrium, all banks locate in the larger country. The smaller market is empty. This result is consistent with the literature of economic geography (Krugman, 1991). Moreover, empirical evidence shows that when a bank from a small country lists its stock in a larger financial market, its stock price increases (Martin and Rey, 2004). In contrast, when a country is more efficient in terms of the cost of exerting macroprudential effort, it can relax the advantage of a larger demand. Indeed, even a smaller country can attract banks if its cost advantage is large enough. Therefore, this result may explain the existence of financial markets in small countries (Luxembourg, Switzerland, etc,...). Hence, an important contribution of this paper to the economic geography literature is the impact of quality on stock listing equilibrium of banks. Quality can therefore modify the stock listing equilibrium and diminish the larger demand advantage.

Finally, we examine the first best optimum for a social welfare maximizing regulator in either a closed or open economy. The results are the same in both cases. In contrast to banks' decisions, the incentive to impose macroprudential regulation increases with the number of banks in the economy.

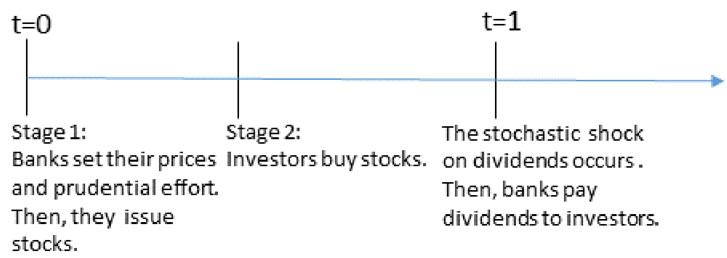
The paper is structured as follows. The next section presents the closed economy model where stocks' demand and supply are characterized. Section 3 analyzes the equilibrium properties of prices and self-regulation in a closed economy. Section 4 presents the first best and second optimum of a welfare-maximizing regulator. Section 5 discusses the open economy and presents the stock listing equilibrium. Section 6 analyzes optimal decision of an international welfare-maximizing regulator. Finally, section 7 concludes.

1.2 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 issue stocks on the financial market with the aim of raising funds to finance internal projects. 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 bank 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 1.1 summarizes the timing.

Figure 1.1 Timeline of the model



1.2.1 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):

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

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:

$$\underset{\{x_0, x_1, q_k\}_{k=1,\ldots,N}}{\text{Max}} \quad \mathbb{E}U = x_0 + \mathbb{E}\left[x_1 \left(1 - r x_1\right)\right], \tag{1.1}$$

subject to

$$x_1 = \sum_{k=1}^{N} D_k q_k, \tag{1.2}$$

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{1.3}$$

For simplicity, the coefficient of risk aversion r is normalized to $\frac{1}{2}$. Equation (1.3) 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 $\phi + N\psi = 1$. This excludes a state of nature in which no shocks happen.

The consumption in period 1 is summarized as follows:

$$x_1 = \begin{cases} Q(1-\gamma) & \text{at prob}(\omega = 0) = \phi, \\ Q-\beta q_k & \text{at prob}(\omega = k,\ k\in \{1,..,N\}\ ) = \psi. \end{cases} \tag{1.4}$$

Stock demand

We are now able to solve the investor's problem. Replacing (1.4) in the maximization problem given by (1.1), (1.2) and (1.3), we get

$$\underset{\{q_k\}_{k=1,\dots,N}}{\text{Max}} \quad \mathbb{E}U = x_0 + \phi(1-\gamma)Q[1-\frac{1}{2}(1-\gamma)Q] + \sum_{k=1}^{N}\psi(Q-\beta q_k)\left[1-\frac{1}{2}(Q-\beta q_k)\right], \tag{1.5}$$

subject to

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{1.6}$$

Assuming $q_k > 0$ for all k, the first order condition of the maximization problem described by (1.5) and (1.6) with respect to q_k is:

$$\phi(1-\gamma)[1-(1-\gamma)Q] - \psi Q(N-2\beta) + \psi(N-\beta) - \beta^2 q_k \psi - p_k = 0. \tag{1.7}$$

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

$$N\phi(1-\gamma)[1-(1-\gamma)Q] - \psi Q(N-2\beta)N - \beta^2 Q\psi + \psi(N-\beta)N - P = 0. \tag{1.8}$$

where $P = \sum_{k=1}^{N} p_k$ is a price index. Solving (1.8) with respect to Q gives:

$$Q = \frac{N\phi(1-\gamma) + \psi(N-\beta)N - P}{N\phi(1-\gamma)^2 + \psi(N-\beta)^2}. \tag{1.9}$$

Finally, plugging (1.9) in (1.7) and solving for q_k yields:

$$q_k = \alpha - bp_k + \chi P, \tag{1.10}$$

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 (1.10) 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.

1.2.2 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

$$a = \frac{1}{N-\beta}, \quad d = \frac{\eta\phi}{\psi(N-\beta)^2} \quad \text{and} \quad c = \frac{(N-2\beta)}{(N-\beta)^2\psi\beta^2}. \tag{1.11}$$

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

$$q_k = a - bp_k + cP + dE. \tag{1.12}$$

[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).

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 (1.12), 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:

$$\underset{p_k \geq 0, e_k \in [0, e_0]}{\text{Max}} \quad \pi_k = (p_k - n - me_k)(a - bp_k + cP + dE), \tag{1.13}$$

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.

1.3 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 (1.13). Since the problem is convex in e_k, we find two different equilibria: one with self-regulation $e^* = e_0$ and

$$p^* = \frac{a + de_0 N + (n + me_0)(b-c)}{2b - c - Nc},$$

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

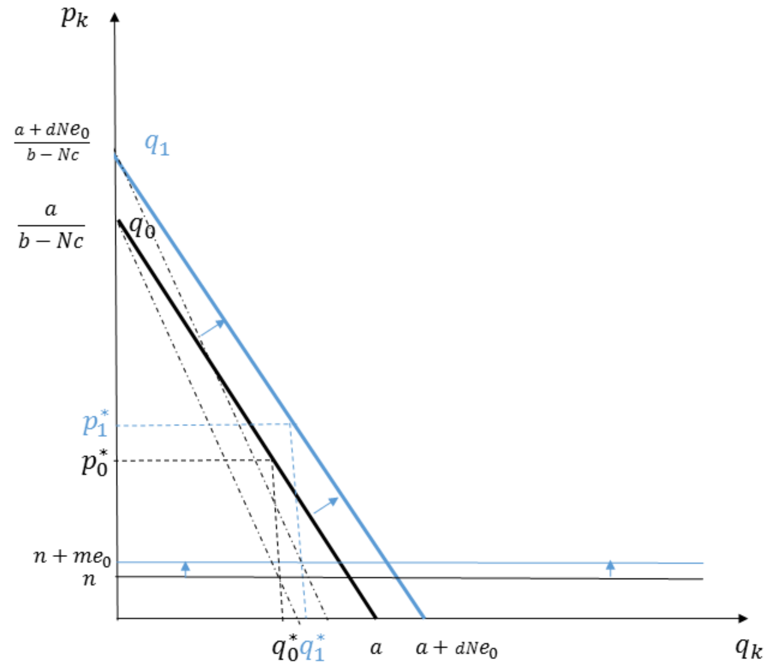
$$\frac{m}{\eta} \leq \phi \left[\frac{\beta^2}{(N-\beta)^2 - (N-2\beta)} \right]. \tag{1.14}$$

Proposition 1. If condition (1.14) holds the banking sector self-regulates. Otherwise, it prefers to not exert self-regulation. This condition is less likely to hold for a larger number of banks.

Figure 1.2 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 (1.14) holds.

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

Figure 1.2 Effect of self-regulation on equilibrium



Banks' self-regulation decision can be seen as a quality decision as in models of competition with quality (Feenstra, 1994; Broda and Weinstein, 2006; Baldwin and Harrigan, 2011). Thus, bank k increases self-regulation as long as the cost of self-regulation is lower than the gain from increasing the demand. The left-hand side of (1.14) is the self-regulation cost over efficiency and the right-hand side represents the self-regulation gain. Condition (1.14) shows that the number of banks N has a negative impact on banks' decision to self-regulate. The intuition is that macroprudential effort can be seen as a public good, thus, a larger number of banks amplifies the free ride problem. Indeed, when a particular bank increases its quality by exerting more macroprudential effort, all banks demand shifter are positively impacted. In contrast, 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 of this latter effect is that a high 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 endogenous 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 positive.

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:

$$q^* = \left[\frac{a - n(b - Nc)}{2b - c - Nc}\right](b-c) \text{ and } \pi^* = \left[\frac{a - n(b - Nc)}{2b - c - Nc}\right]^2 (b-c). \tag{1.15}$$

1.4 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:

$$W = \Pi + IS.$$

Combining (1.5), (1.6), (1.7) and (1.12) investors surplus IS is given by

$$IS = \sum_{k=1}^{N} (a - bp_k + cP + dE)^2 \left[\frac{\psi}{2} (N - \beta)^2 \right]. \tag{1.16}$$

We distinguish two different cases. The first best optimum 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.

1.4.1 First best optimum

In the first best optimum, 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 (1.16), the first best optimum 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

$$\frac{m}{\eta} \leq \phi N. \tag{1.17}$$

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 parameter. The incentive to enforce banking regulation increases with a higher number of banks. Indeed, a large number of banks increases the gain from the regulation. The idiosyncratic shock β has no impact on the regulator's first best optimum.

Proposition 2. If condition (1.17) holds, the regulator's first best optimum is to regulate. Compared to the self-regulation equilibrium, condition (1.17) is less difficult to satisfy and the gain from imposing macroprudential effort increases with a large number of banks.

1.4.2 Second best optimum

The second best optimum 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

$$\frac{m}{\eta} \leq \phi N \left[1 + \frac{(N-\beta)^2 - (N-2\beta)}{(N-\beta)^4 \psi^2 \beta^2} \right]. \tag{1.18}$$

Compared to the self-regulation equilibrium and the first best optimum, 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 optimum.

Proposition 3. If condition (1.18) holds, the regulator imposes a regulation. Compared to the self-regulation equilibrium and the first best optimum, condition (1.18) 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 optimum.

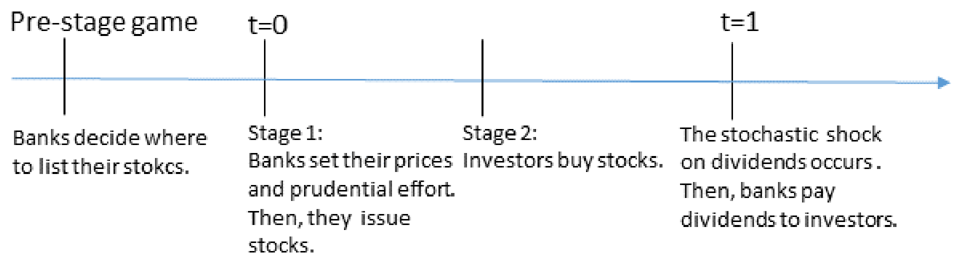
1.5 Open economy

In this section, we extend our baseline model by allowing banks to choose where to list their stocks among two 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 1.3 summarizes the timing of the open economy model.

Figure 1.3 Timeline of the open economy model



1.5.1 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:

$$q_k = \theta_i q_{ki} + \theta_j q_{kj}, \tag{1.19}$$

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 (1.19) 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 (1.12), 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 1.2.2.

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).[4] The home bias for country i, for a given price p_k, is given

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

by:[5]

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

We show in Appendix E 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.

1.5.2 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 others as given and chooses its best share price p_k and its macroprudential effort e_k simultaneously. Using (1.19), profit of bank k, $k \in \mathcal{N}_i$ is given by:

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

[5]See Appendix D for computation details.

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.

$$\underset{p_k \geq 0, e_k \in [0,e_0]}{\text{Max}} \quad \pi_k = (p_k - n - m^i e_k)[\theta_i(a - bp_k + cP_i + dE) + \theta_j(a - b(p_k + t) + cP_j + dE)], \tag{1.20}$$

where

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

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

and

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

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

1.5.3 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 (1.20), 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

$$p^*_k = \frac{a + de_0 N}{2b - c - Nc} + \frac{(n + m^i e_0)(b-c) - \theta_j bt}{2b - c} \tag{1.21}$$

$$+ \frac{c(b-c)\left[nN + e_0(m^i N_i + m^j N_j) + t(\theta_i N_j + \theta_j N_i)\right]}{(2b-c)(2b-c-Nc)}, \tag{1.22}$$

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

$$p_k^* = \frac{a}{2b-c-Nc} + \frac{n(b-c)-\theta_j bt}{2b-c} + \frac{c(b-c)[nN + t(\theta_i N_j + \theta_j N_i)]}{(2b-c)(2b-c-Nc)}, \tag{1.23}$$

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

$$p_k^* = \frac{a + de_0 N_i}{2b-c-Nc} + \frac{(n + m^i e_0)(b-c) - \theta_j bt}{2b-c} + \frac{c(b-c)\left[nN + e_0 m^i N_i + t(\theta_i N_j + \theta_j N_i)\right]}{(2b-c)(2b-c-Nc)}, \tag{1.24}$$

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

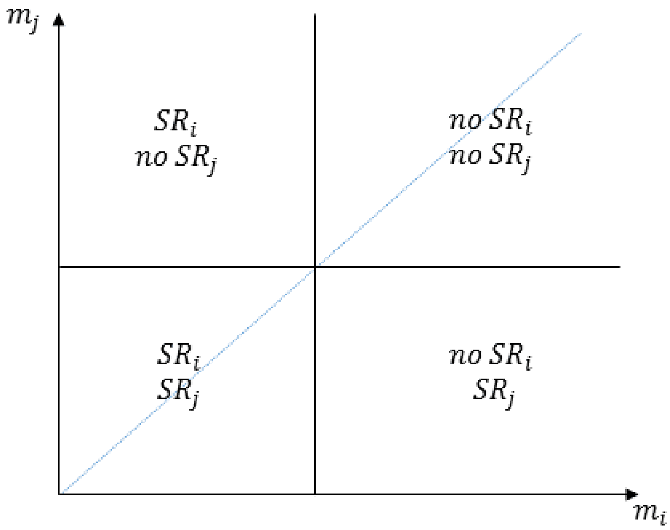
$$m^i \text{ and } m^j \leq \overline{m}. \tag{1.25}$$

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

$$m^i \leq \overline{m} < m^j. \tag{1.26}$$

Figure 1.4 summarizes the different possible self-regulation equilibria.

Figure 1.4 Self-regulation equilibria



Proposition 5. If condition (1.25) holds the global banking sector self-regulates. Otherwise, it prefers to not exert self-regulation. If condition (1.26) holds, only the banking sector in country i self-regulates.

The proof of proposition 5 is presented in Appendix F.

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 conditions (1.25) and (1.26) 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).

1.5.4 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 (1.20) with prices (1.22), (1.23), (1.24) 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 are more efficient in terms of costs to exert macroprudence.

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 1.4).

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 G. In presence of trade cost t, all banks list themselves in the market with the larger amount of investors. There is no dispersion force (crowding out) as in 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:

$$q^{i*} = \begin{bmatrix} \frac{1}{2b-c-Nc}\left[a + dNe_0\right] + \frac{c(b-c)[nN+m^iN_i+m^jN_j+t(\theta_iN_j+\theta_jN_i)]}{(2b-c)(2b-c-Nc)} \\ \\ -b\frac{(n+m^ie_0+\theta_jt)}{2b-c} \end{bmatrix}(b-c). \tag{1.27}$$

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

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 economic geography literature is the impact of quality on stock listing equilibrium of banks. Quality 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 states that the difference in proportion of investors times the transaction cost is higher than the macroprudence marginal cost. It holds only for large values of θ_i. When this condition 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.

1.6 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 optimum. 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.

First best optimum

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

$$\underset{p_k \geq 0, e_k \in [0, e_0]}{\text{Max}} \mathbb{W} = \Pi^i + \Pi^j + IS. \tag{1.28}$$

Solving for the maximization problem described by (1.28), the first best optimum 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

$$\frac{m}{\eta} \leq \phi N. \tag{1.29}$$

This condition is the same as in the first best condition in the closed economy (1.17). 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 optimum

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

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

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.

1.7 Concluding remarks

The present paper studies the effect of macroprudential effort on stock prices and the stock listing of banks. In this model investors increase their demand for all stocks when banks exert macroprudential effort. Banks self-regulate as long as the cost of self-regulation is lower than its gain from safeguarding the macroeconomic. The self-regulation's gain increases with the probability of macroeconomic shock and the self regulation efficiency. In contrast, self-regulation incentive decreases with a large number of banks in the economy. Since macroprudential effort is considered as a public good, this is consistent with the free-riding problem. Self-regulation has a positive impact on prices, demand and profits for all banks. In the open economy model, we show that in the absence of self-regulation, all banks list themselves in the larger market. This result also holds for the equilibrium with self-regulation when both countries have the same marginal costs. However, introducing different macroprudence costs allows us to relax the advantage of a larger demand. Therefore, small sized countries with lower macroprudence cost can attract banks and be the stock listing equilibrium. We also show that a social welfare maximizing regulator enforces macroprudential regulation when the number of banks in the economy is large. This result contrasts with the bank decision. Therefore an important policy implication can be detected here, for a large number of banks in the economy, banks do not self-regulate. Thus, the regulator has to enforce macroprudential regulation to improve social welfare.

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1.9 Appendix

Appendix A

We prove that the second order condition of problem (1.5) for a maximum is verified.

The second order condition of (1.5) with respect to q_k is:

$$-[\phi(1-\gamma)^2+\psi(N-2\beta)+\beta^2\psi]<0. \tag{1.30}$$

Since $N \geq 2, \beta \in (0,1]$ and $\gamma \in (0,1]$, (1.30) is always verified.

Appendix B

We show that $b > c, \forall \beta, \psi, \phi$ and $N \geq 2$.
From (1.11), $b > c$ implies:

$$(N-1)(N-2\beta)+\beta^2>0. \tag{1.31}$$

Since $N \geq 2$, (1.31) is always positive.

Appendix C

This appendix presents the solution of the maximization problem described by (1.13). 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

$$\frac{\partial \pi_k}{\partial p_k} = q_k - (p_k - n - me_k)(b-c). \tag{1.32}$$

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 (1.32), we have

$$q_k = (p_k - n - me_k)(b-c). \tag{1.33}$$

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 (1.33), this is equal to

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

Under positive demand, this implies $\frac{\partial \pi_k}{\partial e_k} \lesseqgtr 0$ if and only if $d - m(b-c) \lesseqgtr 0$. 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 (1.33) 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

$$q_k^* \equiv q^* = \left[\frac{a + dNe^* - (n + me^*)(b - Nc)}{2b - c - Nc}\right](b - c). \tag{1.34}$$

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 (1.34) 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 (1.15) 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

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

$$q^i_{ki} - q^i_{kj} = a - bp^i_k + cP_i + dE - a + b(p^i_k + t) - cP_j - dE = bt + c(P_i - P_j).$$

Appendix E

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

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

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

$$P_i - P_j = \sum_{k=1}^{N_i} p^i_k + \sum_{k=1}^{N_j} (p^j_k + t) - \sum_{k=1}^{N_i} p^j_k - \sum_{k=1}^{N_j} (p^i_k + t) = t(N_j - N_i).$$

Appendix F

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 $q_k = \theta_i(a + dE - bp^i_k + cP_i) + \theta_j(a + dE - b(p^i_k + t) + cP_j)$ 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

$$\frac{\partial \pi_k}{\partial p_k} = q_k - (p_k - n - m^i e_k)(b - c). \tag{1.35}$$

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 (1.32), 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 (1.35), 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 (1.35) 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 G

Appendix G 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: :

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

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 $\theta_i > \theta_j$.

Chapter 2

An Empirical Investigation: Institutional Quality, Systemic Shock and Dividends

(joint with Chiara Peroni)

Abstract

The present research studies the impact of countries' institutional quality on firms' performance and on demand for stocks. It also focuses on the effect of institutional quality on firms resilience to systemic shocks. We, first, build a theoretical model where investors buy stocks from the financial market and hold a portfolio of risky investment. We assume that systemic shocks reduce dividends for all firms in the economy and that high institutional quality reduces the negative impact of systemic shocks on dividends. Thus, under our assumptions, we show that institutional quality raises the demand for stocks. Second, we test the two key assumptions of the theoretical model. Our findings show that the two main hypotheses are verified and are robust to different specifications. Moreover, results suggest the existence of a persistence in dividends payout. Therefore, firms that paid large dividends in the previous year are more likely to distribute large dividends in the current year.

2.1 Introduction

The global financial crisis of 2007-2009 affected all countries, those with good and bad macroeconomic fundamentals. However, the extent of output losses differed widely across countries (Giannone et al., 2011). The global nature of the financial crisis and the heterogeneity of countries institutional quality gives an opportunity to identify key factors related to firms' and countries' resilience to systemic shocks. Institutional quality is recognized to impact the economic performance of firms, and this is because the quality of institutional framework shapes the business environment. In countries with high quality of institutional frameworks, firms and investors enjoy better auditing, more efficient judicial systems and greater enforcement of property rights. Besley (1995) and Johnson et al. (2002) state that strong enforcement of property rights attract more investment. Asgharian et al. (2014) analyze stock market participation in a large sample of European data on households in fourteen European countries with variable levels of institutional quality. They find that institutional quality has a significant effect on trust, and that trust, particularly the part that is explained by institutional quality, affects significantly stock market participation. The authors argue that if people trust that financial contracts are being enforced, and that the cost of fraudulent behavior is sufficiently high, there is presumably a higher propensity to invest. In addition, Pieretti et al. (2007) and Han et al. (2013) suggest that institutional quality allows small countries to attract firms. Thus, the role of institutional quality might offer an explanation of why countries with a small number of investors develop in prominent financial centers.

This research contributes to this literature analyzing the impact of countries' institutional quality on the performance of firms and on the demand for stocks. It also studies the effect of institutional quality on firms' resilience to systemic shocks. The main idea is to provide evidence on the role of institutional quality on the developing of financial center.

This chapter is divided into two parts. Firstly, we use the theoretical model developed in Chapter 1 of the present thesis to model the market for stocks. Following the study of Acemoglu and Zilibotti (1997), the model allows two types of shock to affect dividends: a systemic shock which reduces dividends for all firms, and an idiosyncratic shock that only reduces dividends of a particular firm. The model assumes that the negative impact of a systemic shock on dividends is mitigated by a favorable institutional setting. The model's solution delivers a typical demand function under horizontal product differentiation (Singh and Vives, 1984; Belleflamme et al., 2000; Ottaviano et al., 2002). Results imply that increasing institutional quality raises the demand for stocks, by reducing the loss in dividends when a systemic shock occurs. This is consistent with the results of Asgharian et al. (2014) who find that institutional quality has a significant effect on trust and that trust, in turn, determines significantly stocks market participation.

Secondly, it analyzes empirically the relationship between institutional quality, systemic shocks and dividends payout. The aim of the analysis is to estimate the effect of markets' institutional quality on dividends payout by firms since the theoretical model predicts that this variable affects the demand for stocks. An empirical model is developed and used to test the key assumptions of the theoretical model. These are as follows: 1) a systemic shock reduces dividends for all firms in the economy; 2) high institutional quality reduces the negative impact of a systemic shock on dividends. The model is estimated using data on balance sheets and income statements of EU listed companies sourced from the COMPUSTAT database, as well as indicators of institutional quality available at country level. Namely, institutional quality is measured by two different indicators as in Giannone et al. (2011). These are, respectively, the World Bank's *Regulatory Quality* index and the *Economic Freedom* index released by the Fraser Institute. The sample ranges from 2004 to 2011, which allows us to study different economic environments. We run different regressions. First, we split countries into high and low institutional quality categories. Results suggest that the negative effect on dividends stemming from a systemic shock is mitigated by institutional quality, which supports our two main hypotheses. We run several robustness checks. Our hypotheses are also verified when the institutional quality indexes are specified as continuous variables instead of dummies. Additional results suggest the existence of a persistence in dividends payout, which is consistent with previous findings (Lintner, 1956). Firms that paid larger dividends in the previous year are more likely to distribute large dividends in the current year. We show that our hypotheses are still verified with this specification.

This research contributes to the understanding of the relationship between firms' performance and institutional quality, showing that institutional quality mitigates the negative effect on dividends of systemic shock. While it is recognized that institutions are important to economic development, empirical evidence is scarce. Acemoglu et al. (2005), in a review of the literature on the relationship between institutional quality and growth, argue that good institutions are a fundamental determinant of long-run growth. Several authors and policy makers have discussed the resilience of countries to systemic shocks (see, for example, Hellman et al., 1997; Beck et al., 2009; Giannone et al., 2011). Some of these studies came to surprising conclusions. Giannone et al. (2011), who study the difference in the degree of losses due to the 2008 financial crisis, show that countries with high regulatory quality were less able to resist to the financial crisis and experienced the greatest losses. This study differs with Acemoglu et al. (2005) and Giannone et al. (2011) in that it analyzes the effect of institutional quality on firms' performance and resilience to systemic shocks adopting a microeconomic perspective. Our results show that institutional quality reduces the negative impact of a systemic shock on dividends payout and as consequence on demand for stocks. So, we observe that countries with highest institutional quality are not worse off. When in fact we look at microdata, we see that results are different, at least for financial markets.

This chapter also contributes to the economic literature which focuses on the emergence of financial markets in small countries (Pieretti et al., 2007; Han et al., 2013). This literature argues that small countries can attract firms by providing a good institutional quality framework to investors.

The remaining of this chapter is as follows. The next section presents the theoretical model. Section 3 describes the data and presents the empirical model. Main results are analyzed in section 4. Discussion and additional results are considered in section 5. Finally, section 6 concludes.

2.2 Theoretical model

In this section, we use the theoretical framework developed in Chapter 1 of the present thesis to analyze the effect of institutional quality on dividends and on demand for stock. Our model considers 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 firms 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):

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

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:

$$\underset{\{x_0, x_1, q_k\}_{k=1,\ldots,N}}{\text{Max}} \mathbb{E}U = x_0 + \mathbb{E}\left[x_1\left(1 - r x_1\right)\right], \tag{2.2}$$

subject to

$$x_1 = \sum_{k=1}^{N} D_k q_k, \tag{2.3}$$

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{2.4}$$

For simplicity, the coefficient of risk aversion r is normalized to $\frac{1}{2}$. Equation (2.4) 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 wages are large enough for investors to purchase all stocks $q_k > 0$. In order to solve the investor problem, dividends should be explicitly defined. 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, firms pay a unit dividend in the absence of shocks. As mentioned above, there are two alternative types of shock: idiosyncratic (independent) shocks and a macroeconomic (correlated) shock. The idiosyncratic shock only impacts a particular firm, while the macroeconomic shock impacts all firms 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 firms simultaneously pay the same dividend $D_k = 1-\gamma$ to investors where $\gamma \in (0,1]$. Here, we assume that systemic shocks reduce dividends for all firms in the economy. This assumption will be the first hypothesis that we will test in the empirical model of the present chapter, we call it assumption 1. State $\omega = 0$ takes place with probability ϕ. In state of nature $\omega = k, k \in \{1,..,N\}$, an idiosyncratic shock occurs for firm k. All firms pay the maximum dividend except firm $k = \omega$, 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: $\phi + N\psi = 1$. This excludes a state of nature in which no shocks happen.

The consumption in period 1 is summarized as follows:

$$x_1 = \begin{cases} Q(1-\gamma) & \text{at prob}(\omega = 0) = \phi, \\ Q - \beta q_k & \text{at prob}(\omega = k,\ k\in \{1,..,N\}\ ) = \psi. \end{cases} \tag{2.5}$$

Stock demand

We are now able to solve the investor's problem. Replacing (2.5) in the maximization problem given by (2.2), (2.3) and (2.4), we get

$$\underset{\{q_k\}_{k=1,\dots,N}}{\text{Max}} \quad \mathbb{E}U = x_0 + \phi(1-\gamma)Q[1-\frac{1}{2}(1-\gamma)Q] + \sum_{k=1}^{N} \psi(Q-\beta q_k)\left[1-\frac{1}{2}(Q-\beta q_k)\right], \tag{2.6}$$

subject to

$$\sum_{k=1}^{N} p_k q_k + x_0 = w. \tag{2.7}$$

Assuming $q_k > 0$ for all k, the first order condition of the maximization problem described by (2.6) and (2.7) with respect to q_k is:

$$\phi(1-\gamma)[1-(1-\gamma)Q] - \psi Q(N-2\beta) + \psi(N-\beta) - \beta^2 q_k \psi - p_k = 0. \tag{2.8}$$

In Appendix A, we show that the second order condition for a maximum is verified.

Aggregating over all stocks yields:

$$N\phi(1-\gamma)[1-(1-\gamma)Q] - \psi Q(N-2\beta)N - \beta^2 Q\psi + \psi(N-\beta)N - P = 0. \tag{2.9}$$

where $P = \sum_{k=1}^{N} p_k$ is a price index. Solving (2.9) with respect to Q gives:

$$Q = \frac{N\phi(1-\gamma) + \psi(N-\beta)N - P}{N\phi(1-\gamma)^2 + \psi(N-\beta)^2}. \tag{2.10}$$

Finally, plugging (2.10) in (2.8) and solving for q_k yields:

$$q_k = \alpha - bp_k + \chi P, \tag{2.11}$$

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 (2.11) 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. β is the stochastic element which impacts negatively the dividend of a particular firms. 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 substitution. In particular, when $\chi \to 0$ stocks are perfectly differentiated, while they become perfect substitutes when $\chi \to \infty$.

We assume that the amplitude of the macroeconomic shock can be reduced by increasing the institutional quality I such that

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

where $\eta > 0$ is *an institutional efficiency parameter* and

$$\frac{\mathrm{d}(1-\gamma)}{\mathrm{d}I} = \eta.$$

This assumption will be the second hypothesis (assumption 2) that we will test in the empirical model presented in section 2.3.

Under assumptions 1 and 2, the above framework allows us to analyze the impact of institutional quality on the demand for stocks. 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 around $\gamma = 1$ as:

$$\alpha \simeq a + dI,$$

$$\chi \simeq c,$$

where

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

are the values of $\alpha, \mathrm{d}\alpha/\mathrm{d}\gamma$ and χ at $\gamma = 1$. Note that $\mathrm{d}b/\mathrm{d}\gamma = \mathrm{d}^2 b/\mathrm{d}\gamma^2 = ... = 0$ and $\mathrm{d}\chi/\mathrm{d}\gamma = 0$ at $\gamma = 1$. Assuming symmetric firms $k, k \in \{1,..,N\}$, assumptions 1 and 2 give the following demand function:

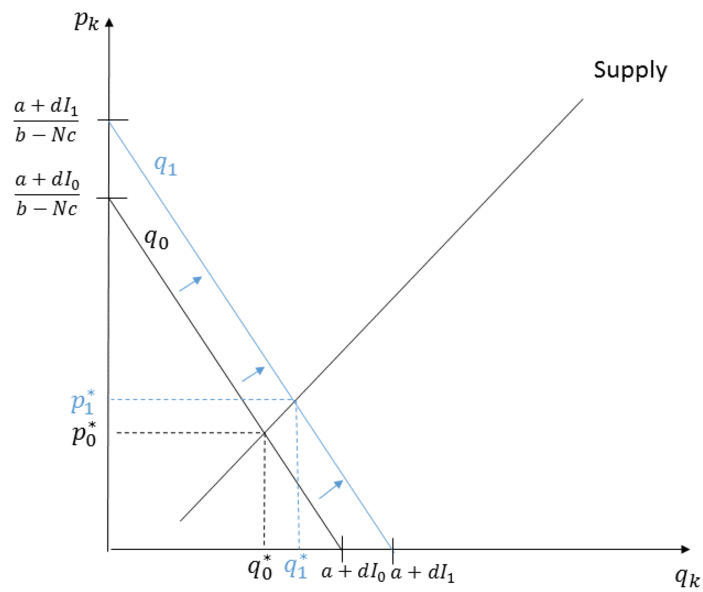
$$q_k = a + dI + p_k(Nc - b),$$

where

$$\frac{\mathrm{d}q_k}{\mathrm{d}p_k} = (Nc - b).$$

The demand shifter α is an increasing function of dividends payout when a systemic shock occurs $(1-\gamma)$. Better institutional quality reduces the negative impact of systemic shocks on dividends and as a consequence increase the demand for stocks. Under assumptions 1 and 2, Figure 2.1 shows that, for a given supply, the equilibrium price and quantity of stock k increases with the rise of institutional quality from I_0 to I_1. Indeed, an increase of institutional quality shifts the demand for stocks to the right. Therefore, firms have an incentive to ask for improvement of institutional quality and/or to list their stocks in a country with better institutional quality.

Figure 2.1 Effect of institutional quality on the demand for stocks



2.3 Empirical analysis

This section presents an empirical model to test the key assumptions of the theoretical model discussed in the previous section, namely that first, systemic shock reduces dividends for all firms in the economy (assumption 1), and second, better institutional quality reduces the negative impact of a systemic shock on dividends (assumption 2). The aim of testing those assumptions is to verify the impact of institutional quality on demand for stocks as predicted by the implication of the theoretical model. Indeed, under assumptions 1 and 2, the theoretical model implies that the equilibrium price and quantity of stock k increases with the rise of institutional quality. Thus, firms have an incentive to ask for improvement of institutional quality. Firstly, this section presents the data used in the analysis, then outlines the empirical strategy.

2.3.1 Data and descriptive

The dataset used in this analysis includes annual observations on balance sheets and income statements of EU listed companies, as well as indicators of institutional quality constructed at country level. The sample ranges from 2004 to 2011, thus including the years of the financial crisis, which is interpreted here as a systemic shock (Brunnermeier and Sannikov, 2014; Bernanke et al., 2008). The firm-level data are an unbalanced panel of 1906 firms sourced from COMPUSTAT, a large database that contains information on firms' balance sheets and income statements. The total number of observations on firms is 9173 observations. Since we are interested in explaining changes in dividends, we only include firms that pay dividends. The country level data are indicators of institutional quality. We use the Regulatory Quality index released by the World Bank and the Economic Freedom computed by the Fraser Institute as in Giannone et al. (2011). To eliminate exchange rate risk, we consider companies with headquarters in one of the following countries of the Euro-zone: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia and Spain.[1]

The aim of this analysis is to estimate the effect of systemic shocks and institutional quality on firms dividends payout, in order to verify assumptions 1 and 2. The implication of the theoretical model suggests that if those two

[1] COMPUSTAT includes 96% of companies listed in Europe. For our purpose, we consider firms that are listed in the Euro-zone and in, particular, in one of the above 17 countries. The number of firms in our dataset is 1906, which represents 50% of Euro-zone firms that are included in COMPUSTAT. For example, 1300 companies are listed in Euronext.

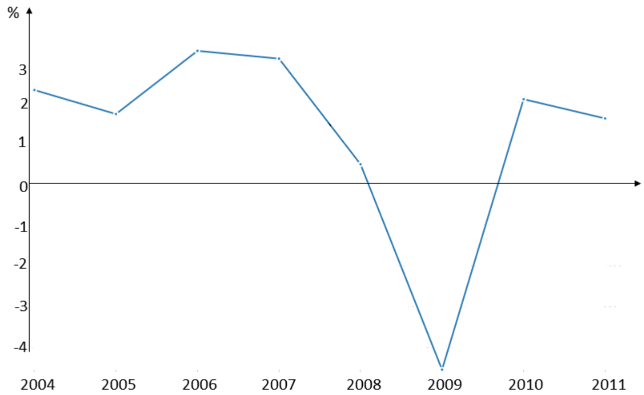
assumptions are verified, institutional quality has a positive effect on the demand for stocks. Therefore, the dependent variable used in this analysis is dividends payout. The main variables of interest are institutional quality and systemic shock. We consider two proxies for the institutional quality: the regulatory quality index and the economic freedom index. The regulatory index represents an indicator of governance and "market friendliness". This index is computed by the World Bank, it is a measure of "the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development" (Kaufmann et al., 2002). It is based on surveys of firms and industries and on the assessment of commercial risk rating agencies, non-governmental organizations and various multilateral aid agencies and public sector organizations. For example, it includes price liberalization, competition policies in various sectors, discriminatory taxes and tariffs, trade and exchange rate controls, access to capital markets. Using the above information, the World Bank attributes a score to countries according to their level of regulatory quality, the score is between [-2.5, 2.5]. Countries that have the lowest regulatory quality have the minimum grade of -2.5. In contrast, countries that have the grade of 2.5 have the highest regulatory quality.

The economic Freedom of the World (EFW) is the second indicator of institutional quality. It measures the degree to which the policies and institutions of countries are supportive of economic freedom. This index, released by the Fraser Institute, is constructed measuring five areas, size of government (expenditures, taxes, and enterprises), legal structure and security of property rights, access to sound money, freedom to trade internationally, and regulation of credit, labor, and business. In particular, for our research, we use the regulation index (fifth area). This index has three sub-components: credit market regulation, labor market regulation and business regulation. The credit market regulation component considers ownership of banks as described by Barth et al. (2013). The rating for this sub-component is computed using the percentage of bank deposits held in privately owned bank. It also examines the private-sector credit which measures the extent of government borrowing relative to private-sector borrowing and the level of interest rate controls. Labor market regulation includes among others hiring and firing market regulation, centralized collective bargaining and working-time regulations. Finally, business regulation uses for example data on administrative requirements, bureaucracy costs and ease of starting a business. Each country is rated between 0 to 10, where 10 is the maximum. Note that the Regulatory Quality index is recognized to have a broader scope than the Economic Freedom indicator (Giannone et al., 2011).

For our baseline empirical model, countries are divided in two categories according to the level of regulatory quality and economic freedom. The high regulatory quality category includes countries that have a minimum grade of 1.3/2.5 (sample average) for the regulatory quality index. Thus, the regulatory quality variable takes the value of one if the firm is in a high regulatory quality country and zero otherwise. The high economic freedom group contains countries that have a minimum grade of 6.94/10 (sample average) for the economic freedom index. Economic freedom variable takes the value of one if the firm has its headquarters in a country with high economic freedom and zero otherwise.

The systemic shock is a dummy variable that takes value 1 during the period 2008-2009 and zero otherwise. This allows us to model two distinct macroeconomic environments: the normal period and the crisis period. This follows Brunnermeier and Sannikov (2014) and Bernanke et al. (2008), who interpreted the Great Recession as a systemic shock. Figure 2.2, which presents the GDP growth in the Euro area, shows that 2008 is characterized by a large fall in GDP growth, only 0,5% of growth and that 2009 saw negative growth of -4,5%.

Figure 2.2 Annual GDP growth (%), Euro area



Source: World bank, annual GDP growth in percentage, Period 2004-2011.

We also control for several key financial characteristics of firms that are regarded as determinants of dividends payout: size, profitability, growth, leverage, tax, retained earnings and cash holdings. These variables have been identified and described by Boldin and Leggett (1995), Fama and French (2001) and Jiraporn et al. (2011). Those characteristics are computed using information from balance sheets and income statements. Table 2.1 lists the different control variables and summarizes their expected effect on dividends. The size is measured by the total assets of firms. We expect that this variable impacts dividends positively.[2] Profitability, growth, retained earnings, and cash are, respectively, measured by net income over total sales, capital expenditures over total assets, retained earnings over total equity and cash over total assets. These four variables are expected to have a positive impact on dividends. Leverage is the total debt over total assets, which represents the use of borrowed money to increase firms' size. It is expected to have a negative impact on dividends. The intuition is that firms with high levels of leverage earn lower profits since they pay a large amount of interests to debt owners. As a consequence, they have less money to distribute in dividends. Finally, tax is the income taxed paid by firms over total assets. This last variable is also expected to have a negative impact on dividends.

[2]Total assets is given by the sum of the asset side of the balance sheet.

Table 2.1 Control variables

Control Variables	Measurement	Expected effect on dividends
Size	Natural logarithm of total assets	+
Profitability	Net income over total sales	+
Growth	Capital expenditures over total assets	+
Leverage	Total debt over total assets	-
Tax	Income taxes over total assets	-
Retained earnings	Retained earnings over total equity	+
Cash	Cash over total assets	+

Tables 2.2 and 2.3 present, respectively, summary statistics and correlations for the selected variables. Table 2.2 allows comparisons across economic environment; the normal period and the crash period. The level of regulatory quality and economic freedom indexes are pretty stable across both periods. To ensure that the results are not driven by stock price, we compare dividends-to-total asset ratio for each period as in Abreu and Gulamhussen (2013). Dividends over total assets decreases from 3% in normal period to 2.8% during the crash period. Note that dividends during the crash period are those resulting from the activity in 2008-2009 and distributed in 2009-2010. The mean of dividends is larger during the crash period than in normal period. This contrasts with the key assumption of the theoretical model which predicts that dividends payment is lower during the crash period. This can be due to a price effect. We also suspect that this comes from the decrease in leverage during the crisis period. Since summary statistics provide the average of dividends without controlling for the effect of other variables, the decrease in leverage might positively affect dividends in the crash period. The same result is observed for the mean of profitability. However, the median of profitability is lower in the crash period at 3% than in normal period with 4,7%. Moreover, growth has decreased from 5.2% for the normal period to 4.1% for the crash period. From Table 2.2, the effect of the systemic shock on dividends is uncertain and unclear.

Table 2.2 Summary statistics

	Full sample			Sub-sample: normal period			Sub-sample: crash period		
Variables	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
Dividends over total assets (%)	3	7.2	1.6	3	7.9	1.6	2.8	4.7	1.5
Dividends (in million euros)	93.673	388.769	6.168	90.802	373.902	6.11	102.797	432.593	6.26
Total assets (in million euros)	4790.177	17298.38	400.318	4639.821	16818.78	386.907	5267.881	18736.93	446.842
Leverage (%)	8.6	9.1	5.8	8.8	9.3	6.1	7.8	8.7	5
Profitability (%)	-15	1914.4	4.5	-26.7	2180.2	4.7	20.3	454.9	3.9
Growth (%)	4.9	4.7	3.7	5.2	4.8	3.9	4.1	4.2	3
Tax (%)	0.2	2.5	0	0.1	2.5	0	0.7	2.5	0.5
Retained Earnings (%)	32.1	80	27.5	30.1	87.5	25.8	36.8	.521	34.3
Cash (%)	12.3	12.6	8.3	12	12.5	8	13.3	12.8	9.6
Regulatory Quality	1.30	.305	1.28	1.30	.3	1.28	1.296	.326	1.31
Economic Freedom	6.94	.603	7.1	6.981	0.603	7.1	6.81	.585	7
N		9173			6977			2196	

Table 2.2 presents some summary statistics for the full sample for the period 2004-2011, for the normal period 2004-2007 and 2010-2011, and for the crash period 2008-2009. Dividends over total assets, dividends, total assets, Leverage, profitability, growth, tax, retained earnings and cash are taken from COMPUSTAT. Regulatory quality indexes and Economic Freedom are respectively taken from the World Bank and the Fraser Institute.

Table 2.3 Cross-correlation table

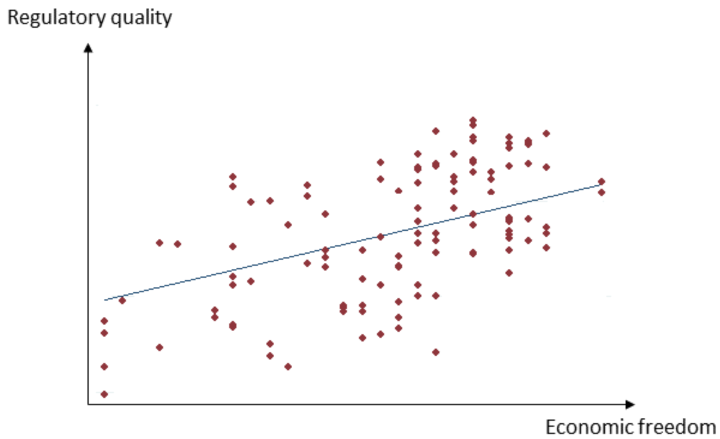
Variables	Dividends	Total Assets	Leverage	Profitability	Growth	Tax	Retained Earnings	Cash	Regulatory quality	Economic Freedom
Dividends	1.000									
Total Assets	0.733	1.000								
Leverage	-0.054	-0.028	1.000							
Profitability	0.003	0.003	0.001	1.000						
Growth	0.033	0.014	0.023	0.012	1.000					
Tax	-0.047	-0.015	-0.015	0.001	-0.025	1.000				
Retained Earnings	0.034	0.032	-0.072	0.003	0.024	-0.029	1.000			
Cash	-0.066	-0.067	-0.313	-0.046	-0.159	0.011	0.031	1.000		
Regulatory quality	0.019	0.026	-0.237	-0.007	0.011	-0.004	0.084	0.082	1.000	
Economic Freedom	0.028	0.004	-0.183	0.017	0.006	0.060	0.020	0.027	0.440	1.000

Table 2.3 presents correlation for the entire sample 2004-2011. Dividends, total assets, Leverage, profitability, growth, tax, retained earnings and cash are taken from COMPUSTAT.

Regulatory quality indexes and Economic Freedom are respectively taken from the World Bank and the Fraser Institute.

Table 2.3 shows that dividends are positively correlated with total asset, profitability, growth, tax, retained earnings, regulatory quality and economic freedom. In contrast, dividends are negatively correlated with leverage, tax and cash holdings. Except for the cash variable, the cross-correlation table confirms the expected effect on dividends of the control variables as described by Table 2.1 and the main variable (institutional quality) as expected by the theoretical model. Figure 2.3, which plots correlation between regulatory quality and economic freedom, suggests that these two variables have a positive linear relationship.

Figure 2.3 Correlation between Regulatory Quality and Economic Freedom



Source: World Bank (regulatory quality) and the Fraser Institute (Economic freedom).

2.3.2 The empirical model

The baseline empirical model is specified as follows:

$$\ln(\text{dividends payout}_{it}) = \alpha_i + \beta X_{it} + \alpha_8 \text{ shock}_t + \alpha_9 \text{ institutional quality}_{it} + \alpha_{10} \text{ institutional quality}_{it} {}^{*} \text{ shock}_t + u_{it},$$

where X_{it} is the vector of control variables which includes size, profitability, growth, leverage, tax, retained earnings and cash holdings and β is the vector of control variables' coefficients. Firms are denoted by $i = 0, ..., \mathcal{I}$ and time by

$t = 0, ...T_i$. The coefficient α_i is a firm fixed effect and u_{it} is the normal error term of mean 0 and variance σ^2. The explanatory variables of interest are shock and institutional quality. Note that all firms in the same countries have the same level of institutional quality. The parameter α_8 estimates the direct effect of the shock on dividends. To test the hypothesis that better institutional quality reduces the negative impact of a systemic shock on dividends, we include the interaction of the shock with the institutional quality. To simplify the interpretation of marginal effects, without loss of generality, we consider institutional quality as a dummy variable. Countries are divided into two categories: high institutional quality and low institutional quality. Firms are located in one of the two types of countries. Therefore, institutional quality is a dummy variable which takes the value of zero when the firm has its headquarter in a country with low institutional quality and the value of one otherwise.

Table 2.4 summarizes the empirical model for the different possible states of nature (normal vs. crash) and for the different levels of institutional quality (high vs. low). Recall the dependent variable $y_{it} = \ln(\text{dividends payout}_{it})$.

Table 2.4 Institutional quality

	State of the economy	
	Normal (shock=0)	Crash (shock=1)
Low	$y_{it} =_{it} + u_{it}$	$y_{it} = \beta X_{it} + \alpha_8 + u_{it}$
High	$y_{it} = \beta X_{it} + \alpha_9 + u_{it}$	$y_{it} = \beta X_{it} + \alpha_8 + \alpha_9 + \alpha_{10} + u_{it}$

Table 2.5 presents the percentage change in dividends from a period of normality to a crash period for firms listed in countries with low and high institutional quality. It also describes the percentage change in dividends for firms that are in low institutional quality countries compared to firms that are listed in high quality countries in both economic environment. Note that the percentage changes in dividends are calculated assuming no change in the model error.

Tables 2.4 and 2.5 show that going from a normal to a crash period modifies dividends by α_8 for firms in low institutional quality countries and by $\alpha_8 + \alpha_{10}$

Table 2.5 Marginal effects on dividends: shock and institutional quality

% change in dividends	
Normal to crash, low institutional quality country	$100\,[exp(\alpha_8)-1]$
Normal to crash, high institutional quality country	$100\,[exp(\alpha_8+\alpha_{10})-1]$
Low to high institutional quality, normal period	$100\,[exp(\alpha_9)-1]$
Low to high institutional quality, crash period	$100\,[exp(\alpha_9+\alpha_{10})-1]$

for firms in high institutional quality countries. Therefore, since assumption 1 from theoretical model predicts that a systemic shock reduces dividends for all firms in the economy, we expect that $\alpha_8 < 0$ and $\alpha_8 + \alpha_{10} < 0$. In addition, this table shows that improving the regulatory quality for firms leads to a change in dividends of α_9 in a normal period and of $\alpha_9 + \alpha_{10}$ in crash period. Assumption 2 from the theoretical model suggests that better institutional quality reduces the negative impact of systemic shocks on dividends. Therefore, $\alpha_9 + \alpha_{10}$ should be positive. Our three main testable hypotheses on parameters are summarized as follows:

$$(H1): \quad \alpha_8 < 0$$
$$(H2): \quad \alpha_8 + \alpha_{10} < 0$$
$$(H3): \quad \alpha_9 + \alpha_{10} > 0$$

Hypotheses $(H1)$ and $(H2)$ verify assumption 1 of the theoretical model. Finally, the hypothesis $(H3)$ tests the theoretical assumption 2. Note that the theoretical model makes no assumption on the impact of institutional quality on dividends in normal period.

2.4 Results

Table 2.6 presents results from the estimation of the empirical model of dividends related to institutional quality, as discussed in the previous section.[3] Note that

[3]We have run our regressions using two different estimators of dividends payout; dividends-over-total assets ratio and dividends in euros. Results are the same in both cases, except for

the empirical results are valid conditional on the event that firms distribute a positive dividend payout each period.[4] Column (1) of Table 2.6 gives the estimate of the baseline regression, where institutional quality is measured by the regulatory quality dummy.[5] Results show that the direct effect of the systemic shock on dividends, captured by the parameter α_8, is significant and negative, which confirms ($H1$). In contrast, the coefficient of regulatory quality, α_9, is not significantly different from zero. A possible explanation is that it is costly for firms to comply with countries institutional standards. Thus, in normal period the positive effect of regulatory quality on dividends can be canceled out by the cost. Finally, and most importantly, the interaction term parameter, α_{10}, is significant and positive. This parameter captures the effect of regulatory quality on dividends when a systemic shock occurs.

One can also see that the larger the firms, the higher is the increase in dividends. In particular, an increase of 1% of assets leads to an increase of 0.76% in dividends. Growth and retained earnings have also significant positive impacts on dividends. The intuition is that firms which invest using capital expenditures and retained earnings earn more profits and then distribute more dividends. In contrast, by raising leverage by 1%, dividends fall by 1.71%. Indeed, firms with a high level of debt have lower profits because they pay substantial interest, resulting in fewer resources available to distribute in dividends. Profitability, tax and cash have no significant effect on dividends growth. These reported results confirm outcomes found in previous literature on the effects of controls variables on dividends (Boldin and Leggett, 1995; Fama and French, 2001; Jiraporn et al., 2011).

The bottom rows of column (1) of Table 2.6 reports the results of the F-tests for $\alpha_8 + \alpha_{10} > 0$ and $\alpha_9 + \alpha_{10} < 0$, which are, respectively, 11.50 (p-

the coefficient of total assets, which is normal. To facilitate the intuition, we have decided to use the dividends in euros as the dependent variable.

[4] This assumption has reduced the sample by 921 firms over a total sample of 10024 firms ($\approx 9\%$).

[5] 45,44% of total observations are in the high regulatory quality group, and thus, 54,56% of observations are in the low regulatory category.

value=0.0007) and 11.07 (p-value=0.0003). The tests reject the null hypothesis. Thenceforward, (H2) and (H3) are verified. Thus, assumption 1 and 2 are confirmed by the first regression of Table 2.6.

To evaluate the goodness of fit of this regression, we use the R^2 measure which is equal to 0.69. This shows that the model fits the data.[6]

Table 2.6 Regulatory Quality and Economic Freedom (dummies)

	(1) ln(dividends)	(2) ln(dividends)	(3) ln(dividends)
ln(assets)(α_1)	.762***	.768***	.763***
	(.052)	(.053)	(.052)
Leverage (α_2)	-1.708***	-1.758***	-1.717***
	(.388)	(.393)	(.388)
Profitability (α_3)	.000	.000	.000
	(.000)	(.000)	(.000)
Growth (α_4)	2.231***	2.199***	2.197***
	(.426)	(.425)	(.426)
Tax (α_5)	.284	.359	.343
	(.432)	(.444)	(.439)
Retained Earnings (α_6)	.068*	.069*	.068*
	(.039)	(.040)	(.039)
Cash (α_7)	.103	.107	.103
	(.213)	(.213)	(.212)
Shock (α_8)	-.260***	-.164***	-.262***
	(.051)	(.035)	(.052)
Regulatory quality dummy (α_9)	.035		-.006
	(.043)		(.047)
Regulatory quality dummy*Shock (α_{10})	.162***		.219***
	(.056)		(.061)
Economic freedom dummy (α_{11})		-.038	-.031
		(.037)	(.037)
Economic freedom dummy*Shock (α_{12})		-.018	-.137**
		(.054)	(.058)
Fixed effect (α_i)	-2.763***	-2.758***	-2.733***
	(.327)	(.330)	(.327)
Tests of null hypothesis:	F-test	F-test	F-test
$\alpha_8 + \alpha_{10} > 0$	11.50***		0.99
$\alpha_9 + \alpha_{10} < 0$	11.07***		15.47***
$\alpha_8 + \alpha_{12} > 0$		18.30***	29.87***
$\alpha_{11} + \alpha_{12} < 0$		0.92	8.03***
Observations	9173	9173	9173
R^2	0.6867	0.6836	0.6843

Columns (1)-(3) report the outcome of three panel regressions with fixed effect. Heteroskedasticity robust standard errors are given in parenthesis. Each coefficient is significant at 10%*, 5%** or 1%*** level. Units: Dividends and assets are in euros. Others variables are in percentage. Sources: COMPUSTAT, World Bank and the Fraser Institute.

[6] see Appendix B for a graphical analysis of residuals.

Table 2.7 summarizes the marginal effects of variables of interest from the regression in column (1) of Table 2.6. A macroeconomic shock induces a $100[\exp(\alpha_8 + \alpha_{10}) - 1]$ percentage change in dividends for firms that are listed in high institutional quality countries, other things held equal and a percentage change in dividends of $100[\exp(\alpha_8) - 1]$ for firms in low institutional quality countries. Finally, a positive change in quality leads to a percentage change in dividends of $100[\exp(\alpha_9 + \alpha_{10}) - 1]$.

Table 2.7 Marginal effects on dividends: systemic shock and regulatory quality

% change in dividends	
1. Normal to crash, low regulatory quality country	$100[\exp(\alpha_8) - 1] = -22.89 < 0$
2. Normal to crash, high regulatory quality country	$100[\exp(\alpha_8 + \alpha_{10}) - 1] = -9.33 < 0$
3. Low to high regulatory quality, crash period	$100[\exp(\alpha_{10}) - 1] = 17.58 > 0$

Results in Table 2.7 suggest that systemic shocks reduce dividends by 22.89% for firms based in countries with low regulatory quality, and only by 9.33% for firms in high regulatory quality countries. Moreover, during a crash period, firms that are in high regulatory quality environment distribute 17.58% more dividends than firms based in low regulatory quality countries.

Column (2) of Table 2.6 reports results of the baseline empirical model using an alternative measure of institutional quality, that is, the economic freedom index specified as a dummy variable.[7] Results show that the effect of the systemic shock and institutional quality are again, respectively significant and negative and not significant, thus confirming results obtained with the regulatory quality index. However, economic freedom has no impact on the response of dividends to the systemic shock. The mitigating effect found for the regulatory quality index is not present. A possible explanation is that the two indicators capture different characteristics of the institutional environment. Thus, in column (3) of Table 2.6, we include both regulatory quality and economic freedom variables as well as their interactions with the shock. Results show that the effect of the systemic shock and institutional

[7] 62,78% of observations are in the high economic freedom category, and thus, 37,22% of observations are in the low economic freedom category.

quality approximated by both regulatory quality and economic freedom are again, respectively significant and negative and not significant, which confirms results obtained with the specification of column (1) and column (2) of Table 2.6. Finally, and most importantly, the interaction term between shock and regulatory quality parameter α_{10} is positive and significant. In contrast with column (2) of Table 2.6, economic freedom has now a negative impact on the response of dividends to the systemic shock. This confirms that the regulatory quality and economic freedom do not capture the same institutional environment. This result is consistent with Giannone et al. (2011) who argue that regulatory quality index has a broader scope and as a consequence it probably captures an important element of the institutional framework that is not included in economic freedom.

The empirical analysis shows that the effect of regulatory quality does not change across specifications, which suggests that the mitigating effect of regulatory quality on systemic shocks impact on dividends is a robust result. The way the dummies are specified might affect the results. The use of dummies only captures a change from low to high institutional quality category. Thus, in order to assess the effect of every small change of institutional quality on dividends, we re-run the regressions of Table 2.6 using regulatory quality and economic freedom modeled as continuous variables instead of dummies.[8]

[8] We transform the original codification of regulatory quality index which ranges between [-2.5,2.5] to a [0,10] range, from lowest to highest.

Table 2.8 Regulatory Quality and Economic Freedom (continuous)

	(1) ln(dividends)	(2) ln(dividends)	(3) ln(dividends)
ln(assets)(α_1)	.795***	.774***	.801***
	(.053)	(.053)	(.053)
Leverage (α_2)	-1.518***	-1.640***	-1.484***
	(.371)	(.376)	(.365)
Profitability (α_3)	.000	.000	.000
	(.000)	(.000)	(.000)
Capital Expenditures Ratio (α_4)	2.042***	2.315***	2.104***
	(.407)	(.432)	(.411)
Tax Ratio (α_5)	.450	.176	.365
	(.424)	(.428)	(.422)
Retained Earnings (α_6)	.063	.072*	.065
	(.040)	(.040)	(.040)
Cash Holdings (α_7)	.142	.126	.154
	(.211)	(.211)	(.210)
shock (α_8)	-1.047**	-2.044***	-1.549***
	(.425)	(.513)	(.556)
Regulatory quality (α_9)	.588***		.561***
	(.107)		(.104)
Regulatory quality*shock (α_{10})	.115**		-.005
	(.054)		(.045)
Economic freedom (α_{11})		.103*	.067
		(.061)	(.057)
Economic freedom*shock (α_{12})		.278***	.209***
		(.073)	(.070)
Fixed effect	-7.434***	-3.557***	-7.740***
	(.940)	(.595)	(1.155)
Tests of null hypothesis:	F-test	F-test	F-test
$\alpha_9 + \alpha_{10} < 0$	33.91***		28.73***
$\alpha_{11} + \alpha_{12} < 0$		14.18***	8.77***
Observations	9159	9159	9159
R^2	0.6933	0.6921	0.6955

Columns (1)-(3) report the outcome of three panel regressions with fixed effect. Heteroskedasticity robust standard errors are given in parenthesis. Each coefficient is significant at 10%*, 5%** or 1%*** level. Units: Dividends and assets are in euros. Others variables are in percentage. Sources: COMPUSTAT, World Bank and the Fraser Institute.

Column (1) of Table 2.8 presents results from the baseline regression, where institutional quality is measured by the regulatory quality index specified as continuous variable. Results show that the direct effect of the systemic shock on dividends, captured by the parameter α_8, is significant and negative, which confirms (H1). In contrast with column (1) of Table 2.6, the coefficient of regulatory quality α_9 is, now, significant and positive. A possible explanation is that using the continuous regulatory quality allows the capture of the exact effect of an increase of regulatory quality in a normal period. Indeed, it considers not only a change from low to high regulatory quality as in Table 2.6 but every small change. Finally, and most importantly, the interaction term parameter α_{10} is significant and positive. This parameter captures the effect of regulatory quality on dividends when a systemic shock occurs.

Column (2) of Table 2.8 repeats the same estimation using the Fraser institute's economic freedom index to proxy institutional quality. Results show that the effect of the systemic shock and the economic freedom are, respectively significant and negative (H1) and significant and positive. This latter effect of economic freedom contrasts with the results obtained in Column (2) of Table 2.6. Moreover, the interaction term parameter is here significant and positive. These results are consistent with column (1) of the present table.

In column (3) of Table 2.8, we include both regulatory quality and economic freedom variables as well as their interactions with the shock. Results show that the effect of the systemic shock and the regulatory quality are, respectively significant and negative (H1) and significant and positive. However, the direct effect of the economic freedom index is not significant. The interaction terms parameters α_{10} and α_{12} are respectively not significant and significant and positive. A possible explanation is that the regulatory quality index captures the effect of institutional quality in a normal period. However, economic freedom represents the institutional quality in a period of shock.

Since Table 2.8 uses continuous variables as indicators of institutional quality, the marginal effect of the systemic shock on dividends is given by $100[\exp(\alpha_8 + \alpha_{10}\text{institutional quality}) - 1]$. Thus, the change in dividends depends on the level of institutional quality. Using conventional statistics test developed for point estimates, only (H3) can be tested. The F-tests for $\alpha_9 + \alpha_{10} < 0$ and $\alpha_{10} + \alpha_{12} < 0$ are respectively 33.91 (p-value=0.0000) for column (1) and 28.73 (p-value=0.0000) for column (2). Thus, assumption 2 is verified for the various specifications.

The goodness of fit of regressions in column (1), (2) and (3) of Table 2.8, are evaluated using the R^2 measure. The R^2 measures reported in Table 2.8, suggest that the different specifications fit the data well.

Table 2.9 measures the marginal effects of a change of regulatory quality in both economic state for the columns (1), (2) and (3) of Table 2.8. Results given by Table 2.9 quantify the effect of institutional quality on dividends.

Table 2.9 Marginal effects on dividends: systemic shock, regulatory quality and economic freedom

% change in dividends	
Column(1)	
Increase of 1% of regulatory quality, normal period	$10\alpha_9 = 5.8$
Increase of 1% of regulatory quality, crash period	$10(\alpha_9 + \alpha_{10}) = 7 > 0$
Column(2)	
Increase of 1% of economic freedom, normal period	$10\alpha_{11} = 1.3$
Increase of 1% of economic freedom, crash period	$10(\alpha_{11} + \alpha_{12}) = 3.8 > 0$
Column(3)	
Increase of 1% of regulatory quality, normal period & crash period	$10\alpha_9 = 5.6 > 0$
Increase of 1% of economic freedom, crash period	$10\alpha_{12} = 2.09 > 0$

2.5 Discussion and additional results

This section focuses on the potential persistence of dividends. Lintner (1956) analyzes the behavior of 28 US firms during the period of 1918-1941. He argues that dividends are sticky around a target dividend level. Therefore, the Lintner empirical model consists of a regression of current dividends against lagged dividends and other control variables. The intuition is that firms that paid large dividends in the previous year are more likely to distribute large dividends in the subsequent year.

In order to identify the shock period in a dynamic model, we use the variable "GDP Growth" which captures the GDP growth in the euro area during the period of 2004 to 2011. Indeed, the use of this variable allows us to capture every small changes in economic growth that have an impact on dividends. Using a dummy to capture the shock in this model leads to less significant effect of the macroeconomic environment on dividends. Note that the use of

GDP growth in the baseline model gives the same results that those with the shock dummy variable. The data on GDP Growth are sourced from Eurostat.[9]

The empirical model with persistence of dividends is specified as follows:

$$\begin{aligned}\ln(\text{Dividends payout}_{it}) &= \alpha_i + \beta X_{it} + \delta \ln(\text{Dividends payout}_{it-1}) \\ &\quad + \alpha_8 \text{ GDP growth}_t + \alpha_9 \text{ institutional quality}_{it} \\ &\quad + \alpha_{10} \text{ institutional quality}_{it} * \text{GDP growth}_t + \text{u}_{it}.\end{aligned}$$

Firms are denoted by $i = 0, ..., \mathcal{I}$ and time by $t = 0, ...T_i$. The above regression includes the lag of dividends. The parameter δ estimates the effect of past dividends on current dividends. As in the baseline model, the vector X_{it} of control variables includes size, profitability, growth, leverage, tax, retained earnings and cash. The vector β contains coefficients of control variables. The coefficient α_i is a firm fixed effect and u_{it} is the normal error term of mean 0 and variance σ^2. Parameters α_8 and α_9 estimate, respectively, the direct effect of GDP growth and institutional quality on dividends. In contrast to the baseline model, α_8 is now expected to be positive. Indeed, for positive value of GDP growth, we expect that the effect on dividends is positive. Symmetrically, negative value of GDP growth should impact negatively dividends. The parameter α_{10} is the coefficient of the interaction of GDP growth with institutional quality. When α_{10} is negative, institutional quality has a positive effect on dividends in shock periods (negative GDP).

Since the above regression includes the lag of dividends as an explanatory variable of dividends, the strict exogeneity condition between the error term and the regressors is ruled out. However, as argued by Keane and Runkle (1992) and Wooldridge (2010), we can assume sequential exogeneity. Hsiao (1986) shows that the fixed effect estimator is not consistent for dynamic panel data under sequential exogeneity. Thus, Arellano and Bond (1991) propose using the Generalized Method of Moments (GMM).

[9]http://ec.europa.eu/eurosta

Table 2.10 presents results when the lag of dividends is included as an explanatory variable of current dividends. Columns (1) and (2) consider, respectively, regulatory quality and economic freedom as a proxy of institutional quality.

Table 2.10 Regulatory Quality and Economic Freedom: dynamic

	(1) ln(dividends)	(2) ln(dividends)
lag of ln(dividends) (δ)	.380***	.383***
	(.068)	(.066)
ln(assets) (α_1)	.314***	.298***
	(.066)	(.066)
Leverage (α_2)	.339	.296
	(.263)	(.262)
Profitability (α_3)	.004***	.004***
	(.001)	(.001)
Growth (α_4))	2.376***	2.387***
	(.431)	(.431)
Tax Ratio (α_5)	-.459	-.506
	(.664)	(.664)
Retained Earnings (α_6)	.087***	.087***
	(.023)	(.023)
Cash (α_7)	-.662***	-.658***
	(.250)	(.250)
GDP Growth (α_8)	.030***	.034***
	(.006)	(.005)
Regulatory quality (α_9)	.156*	
	(.091)	
GDP Growth*regulatory quality(α_{10})	-.004***	
	(.001)	
Economic freedom (α_{11})		-.046
		(.067)
GDP Growth*economic freedom (α_{12})		-.004***
		(.001)
Fixed effect	-1.939**	-.328
	(.814)	(.675)
Observations	5132	5132
log(likelihood)		

Columns (1)-(2) report the outcome of two panel regressions with fixed effect. Heteroskedasticity robust standard errors are given in parenthesis. Each coefficient is significant at 10%*, 5%** or 1%*** level. Units: Dividends and assets are in euros. Others variables are in percentage. Sources: COMPUSTAT, Eurostat, World Bank and the Fraser Institute.

Results of column (1) in Table 2.10 show that the lag of dividends is significant and positive. Thus, this suggests that there exits a persistence in paying dividends. An increase of 1% of dividends in previous period raises current dividends by 0.38%. The direct effect of GDP growth captured by α_8 and the effect of regulatory quality α_9 are both significant and positive on dividends. The parameter α_8 is consistent with the negative impact of systemic shock assumption (H1). The interaction coefficient α_{10} is significant and negative as expected. Concerning the control variables, Table 2.10 shows that the size effect represented by the natural logarithm of assets on dividends is reduced to half compared to Tables 2.6 and 2.8. This can be explained by the fact that the lag of dividends captures a positive effect that was considered as a size effect. Here, leverage has no significant effect any longer. Coefficients of growth and retained earnings are similar to those in Tables 2.6 and 2.8. In contrast, profitability and cash are now significant. The negative effect of cash can be explained by the fact that when firms hold cash, they do not invest in their assets and therefore the return on this investment is nil. Results from column (2) suggest similar results than that in column (1) except for the direct effect of economic freedom on dividends (α_{11}) which is not significant.

2.6 Conclusion

The present research studies the impact of countries' institutional quality on firms' performance and on demand for stocks. It also focuses on the effect of institutional quality on firms resilience to systemic shocks. In the theoretical model, we assume that systemic shocks reduce dividends for all firms in the economy and that high institutional quality reduces the negative impact of systemic shocks on dividends. Thus, under our assumptions, we show that institutional quality raises the demand for stocks. Second, we build an empirical model to test the two key assumptions of the theoretical model. We show that our main hypotheses are verified and robust to various specifications. Moreover, additional results suggest the existence of a persistence in dividends payout. Therefore, firms that paid large dividends in the previous year are more likely to distribute large dividends in the subsequent year.

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2.8 Appendix

Appendix A

We prove that the second order condition of problem (2.6) for a maximum is verified.

The second order condition of (2.6) with respect to q_k is:

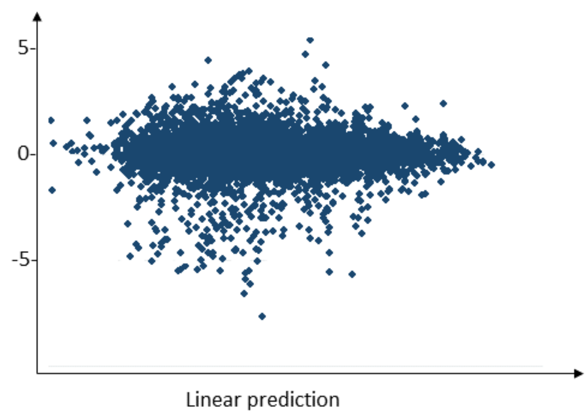
$$-\left[\phi(1-\gamma)^2+\psi(N-2\beta)+\beta^2\psi\right]<0. \tag{2.12}$$

Since $N \geq 2, \beta \in (0,1]$ and $\gamma \in (0,1]$, (2.12) is always verified.

Appendix B

Here, we show that the residuals are well distributed around 0.

Figure 2.4 Residuals



Chapter 3

Regulation and Rational Banking Bubbles in Infinite Horizon

(joint with Claire Océane Chevallier)

Abstract

This chapter develops a dynamic stochastic general equilibrium model in infinite horizon with a regulated banking sector where stochastic banking bubbles may arise endogenously. We analyze the condition under which stochastic bubbles exist and their impact on macroeconomic key variables. We show that when banks face capital requirements based on Value-at-Risk, two different equilibria emerge and can coexist: the bubbleless and the bubbly equilibria. Alternatively, under a regulatory framework where capital requirements are based on credit risk only, as in Basel I, bubbles are explosive and as a consequence cannot exist. The stochastic bubbly equilibrium is characterized by positive or negative bubbles depending on the tightness of capital requirements based on Value-at-Risk. We find a maximum value of capital requirements under which bubbles are positive. Below this threshold, the stochastic bubbly equilibrium provides larger welfare than the bubbleless equilibrium. In particular, our results suggest that a change in banking policies might lead to a crisis without external shocks.

Key words: Banking bubbles, banking regulation, DSGE, infinitely lived agents, multiple equilibria, Value-at-Risk.

3.1 Introduction

The Great Recession of 2007-2009 has highlighted the importance of the banking sector in the worldwide economy and its role in the propagation of the crisis. Valuation and liquidity problems in the U.S banking system are recognized to be a cause of the crisis (Miao and Wang, 2015). In particular, Miao and Wang (2015) argue that changes in agents' beliefs about stock market value of banks are suspected to explain sudden financial market crashes.

As a consequence, there has been a greater awareness among both academics and policy makers about the failure of banking regulation in preventing crises. The Basel committee on Banking Supervision was created in 1973 "to enhance understanding of key supervisory issues and improve the quality of banking supervision worldwide".[1] They released the first Basel Accord, called "Basel I" in 1988. The goal of Basel I was to create a framework for internationally active banks, in particular seeking, to prevent international banks from growing without adequate capital. Therefore, the committee imposed minimum capital requirements which were calculated based on credit risk weights of loans. Credit risk weights take into account possible losses on the asset side of a bank's balance sheet. The idea was that banks holding riskier assets had to hold more capital than other banks in order to ensure solvency. This approach has been criticized by researchers and regulatory agencies because it only considers credit risk and does not encompass market risk.[2] Market risk refers to the risk of losses from changes in market prices, which increases banks' default risk. The Basel committee has recognized this problem and released the Basel II Capital Accord.[3] This new accord also considers market values into the banking regulation framework in order to take into account market

[1]For more details, see The Basel Committee overview, https://www.bis.org/bcbs/.

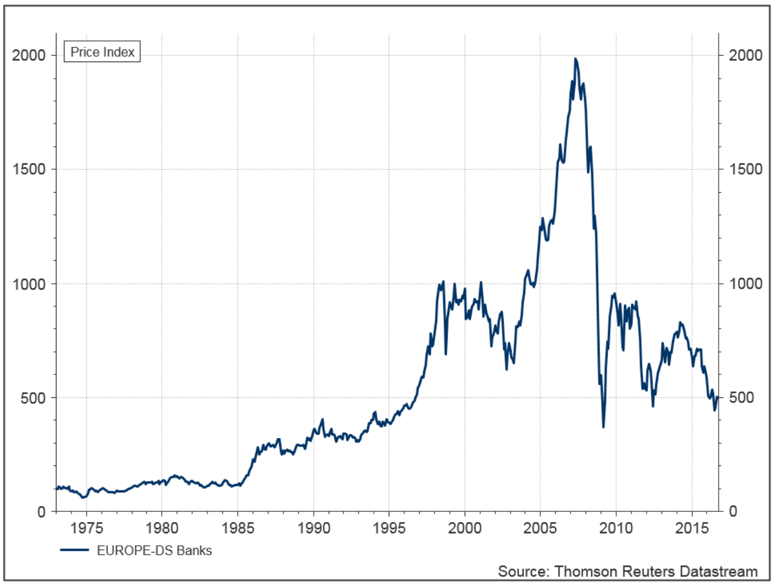
[2]For example, Dimson and Marsh (1995) analyze the relationship between economic risk and capital requirements using trading book positions of UK securities firms. They find that the Basel I approach leads only to modest correlation between capital requirements and total risk.

[3]See Basel Committee on Banking Supervision (2004).

risk of the trading book. It allows banks to use an internal model based on *Value-at-Risk* to quantify their minimum capital requirements. The idea of capital requirements based on Value-at-Risk is to impose a solvency condition for banks which requires that the maximum amount of debt that banks can hold, do not exceed the market value of banks assets in the worst case scenario.[4]

The aim of this chapter is to analyze the impact of banking regulation and in particular, Basel II, on the development of *stochastic bubbles* on banks' stock prices. A stochastic bubble on bank's stock price is defined as a temporary deviation of the bank's stock price from the bank's fundamental value. Figure 3.1 plots the price index of 168 banks listed in Europe from 1973 to 2016. It shows that the price index has sharply increased from 2004, which coincides with the release of Basel II. Therefore, we suspect that the Basel II regulatory framework has allowed the existence of bubbles in the banking sector.

Figure 3.1 Banks price index



[4]Basel III, released in 2011, also proposes to use the Value-at-Risk to measure the minimum capital requirement. The difference with Basel II is that it is amended to include a Stressed-Value-at-Risk (SVaR). It aims at reducing pro-cyclicality of the market risk approach and insures that banks hold enough capital to survive long periods of stress.

This paper also focuses on the effect of bubbles on macroeconomic key variables. Following Blanchard and Watson (1982) and Weil (1987), stochastic bubbles are bubbles that have an exogenous constant probability of bursting. Once they burst, they do not reemerge. We develop a dynamic stochastic general equilibrium model with three types of infinitely lived agents, banks, households, and firms, as well as a regulatory authority. Banks raise funds by accumulating net worth and demanding deposits (supplied by households) to provide loans to firms. Firms produce the consumption goods, invest and are subject to productivity shocks. The regulatory authority imposes two banking regulations. The first requires that banks keep a fraction of deposits as reserves. These reserves cannot be used to invest in loans (risky assets). The second measure requires banks to have an upper limit on the quantity of deposits based on Value-at-Risk capital requirements.

We show that bubbles emerge if agents believe that they exist. Thus, expectations of agents are self-fulfilling. Results suggest that when banks face capital requirements based on Value-at-Risk, two different equilibria emerge and can coexist: the bubbleless and the stochastic bubbly equilibria. The capital requirement based on Value-at-Risk allows bubbles to exist. In contrast, under a regulatory framework where capital requirement is based on credit risk only, as in Basel I, banking bubbles are explosive and as a consequence cannot exist. The stochastic bubbly equilibrium before the bubble bursts is characterized by positive or negative bubbles depending on the tightness of capital requirements. A positive (resp. negative) bubble is a "persistent" overvaluation (resp. undervaluation) of banking stock price. We find a maximum value of the capital requirement based on Value-at-Risk under which bubbles are positive. Below this value and until the bubble bursts, the stochastic bubbly equilibrium provides larger welfare than the bubbleless equilibrium. The intuition is that, when agents consider that a bubble exists, lower capital requirements lead to optimistic beliefs about bank valuation. Bubbles allow banks to relax the capital requirement constraint, and thus banks demand more deposits and make more loans. This effect reduces the lending rate and provides higher welfare. Profits of banks rise which increases the value of banks. As a consequence, initial beliefs about the value of banks are realized. In contrast, above this maximum capital requirement, bubbles are negative leading to a credit crunch and thus, reduce welfare. Therefore, our model shows that a change in regulation might lead to a crisis, by shifting the economy from higher to lower welfare. This can explain the existence of crises without external shocks. We also show that the equilibrium with positive stochastic bubbles exists if the probability that bubbles collapse is small. This is consistent with Weil (1987) and Miao and Wang (2015). Moreover, as in Miao and Wang (2015), our results suggest that after the bubble bursts, consumption, welfare, and output fall. Consequently, a change in beliefs also modifies the equilibrium, from higher to lower welfare. Finally, we simulate impulse response functions to a negative productivity shock. The results show that bubbles do not amplify the effect of a negative productivity shock on the economy.

This chapter is related to two strands of literature. First, it is related to the literature on banking regulation. Indeed, there is a very recent move towards macroeconomic models incorporating a banking sector (de Walque et al., 2010; Gertler and Kiyotaki, 2011; Gertler and Karadi, 2011; Gertler et al., 2012; He and Krishnamurthy, 2012; Brunnermeier and Sannikov, 2014). In particular, we focus on banking regulation and their impact on macroeconomic variables as in Dib (2010) and de Walque et al. (2010). As in Dangl and Lehar (2004) and Tomura et al. (2014), we study the impact of Value-at-Risk banking regulation on the economy. Dangl and Lehar (2004) compare the effect of capital regulation based on Basel I and Value-at-Risk internal model approach. They find that the latter regulation reduces risk in the economy. Tomura et al. (2014) introduce asset illiquidity in a dynamic stochastic general equilibrium model and show that capital requirements based on Value-at-Risk can lead banks to adopt macro-prudential behavior. We contribute to this literature by showing that capital requirements based on Value-at-Risk allow bubbles to exist. In contrast, under a regulatory framework where capital requirements are based on credit risk only, as in Basel I, bubbles are explosive and as a consequence cannot exist.

Second, this chapter is related to the literature on the existence and the effect of rational bubbles in infinite horizon and, in particular, on stochastic bubbles. The literature on the existence of bubbles in general equilibrium models with infinitely lived agents is scarce and marked with few important contributions (Miao, 2014). Therefore, the understanding of financial bubbles in infinite horizon models is still under explored. Tirole (1982) shows that bubbles under rational expectations with infinitely lived agents cannot exist. In addition, Blanchard and Watson (1982) argue that "the only reason to hold an asset whose price is above its fundamental value is to resell it at some time and to realize the expected capital gain. But if all agents intend to sell in finite time, nobody will be holding the asset thereafter, and this cannot be an equilibrium". Such behavior implies that agents over save so that they do not consume everything they could. This cannot be an equilibrium since agents would deviate to increase their consumption levels and, thus, the so called *transversality condition* (TVC) is not satisfied. In contrast, Kocherlakota (1992) demonstrates that bubbles may exist in an infinite horizon general equilibrium model with borrowing or wealth constraints. These constraints limit the agent arbitrage opportunities by introducing some portfolio constraints. Foremost, Kocherlakota (2008) shows that equilibrium in which the asset price contains a bubble can coexist with the bubbleless equilibrium in the presence of debt constraints. The only difference between the two states (bubbles and no bubbles) is that the bubbly one modifies the debt limit. The author calls this result the "bubble equivalence theorem". We contribute to this literature by showing that banking bubbles may emerge with banking regulation based on Value-at-Risk in an infinite horizon general equilibrium framework.

Our study is mostly related to Miao and Wang (2015). They insert an endogenous borrowing constraint and show that bubbles can emerge in an infinitely lived general equilibrium framework without uncertainty. Bubbles are introduced through the bank problem. We borrow the same methodology to introduce bubbles. Nevertheless, our model contrasts with Miao and Wang (2015) regarding four major characteristics. First, our key idea is to introduce banking regulation in an infinitely lived agent model to analyze whether stochastic bubbles can arise. Second, our model is a stochastic general equilibrium, in contrast, Miao and Wang (2015) consider a deterministic model. Third, negative bubbles as well as positive bubbles can arise, while they only assume positive bubbles. Fourth, they consider an agency problem to justify a minimum dividend policy that links dividends to net worth. Our model does not impose a dividend policy.

The present paper is organized as follows. Section 2 presents the model. Section 3 and section 4 analyze, respectively, the bubbleless and the stochastic bubbly general equilibrium. Section 5 compares both equilibria. Section 6 presents the calibration, explores local dynamics and compares impulse response functions to a negative productivity shock for both equilibria. Finally, the last section concludes.

3.2 Model

We consider an economy with three types of infinitely lived agents, banks, households, and firms, as well as a regulatory authority. In this model, banking bubbles can arise. They emerge only if agents believe that banks' stock prices contain a bubble. The bubble is, thus, self-fulfilling. Banks, households, and firms are respectively represented by a continuum of identical agents of mass one. Households are shareholders of banks and owners of firms. It is assumed that banks have the necessary technology and knowledge to engage in lending activity while households do not. Thus, the latter do not lend directly to non-financial firms and have recourse to banks. At the end of each period, banks raise funds internally, using net worth, and externally, by taking deposits from households. Using raised funds, they lend to firms which produce consumption goods. In the model, a bubble is introduced through the bank problem, as in Miao and Wang (2015). We consider a bubble with an exogenous probability of burst, i.e., a *stochastic bubble* as in Blanchard and Watson (1982). Although a bubble can only arise if agents believe in its existence, it is not an agent choice. Agents are "bubble takers". The optimization problem of each agent is presented in this section.

3.2.1 Households

Households are represented by a continuum of identical agents of unit mass. Each household starts with an initial endowment of stocks s_0 and deposits D_0. At each period t, it receives net profits π_t generated by firms, it chooses its optimal consumption c_t, the amount of stocks s_{t+1}, and deposits D_{t+1} for the next period. It also receives dividends d_t from the shares s_t it owns, sells its shares at price p_{t+1} and obtains an interest rate r_t on the amount deposited D_t in the previous period. There is no uncertainty on savings and thus r_t is the risk-free interest rate. We assume that preferences of households are represented by a linear utility function in consumption. Given the budget constraint (3.1), each household chooses the optimal amount of shares, deposits and consumption $\{s_{t+1}, D_{t+1}, c_t\}_{t=0}^{\infty}$ that maximizes its expected lifetime linear utility. Each household optimization problem is defined as follows:

$$Max_{\{s_{t+1}, D_{t+1}, c_t\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t c_t,$$

subject to

$$D_t (1 + r_t) + s_t (p_{t+1} + d_t) + \pi_t = D_{t+1} + c_t + s_{t+1} p_{t+1}, \tag{3.1}$$

where $\beta \in]0,1[$ is the discount factor and E_t is the expectation operator.

The first order conditions with respect to D_{t+1} and s_{t+1}, are given by

$$\beta E_t(1+r_{t+1}) = 1, \tag{3.2}$$

$$p_{t+1} = \beta E_t(d_{t+1}+p_{t+2}). \tag{3.3}$$

The combination of (3.2) and (3.3) gives the households no arbitrage condition, $E_t(d_{t+1}+p_{t+2})/p_{t+1} = E_t(1+r_{t+1})$. This last condition states that the return on stocks is equal to the return on deposits. If it is met, households are indifferent between both types of assets and both are held in the portfolio of agents. However, if this condition is not satisfied, the optimal solution of households yields to a corner solution, thus, only stocks or only deposits are held, depending on which has the highest return.

Since the optimization problem has an infinite horizon, we also have to consider the following transversality condition:

$$lim_{t\to\infty}\beta^t p_t s_t = 0. \tag{3.4}$$

Condition (3.4) ensures that the household spends all its budget and thus, does not hold positive wealth when $t \to \infty$. It is a necessary condition for an optimum choice of the household. Tirole (1982) shows that bubbles under rational expectations with infinitely lived agents cannot exist since the transversality cannot be satisfied. However, in our framework, banking bubbles satisfy this condition and therefore, may exist.

3.2.2 Firms

Firms are represented by a continuum of identical producers of unit mass. Each firm starts with an amount of loans L_0 to buy its initial capital K_0. Firms are subject to productivity shocks. The shock process is defined by an AR(1) process such that $A_t = A_{t-1}^{z_A}\exp(u_t)$, where z_A is a strictly positive persistence and u_t is a normally distributed productivity shock with mean 0 and variance

σ_z^2. After the shock, in each period t, firms produce y_t using capital bought in the last period K_t and reimburse their loans with interests r_t^l such that the total reimbursement is $L_t\left(1+r_t^l\right)$. Then, they distribute net profits to households and choose their optimal amount of total loans and capital for the next period $\{L_{t+1}, K_{t+1}\}_{t=0}^{\infty}$ to maximize their future expected discounted profits subject to their budget constraint and the capital constraint. Note that we consider capital that fully depreciates. Each firm optimization problem is defined as follows:

$$Max_{\{L_{t+1}, K_{t+1}\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t \pi_t,$$

subject to

$$\pi_t = y_t - K_t\left(1+r_t^l\right), \tag{3.5}$$

$$y_t = A_t K_t{}^{\psi},$$

$$K_{t+1} = L_{t+1},$$

$$\pi_t \geq 0 \text{ and } L_t, K_t > 0,$$

where $\psi \in]0,1[$ is the output elasticity of capital. Using the Lagrange method, the interior solution of the first order condition with respect to L_{t+1} is given by:

$$\psi E_t\left(A_{t+1} L_{t+1}^{\psi-1}\right) = E_t\left(1+r_{t+1}^l\right). \tag{3.6}$$

In the optimum, (3.6) shows that the marginal product of capital is equal to the marginal cost of loans.

3.2.3 Banks

The banking sector is represented by a continuum of identical banks of unit mass. To provide loans L_{t+1} to firms, banks raise funds by accumulating net worth N_{t+1} and demanding deposits D_{t+1}. The regulatory authority imposes that banks keep a fraction $\phi \in [0,1[$ of deposits as reserves[5]

$$R_t \equiv \phi D_t. \tag{3.7}$$

Each bank has a balance sheet composed of deposit D_t and net worth N_t on the liability side and of loans L_t and reserves R_t on the asset side such that

$$R_t + L_t = N_t + D_t. \tag{3.8}$$

Thus, at the end of each period t, each bank accumulates net worth using profits from assets earned in t net of deposit repayments and dividends. Let r_t^l be the lending rate earned in t and r_t the risk-free interest rate paid in t, so that

$$N_{t+1} = \left(1 + r_t^l\right) L_t + R_t - D_t \left(1 + r_t\right) - d_t - C_t, \tag{3.9}$$

where $C_t = \tau N_t$ represents operational costs paid by banks such as accounting and legal fees and management costs. The parameter $\tau \in]0,1]$ is the percentage of operational costs over net worth. One can think about initial public offering fees paid to a third party, for example to business attorney or business service companies, to get listed on financial markets. Indeed, banks often use a third party such as large business service companies (KPMG, Deloitte) to prepare the legal and accounting side of public offerings. Specialized firms ensure that regulatory and legal compliance are met.

Banks are also subject to capital requirements based on Value-at-Risk as recommended by the Basel committee in Basel II.[6] This regulation imposes that banks hold a minimum of capital which is calculated with the aim of avoiding banks becoming insolvent. The objective of the regulator is to preserve a safety

[5]Note that the reserve requirement ϕ is not crucial for the model nor for the bubble existence. However, it is of interest as it allows the derivation of additional policy implications.

[6]See the BIS publication, the First Pillar Minimum Capital Requirements, http://www.bis.org/publ/bcbs107.htm

buffer, such that the market value of banks' assets VA_t is sufficient to repay depositors. The market value of assets is given by

$$\mathrm{VA}_t = V_t(N_t) + D_t,$$

where $V_t(N_t)$ is banks' equity value. Therefore, the regulator imposes a solvency condition which requires that the maximum amount of deposits banks can hold, do not exceed the market value of banks assets in the worst case scenario such that

$$D_t \leq (1-\mu)\,\mathrm{VA}_t,$$

where $\mu \in [0,1[$ is a regulatory parameter which captures the loss in market value of assets in the worst case scenario, as motivated by the Value-at-Risk regulation. This regulation, based on market values, is the same as in Dangl and Lehar (2004). The above equation is thus equivalent to

$$D_t \leq \eta V_t(N_t),$$

where $\eta = (1-\mu)/\mu > 0$ is the Value-at-Risk regulation parameter. It represents the maximum allowed leverage ratio in market value. We show in Appendix A that without capital requirements, if

$$\tau\beta(1-\phi) > \phi(1-\beta), \tag{3.10}$$

banks always hold the maximum amount of deposits. Indeed, when the marginal benefit from holding deposits exceeds its marginal cost, banks always want more deposits. From now on, we consider that (3.10) is always satisfied. Therefore, the above constraint always binds and becomes

$$D_t = \eta V_t(N_t). \tag{3.11}$$

For low values of η, the regulation is severe. Indeed, the amount of authorized deposits that banks can hold compared to banks value is low. However, for high η, the regulation is considered as lenient.

The aim of our framework is to model the existence of stochastic banking bubbles as in Blanchard and Watson (1982), Weil (1987) and Miao and Wang (2015). In period t, agents may believe in a bubble or not. If agents do not believe a banking bubble exists in period t, a bubble can never emerge. In what follows, first, we present the problem of banks when agents do not believe a bubble exists. We then present the problem of banks when agents believe that it exists. In this latter case, following Blanchard and Watson (1982), we consider that the bubble may burst in the future with a probability $\xi \in]0,1[$. Note that once the bubble bursts, it never reappears.

Bubbleless path

At the end of period t, each bank chooses the optimal net worth $\{N_{t+1}\}$ in order to maximize its current dividends and expected present value of future dividends subject to the reserve requirement (3.7), the balance sheet (3.8), the budget constraint (3.9) and the capital requirement (3.11). If agents do not believe a bubble exists, the value of the bank in period t is denoted $V_t^*(N_t)$. The bank problem can be summarized by the following Bellman equation

$$V_t^*(N_t) = Max_{\{N_{t+1}\}} \left\{ d_t + \beta E_t \left[V_{t+1}^*(N_{t+1}) \right] \right\},$$

subject to

$$d_t = \left(1 + r_t^l\right) N_t + D_t \left[r_t^l (1-\phi) - r_t \right] - \tau N_t - N_{t+1},$$

$$D_t = \eta V_t^*(N_t),$$

$$N_t, D_t \geq 0 \text{ for all } t.$$

We show in Appendix B that the solution of the above maximization problem gives us the following form for the value function:

$$V_t^*(N_t) = q_t^* N_t, \tag{3.12}$$

where $q_t^* \geq 0$ is the marginal value of net worth. It can also be interpreted as the Tobin Q (Tobin, 1969). Define the bank's stock price in $t+1$ by

$$p_{t+1} = \beta E_t \left[V_{t+1}^*(N_{t+1}) \right].$$

Proposition 1. *When agents do not believe a bubble exists, the solution of each bank maximization problem is given by the following system of equations.*

$$E_t\left(q_{t+1}^*\right) = \frac{1}{\beta}, \tag{3.13}$$

$$q_t^* = \left(1 + r_t^l - \tau\right) + \eta q_t^* \left[r_t^l (1 - \phi) - r_t \right]. \tag{3.14}$$

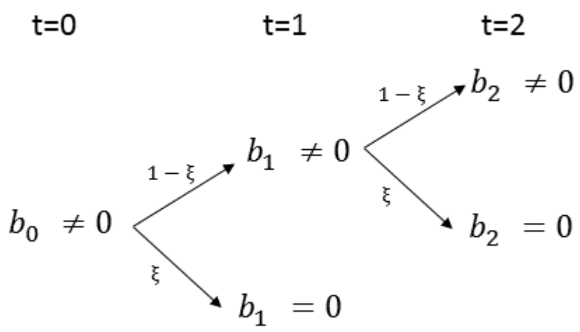
Proof of Proposition 1 is presented in Appendix B.

When agents do not believe a bubble exists, the expected marginal value of net worth given by (3.13) is constant. This comes from the fact the bank is risk-neutral. Thus, by increasing one unit of net worth today, the bank gets the expected discounted marginal value of net worth. Equation (3.14) shows that an additional marginal value of net worth today gives the discounted return due to the increase in loans minus operational costs. It also allows the bank to relax the constraint by taking η units of additional deposits (see equation (3.11)). Then, the bank earns an additional return of $\left[r_t^l (1 - \phi) - r_t \right]$. Using (3.13) and (3.14), results show that the lending rate is also constant, which is consistent with the risk neutrality assumption.

Bubbly path

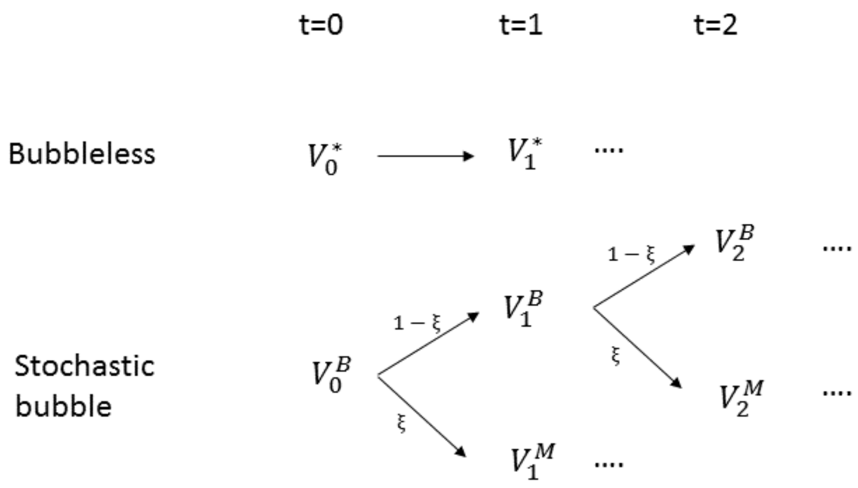
When agents believe that a bubble exists in period t, the bank's value $V_t^B(N_t)$ contains a bubble $b_t \neq 0$. There exists a probability $\xi \in]0,1[$ that the bubble bursts in $t+1$ such that $b_{t+1} = 0$ and thus, that the bank's value becomes $V_{t+1}^{M}(N_{t+1})$. Note that following Blanchard and Watson (1982), we assume that once the bubble bursts, it never reappears. Figure 3.2 defines the bubble over three periods:

Figure 3.2 Bubble definition



Therefore, the bank's value can take two different possible values in $t+1$: $V_{t+1}^{B}(N_{t+1})$ or $V_{t+1}^{M}(N_{t+1})$, which occur, respectively, with a probability $(1-\xi)$ and ξ. The timeline of events can be summarized as follows.

Figure 3.3 Timeline of events



When a banking bubble exists in t, each bank chooses the optimal net worth $\{N_{t+1}\}$ in order to maximize its current dividends and expected present value of future dividends subject to the reserve requirement (3.7), the balance sheet (3.8), the budget constraint (3.9) and capital requirements (3.11).

$$V_t^B(N_t) = Max_{\{N_{t+1}\}}\left\{d_t + \beta E_t\left[V_{t+1}^B(N_{t+1})\right] + \xi\beta E_t\left[V_{t+1}^M(N_{t+1}) - V_{t+1}^B(N_{t+1})\right]\right\}, \tag{3.15}$$

subject to

$$d_t = \left(1 + r_t^l\right)N_t + D_t\left[r_t^l(1-\phi) - r_t\right] - \tau N_t - N_{t+1},$$

$$D_t = \eta V_t^B(N_t),$$

$$N_t, D_t \geq 0 \quad \text{for all } t,$$

where $V_{t+1}^M(N_{t+1})$ is the value of the bank if the bubble bursts in $t+1$ and is defined by $V_{t+1}^*(N_{t+1})$ in the bubbleless equilibrium. Note that the difference between $V_{t+1}^M(N_{t+1})$ and $V_{t+1}^*(N_{t+1})$ lies in their initial values of net worth. The last term of (3.15) represents the change in values when the bubble bursts. Indeed, when the bubble bursts with a probability of ξ, the banks value shifts from $V_{t+1}^B(N_{t+1})$ to $V_{t+1}^M(N_{t+1})$.

We show in Appendix C that the solution of the bank maximization problem with a bubble gives us the following value function, until the bubble bursts:

$$V_t^B(N_t) = q_t^B N_t + b_t, \tag{3.16}$$

where $q_t^B \geq 0$ is the marginal value of net worth and $b_t \neq 0$ is the bubble term on the bank's value. Variables q_t^B and b_t are to be endogenously determined. As it will become clear later, the bubble term is a self-fulfilling component that can be increasing, decreasing or explosive. Note that (3.16) is the same as in Miao et al. (2013). Define the stock price in $t+1$ when agents believe a bubble exists and before the bubble bursts by

$$p_{t+1} = \beta E_t\left[V_{t+1}^B(N_{t+1})\right] + \xi\beta E_t\left[V_{t+1}^M(N_{t+1}) - V_{t+1}^B(N_{t+1})\right].$$

Proposition 2. *When agents believe a bubble exists in t, until the bubble bursts, the solution of each bank maximization problem is given by the following system of equations.*

$$E_t\left(q^B_{t+1}\right) = \frac{1-\xi\beta E_t\left(q^M_{t+1}\right)}{\beta(1-\xi)}, \tag{3.17}$$

$$q^B_t = \left(1+r^l_t-\tau\right)+\eta q^B_t\left[r^l_t(1-\phi)-r_t\right], \tag{3.18}$$

$$(1-\xi)\beta E_t(b_{t+1}) = b_t\left\{1-\eta\left[r^l_t(1-\phi)-r_t\right]\right\}. \tag{3.19}$$

From the regulation based on Value-at-Risk, the regulator forces the bank to satisfy (3.11) such that if $b_{t+1}=0$, the value of q^M_{t+1} is given by

$$q^M_{t+1} = \frac{1}{\eta}\frac{D_{t+1}}{N_{t+1}}. \tag{3.20}$$

Proof of Proposition 2 is presented in Appendix C.

Equation (3.17) shows that, by increasing one unit of net worth today, the bank gets the expected discounted marginal value of net worth if the bubble lasts plus the expected discounted marginal value of net worth if the bubble bursts. The probability of a burst introduces a price distortion because it changes intertemporal arbitrage conditions. An increase in the marginal value of net worth if the bubble bursts, decreases the marginal value of net worth if the bubble stays. Therefore, the bank's incentive to accumulate net worth if the bubble remains is reduced, and then, the bank distributes more dividends compared with when $b_t=0$ for all t. Equation (3.18) has the same intuition than in the case where $b_t=0$ for all t. However, here, the lending rate is not constant anymore and is positively correlated with the marginal value of net worth. The intuition is that the larger the lending rate is, the larger the incentive for banks to accumulate net worth is.

Equation (3.19) exists if and only if agents believe in the bubble such that $b_t \neq 0$. It represents the bubble growth rate. The intuition is that the bubble allows the bank to relax the capital requirement constraint by raising the bank's value and thus increases deposits. In particular, the bubble allows to relax the capital requirement constraint while avoiding the operational costs. By increasing additional units of deposits, the growth of the economy becomes larger. Moreover, the larger the marginal gain from the bubble $\eta\left[r_t^l(1-\phi)-r_t^D\right]$ is, the smaller the growth rate of the bubble is. Finally, the bubble grows faster with ξ to compensate for the probability of bursting.

Proposition 3. *If*

$$\left\{1-\eta\left[r_t^l(1-\phi)-r_t\right]\right\}/\beta(1-\xi)<1/\beta, \tag{3.21}$$

the transversality condition of the household is always satisfied.

Proof of Proposition 3 is presented in Appendix D.

Proposition 3 states that the transversality condition (TVC) is satisfied, i.e bubbles are not ruled out, if the growth rate of the bubble does not exceed the rate of time preference of households. The transversality condition insures that individuals do not hold positive wealth when $t\rightarrow\infty$. An important point to highlight here, is that without the capital requirement constraint the bubble growth is given by $E_t(b_{t+1})/b_t-1=1/[\beta(1-\xi)]-1$, which is ruled out by the TVC. Therefore, the bubble cannot exist. It is also straightforward that under regulation based on book values as in Basel I, instead of on market values such that with the Value-at-Risk, bubbles cannot exist.[7] In addition, the combination of (3.17), (3.18) and (3.19) yield $E_t(b_{t+1})/b_t-1=\left(1+r_t^l-\tau\right)/\left(1-\beta\xi q_t^M\right)$. Thus, the growth rate is larger than $1/\beta$ when $\tau=0$, which is ruled out by the TVC. The intuition is that operational costs ($\tau>0$) reduce the growth rate of net worth and then, by no arbitrage, the growth rate of the bubble. Therefore the bubble is no longer explosive and is not ruled out. Analogously, Miao and Wang (2015) reduce the growth of net worth by assuming a minimum dividend policy as a function of net worth.

[7] The Basel ratio Tier 1 is based on book values and takes the following form: $N_t=\chi D_t$ where $\chi>0$ is a regulation parameter.

The bubble return can be written as follows:

$$b_t\left(\frac{1}{\beta}-1\right)=\underbrace{\frac{1}{\beta(1-\xi)}\left\{\eta\left[r_t^l(1-\phi)-r_t\right]-\xi\right\}b_t}_{\text{dividend yield}}+\underbrace{E_t(b_{t+1})-b_t}_{\text{capital gain}}.$$

This equation shows that the return on the bubble is equal to a capital gain $E_t(b_{t+1})-b_t$ plus a dividend yield. The dividend yield in the infinite horizon model guarantees that the transversality condition does not rule out the bubble. By relaxing the capital requirement, the bubble allows banks to raise η more units of deposits and earn a return $\left[r_t^l(1-\phi)-r_t\right]$ on it.

3.3 Bubbleless general equilibrium

This section defines and analyzes the bubbleless general equilibrium where variables are denoted x_t^*.

Definition 2. A competitive general bubbleless equilibrium with $b_t=0$ for all t, is defined as sequences of allocations, prices and the shock process

$$\mathcal{E}_t^*=\left\{d_t^*,N_{t+1}^*,K_{t+1}^*,L_{t+1}^*,D_{t+1}^*,\pi_t^*,y_t^*,c_t^*,s_{t+1,}^*q_t^*,r_t,r_t^{l*},p_t^*,A_t\right\}\forall t,$$

such that taking prices as given, all agents maximize their future expected payoffs subject to their constraints and the transversality condition is satisfied. Finally, the market for loans, deposits, and stocks ($s_{t+1}^*=1$) clear.

The equilibrium consumption is given by the combination of the three budget constraints (3.1), (3.5) and (3.9), such that

$$c_t^*+\tau N_t^*=y_t^*-L_{t+1}^*-(R_{t+1}^*-R_t^*). \tag{3.22}$$

Equation (3.22) is the condition on the goods market. The sum of households and banks consumption $c_t^*+\tau N_t^*$ is equal to output net of investment and variation in reserves. Households' consumption decreases with the investment which is represented by the amount of loans, the reserve variation and operational costs.

Bubbleless stationary equilibrium

Here, we analyze a stationary bubbleless equilibrium when variables are constant over time such that $\mathcal{E}_0^* = ... = \mathcal{E}_t^* = \mathcal{E}^*$ for all t. The equilibrium deposit rate is given by (3.2) such that $r = \frac{1}{\beta} - 1$. The marginal value of net worth in (3.13) is $q^* = \frac{1}{\beta}$. From the regulation based on Value-at-Risk in (3.11) and the value function (3.12), we have

$$\frac{D^*}{N^*} = \frac{\eta}{\beta}. \tag{3.23}$$

From (3.14), the lending rate is,

$$r^{l*} = \frac{r(\eta + \beta) + \beta\tau}{\beta + \eta(1-\phi)}. \tag{3.24}$$

Proposition 4. *The lending rate r^{l*} in a bubbleless stationary equilibrium increases with the reserves ϕ and operational costs τ. In contrast, it decreases with the Value-at-Risk regulation parameter η.*

Proof of Proposition 4 is presented in Appendix E. The intuition is that larger operational costs and reserves reduce the supply of loans, and as a consequence increase the lending rate. In contrast, a larger Value-at-Risk regulation parameter η allows banks to raise money using cheaply acquired funds, i.e deposits. This effect raises banks' size and reduces the lending rate.

For more insights, we also look at the interest rate spread, which is given by

$$\beta\left(r^{l*} - r\right) = \frac{(1-\beta)\eta}{\beta + \eta(1-\phi)}\phi + \frac{\beta^2}{\beta + \eta(1-\phi)}\tau.$$

The above equation shows that the discounted interest rate spread increases with operational costs τ and the fraction of reserves ϕ. For $\phi = 0$, the interest spread is only a function of operational costs. When there are no costs for the bank such that $\phi = \tau = 0$, the lending rate falls to the safe rate r.

The stationary level of loans is given by the first order condition (3.6) so that $L^* = \left[\left(1+r^{l*}\right)/\psi\right]^{1/(\psi-1)}$. From the balance sheet constraint (3.8) and (3.23), $N^* = L^*/\left[1+(1-\phi)(\eta/\beta)\right]$. Thus, the equilibrium consumption is given by $c^* = (L^*)^{\psi} - L^* - \tau L^*/\left[1+(1-\phi)(\eta/\beta)\right]$. Denote W^* the welfare in a bubbleless stationary equilibrium. Therefore, $W^* = c^*$. The Appendix F shows that W^* and L^* are decreasing in the lending rate r^{l*}.

3.4 Stochastic bubbly general equilibrium

This section defines and analyzes the stochastic bubbly general equilibrium where variables before and after the bubble bursts at $t = T$ are, respectively, denoted x_t^B and x_t^M.

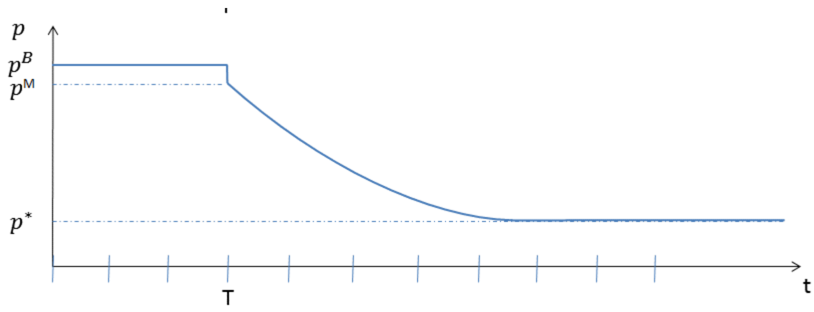
Definition 3. If a bubble exists in t such that $b_t \neq 0$, until the bubble bursts in T, a competitive stochastic bubbly general equilibrium is defined as $\mathcal{E}_t^B = \{d_t^B, N_{t+1}^B, K_{t+1}^B, L_{t+1}^B, D_{t+1}^B, \pi_t^B, y_t^B, c_t^B, b_t, s_{t+1,}^B q_t^B, q_t^{MB}, r_t, r_t^{lB}, p_t^B, A_t\}$ $\forall t < T$, such that taking prices as given, all agents maximize their future expected payoffs subject to their constraints and the transversality condition is satisfied. Finally, the market for loans, deposits, and stocks ($s_{t+1}^B = 1$) clear. At $t = T$, the bubble crashes such that $b_t = 0$ $\forall t \geq T$, a competitive stochastic bubbly general equilibrium $\mathcal{E}_t^M$ is defined as $\mathcal{E}_t^*$ $\forall t \geq T$ with $N_T^M = N_T^B$, such that taking prices as given, all agents maximize their future expected payoffs subject to their constraints and the transversality condition is satisfied. Finally, the market for loans, deposits, and stocks ($s_{t+1}^M = 1$) clear.[8]

As in the bubbleless equilibrium, the condition on the goods market is given by (3.22), where variables correspond to the ones from the stochastic bubbly general equilibrium.

[8] Note that the bank marginal value of net worth q_t^B until the bubble bursts is a function of the marginal marginal value of net worth after the bubble collapses q_t^M. Therefore, this latter value is included in the equilibrium before the burst of the bubble and is called q_t^{MB}.

For simplicity, as in Weil (1987) and Miao and Wang (2015), we study a stochastic bubbly equilibrium with the following properties. The equilibrium is constant until the bubble collapses at $t=T$, such that $\mathcal{E}_0^B = ... = \mathcal{E}_{T-1}^B = \mathcal{E}^B$ with $b_0 = ... = b_{T-1} = b \neq 0$. We call it a semi-stationary equilibrium. At $t=T$, the banking bubble collapses such that $b_T = 0$ and the equilibrium is denoted by $\mathcal{E}_T^M$. Then, for all $t>T$, the equilibrium $\mathcal{E}_T^M$ converges to the bubbleless stationary equilibrium $\mathcal{E}^*$. Figure 3.4 shows the dynamic of the price when a positive banking bubble exists and then bursts.

Figure 3.4 Stock price's dynamic when the positive bubble bursts



At $t=T$, the bubble bursts such that $b_t = 0$ and stays at this value for all $t \geq T$. The price p_t^B for all $t<T$ falls to p_T^M. Then, the bank maximizes dividends and expected discounted future dividends such that the bubble is over and will never reappear. Therefore, the price converges to p^* for all $t>T$.

The semi-stationary equilibrium, i.e until the bubble bursts, is characterized by the following values. As in the bubbleless stationary equilibrium, the deposit rate is given by (3.2) $r = \frac{1}{\beta} - 1$. The lending rate before the bubble collapses is defined by (3.19) such that

$$r^{lB} = \frac{r(\beta+\eta)+\beta\xi}{(1-\phi)\eta}.$$

Proposition 5. *In a semi-stationary bubbly equilibrium, the lending rate increases with the reserves ϕ and the probability of burst ξ. In contrast, it decreases with the Value-at-Risk regulation parameter η.*

Compared to the bubbleless lending rate given by (3.24), the lending rate is independent of operational costs τ. This characteristic will be explained later.

The interest rate spread between the lending rate and the risk-free deposit rate, until the bubble collapses, is

$$\beta\left(r^{lB}-r\right)=\frac{1-\beta}{(1-\phi)}\phi+\frac{\beta(1-\beta)}{(1-\phi)}\frac{1}{\eta}+\frac{\beta^2}{(1-\phi)}\frac{\xi}{\eta}.$$

Therefore, the spread is a function of the bank's costs. It is increasing with a large probability of burst to compensate for the risk and with high fraction of reserves ϕ. In contrast, it decreases with less stringent capital requirement, which is represented by a high η. If $\xi=\phi=0$, then the interest rate spread is is equal to $\beta(1-\beta)/\eta$, which is proportional to the tightness of the regulatory constraint. In addition, operational costs τ have no effects on the spread.

The marginal value of net worth when the bubble lasts and when the bubble collapses are, respectively, given by (3.17)

$$q^B=\frac{1-\beta\xi q^M}{\beta(1-\xi)}=\frac{1-\tau+r^{lB}}{\beta(1-\xi)}, \tag{3.25}$$

and

$$q^{MB}=\frac{\tau-r^{lB}}{\beta\xi}. \tag{3.26}$$

From (3.20), the leverage ratio is

$$\frac{D^B}{N^B}=\eta q^{MB}. \tag{3.27}$$

From the first order condition of firms (3.6), we obtain the equilibrium quantity of loans

$$L^B=\left[\frac{1}{\psi}\left(1+r^{lB}\right)\right]^{\frac{1}{\psi-1}}. \tag{3.28}$$

From (3.7), (3.8), (3.27) and (3.28), we get

$$N^B = \frac{L^B}{1+(1-\phi)\,\eta q^{MB}}.$$

It can be shown that N^B is strictly positive if and only if $q^{MB} > 0$ which is equivalent to

$$\tau > [r(\beta+\eta)+\beta\xi]\,/\,(1-\phi)\,\eta. \tag{3.29}$$

Equation (3.29) is called the "‘non negative net worth condition"’. In what follows, we consider that this condition always holds. From the regulation (3.11) and the value function when the bubble exists (3.16), we get

$$b = \frac{D^B}{\eta} - q^B N^B. \tag{3.30}$$

Using (3.25), (3.27) and (3.30), the bubble term can be re-written as

$$\begin{aligned} b &= \left(q^{MB} - q^B\right) N^B \\ &= \left[\frac{\eta\,(\tau-\xi)\,(1-\phi) - r\,(\eta+\beta) + \beta\xi)}{\beta\xi(1-\xi)\,(1-\phi)\,\eta}\right] N^B. \end{aligned} \tag{3.31}$$

The equation above shows that the bubble increases with large operational costs. An increase in operational costs τ should, without bubble, raise the lending rate. However, in the presence of a bubble, the increase in τ enlarges the bubble, which relaxes the capital requirement constraint. Thus, loans supply increases, canceling out the effect of τ on the lending rate. From (3.11) and (3.1), the equilibrium consumption is $c^B = \left(L^B\right)^{\psi} - L^B - \tau L^B / \left[1+(1-\phi)D^B/N^B\right]$. Finally, we define the bubbly semi-stationary welfare as $W^B = c^B$. Compared to the bubbleless stationary equilibria, the welfare has the same form. However, it depends now on the bubble. Indeed, the bubble modifies the value of lending rate by affecting the capital requirement constraint and thus, the equilibrium quantity of loans. In the next section, the stationary bubbleless and the semi-stationary stochastic bubbly equilibrium will be compared.

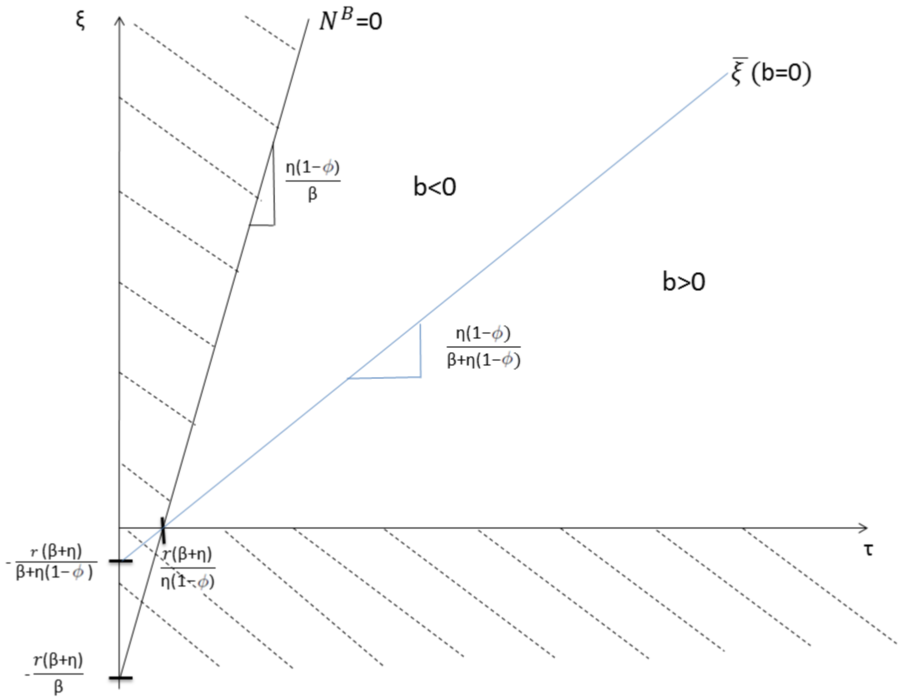
Using (3.31), the condition under which a semi-stationary stochastic bubbly equilibrium exists can be written as $\xi \neq \bar{\xi}$, where

$$\bar{\xi} = \frac{\eta\,[(1-\phi)\tau - r] - (1-\beta)}{\beta + \eta(1-\phi)}. \tag{3.32}$$

Therefore, the semi-stationary stochastic bubbly equilibrium exists if the probability of burst is $\xi \neq \bar{\xi}$. It can be shown that a positive bubble exists for small value of the probability of burst $\xi < \bar{\xi}$. This is consistent with Weil (1987) and Miao and Wang (2015) who also find that positive bubbles exist only for small value of the bursting probability. Thus, suppose we have a positive bubble, a change in beliefs concerning the probability of burst might modify the equilibrium, from a positive semi-stationary bubbly equilibrium to a bubbleless stationary equilibrium.

Figure 3.5 displays the bubble's value in the parameter space (ξ,τ), for a given η and ϕ. At $\xi = \bar{\xi}$, the bubble term is zero. For $\xi < \bar{\xi}$ (resp. $\xi > \bar{\xi}$), the bubble is positive (resp.negative). The slope of the line $\bar{\xi}$ increases with large values of the Value-at-Risk regulation parameter η. Thus, the parameter space for the positive bubble widens. As the regulator becomes more lenient such that η is high, the economy can enter a state in which bubbles are positive, increasing welfare in the economy. As explained above, the space where $\xi > [\tau\,(1-\phi)\,\eta - r(\beta+\eta)]\,/\beta$ does not exist for $N^B > 0$.

Figure 3.5 Bubble's value in the parameter space



Alternatively, we can also write the existence condition of a stochastic semi-stationary bubbly equilibrium in terms of the regulation parameter based on Value-at-Risk η such that $\eta \neq \bar{\eta}$, *where*

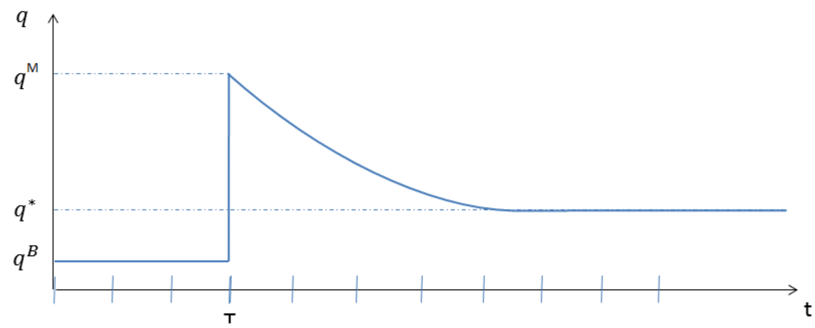
$$\bar{\eta} = \frac{1-\beta(1-\xi)}{(\tau-\xi)(1-\phi)-r}.$$

Proposition 6. *Under (3.10), (3.21), (3.29) and $\eta \neq \bar{\eta}$, a stochastic semi-stationary bubbly equilibrium exists ($b \neq 0$). For $\eta > \bar{\eta}$, the bubble is positive. In contrast, for $\eta < \bar{\eta}$, it is negative.*

Proposition 8 suggests that the semi-stationary equilibrium with a stochastic bubble exists if the regulation parameter based on Value-at-Risk is $\eta \neq \bar{\eta}$. Indeed, under conditions described in Proposition 8, the transversality condition is satisfied. As a result, a positive bubble exists only for large values of the regulation parameter η. Thus, a reduction of the regulation parameter η might modify the equilibrium, from the positive bubbly equilibrium to the bubbleless equilibrium. Another important policy implication, here, is that the reserve requirement parameter ϕ affects negatively the threshold $\bar{\eta}$. As a consequence, when ϕ is large, the regulation parameter η should be even greater to be in the positive bubbly semi-stationary equilibrium.

Figure 3.6 shows the dynamics of the positive stochastic bubbly equilibrium for the marginal value of net worth q_t, before and after the bubble bursts at $t = T$. Suppose $b_t > 0$ for all $t < T$.

Figure 3.6 Transition path when the positive bubble bursts



At $t = T$, the bubble bursts such that $b_t = 0$ and stays at this value for all $t \geq T$. Since deposits and net worth are pre-determined variables, the marginal value of net worth q^B goes straight to q_T^M. Thus, the value of the bank and the price become, respectively, $V_T^M(N_T^B)$ and p_T^M. Then, the bank maximizes dividends and expected discounted future dividends such that the bubble is over and will never reappear. Therefore, the bank net worth converges from N_T^B to the net worth value in the stationary bubbleless equilibrium N^* on the path N_t^M and the marginal value from q_t^M to the bubbleless stationary equilibrium marginal value of net worth q^*. Thus, the price p_t^M converges to p^* for all $t > T$.

3.5 Comparison of both equilibria

This section compares the stationary bubbleless and the stochastic semi-stationary bubbly equilibria.

Proposition 7. *If $\eta \neq \bar{\eta}$ both equilibria with and without a bubble on stock prices coexist.*

Proposition 8. *If $\eta > \bar{\eta}$, the bubbly equilibrium lending rate before that the bubble collapses is lower than the bubbleless lending rate. Thus, welfare is larger with a positive bubble. In contrast, a negative bubble ($\eta < \bar{\eta}$) reduces welfare.*

Proof of Proposition 8 is in Appendix G. Both stochastic bubbly and bubbleless equilibria co-exist for all values of the Value-at-Risk regulation parameter η except at the point $\bar{\eta}$. This point can be viewed as a point of reversal at which you may move from a positive bubbly equilibrium to a negative bubbly stochastic semi-stationary equilibrium. At this reversal point, the equilibrium can move from from higher to lower welfare. For $\eta > \bar{\eta}$, the capital requirement based on Value-at-Risk is less stringent. In that case, the stochastic semi-stationary bubbly equilibrium provides larger welfare than the bubbleless equilibrium. The intuition is that, when agents consider that the bubble exists, a lower capital requirement leads to optimistic beliefs on banks value. The bubble allows banks to relax the capital requirement constraint, and thus banks demand more deposits, which raises their leverage, and make more loans. This effect reduces the lending rate and provides better welfare. In contrast, for more stringent capital requirement $\eta < \bar{\eta}$, the bubble is negative leading to a credit crunch and thus, reducing the welfare compared to the bubbleless equilibrium. An important point to highlight here is that a change in banking regulation may modify the equilibrium and leads to crises, by reducing welfare levels. This effect can explain the occurrence of crises without any external shocks. In addition, using (3.32), results also show that a change in beliefs about the probability of burst may also lead to a crisis, as in Miao and Wang (2015).

The following table summarizes and compares the main results discussed in this section.

Table 3.1 Policy implication

	$\eta > \bar{\eta}$	$\eta < \bar{\eta}$
variables		
b	$b>0$	$b<0$
r^l	$r^{lB} < r^{l*}$	$r^{lB} > r^{l*}$
L	$L^B > L^*$	$L^B < L^*$
$\frac{D}{N}$	$\frac{D^B}{N^B} > \frac{D^*}{N^*}$	$\frac{D^B}{N^B} < \frac{D^*}{N^*}$
W	$W^B > W^*$	$W^B < W^*$

Table 3.1 shows that, when agents believe a bubble exists, a positive bubble arises for lenient regulatory Value-at-Risk constraints, $\eta > \bar{\eta}$. It leads to a highest equilibrium welfare level, highest equilibrium quantity of loans and leverage levels. On the opposite, a negative bubble arises when capital requirement based on Value-at-Risk are more stringent. The negative bubbly semi-stationary equilibrium is characterized by the lowest equilibrium level of welfare, credit and leverage.

3.6 Local dynamics and simulations

The present section, first, presents the calibration. Second, it analyzes local dynamics around the bubbleless stationary equilibrium and the semi-stationary stochastic bubbly equilibrium. Finally, we simulate and compare a negative productivity shock from both equilibria.

3.6.1 Calibration

Here, we calibrate the parameters and we report the implied values for variables in the bubbleless stationary and bubbly semi-stationary equilibria. We present a numerical example. We calibrate $\beta = 0.99$, the capital share of output to $\psi = 0.33$, the probability of burst $\xi = 0.1$. The regulatory parameter is

$\mu = 0.09$, which implies that $\eta = 10.11$. This calibration for μ allows us to have a tier 1 ratio around 8% as recommended by the Basel committee.[9] This ratio is 8.99% for the bubbleless stationary equilibrium and 7.12% for the semi-stationary stochastic bubbly equilibrium. The reserve parameter $\phi = 0.01$ is set as required by the European Central Bank.[10] Finally, we set operational costs to a proportion $\tau = 0.15$ of net worth. Under these values of parameters, Propositions 7 and 8 show that the bubbly and the bubbleless stationary equilibria, until the bubble bursts coexist and that the stochastic bubbly semi-stationary equilibria has a positive bubble ($\eta > \bar{\eta}$). Moreover, under this calibration, the marginal value of net worth in T, once the bubble has burst is $q_T^M = 1.3021$.

Table 3.2 Bubbleless and bubbly equilibria

	Bubbly > 0	Bubbleless
Variables		
N	0.0132024	0.0166121
D	0.173818	0.169664
d	0.000171925	0.000167799
L	0.185282	0.184579
p	0.0170206	0.0166121
q	0.977657	1.0101
r^l	0.0210922	0.0236939
b	0.00428355	0
W	0.386042	0.385514

Table 3.2 confirms results summarized in Table 3.1. Compared to the bubbleless steady state, the quantity of loans supplied by banks is larger in the stochastic bubbly semi-stationary equilibrium. This gives a relatively lower lending rate r^l, leading to a higher welfare W. prices.

[9] This ratio is defined as total net worth over risky assets.

[10] See https://www.ecb.europa.eu/mopo/implement/mr/html/calc.en.html.

3.6.2 Local dynamics

To analyze the stability and uniqueness properties of the system, we log-linearize the system around the stationary and the semi-stationary equilibria. This results in a system of stochastic linear difference equations under rational expectations. When agents do not believe a bubble exists, $b_t = 0$ for all t, as well as when agents believe a bubble exists, $b_t > 0$ for $t = 0,..T$, until the bubble bursts, the eigenvalues associated with the linearized system around, respectively, the stationary bubbleless and the stochastic semi-stationary bubbly equilibria, show that the number of unstable eigenvalues (eigenvalues that lie outside the unit circle) is equal to the number of forward looking variables.[11] Thus, under this calibration, the system of equations when $b_t = 0$ for all t and when $b_t > 0$ for all $t < T$, is determined and both the bubbleless and the bubbly equilibria are stable and unique. This implies that given an initial value of N_t^* in the neighborhood of the stationary bubbleless equilibrium, there exists a unique value of q_t^* such that the system of linear difference equations converges to the unique stationary bubbleless equilibrium along a unique saddle path (see Blanchard and Kahn, 1980). Similarly, given an initial value of N_t^B in the neighborhood of the stochastic semi-stationary bubbly equilibrium, there exists a unique value of q_t^B such that the system of linear difference equations converges to the unique stochastic semi-stationary bubbly equilibrium along a unique saddle path, for all $t < T$.

3.6.3 Simulations

As an illustration, Figure 3.7 displays the impulse response functions of a 1% negative productivity shock from the stationary bubbleless and the semi-stationary positive stochastic bubbly equilibria until the bubble bursts (for all $t < T$). To that end, we calibrate the persistence of the productivity shock z_A to 0.95. This is standard in the real business cycle literature.

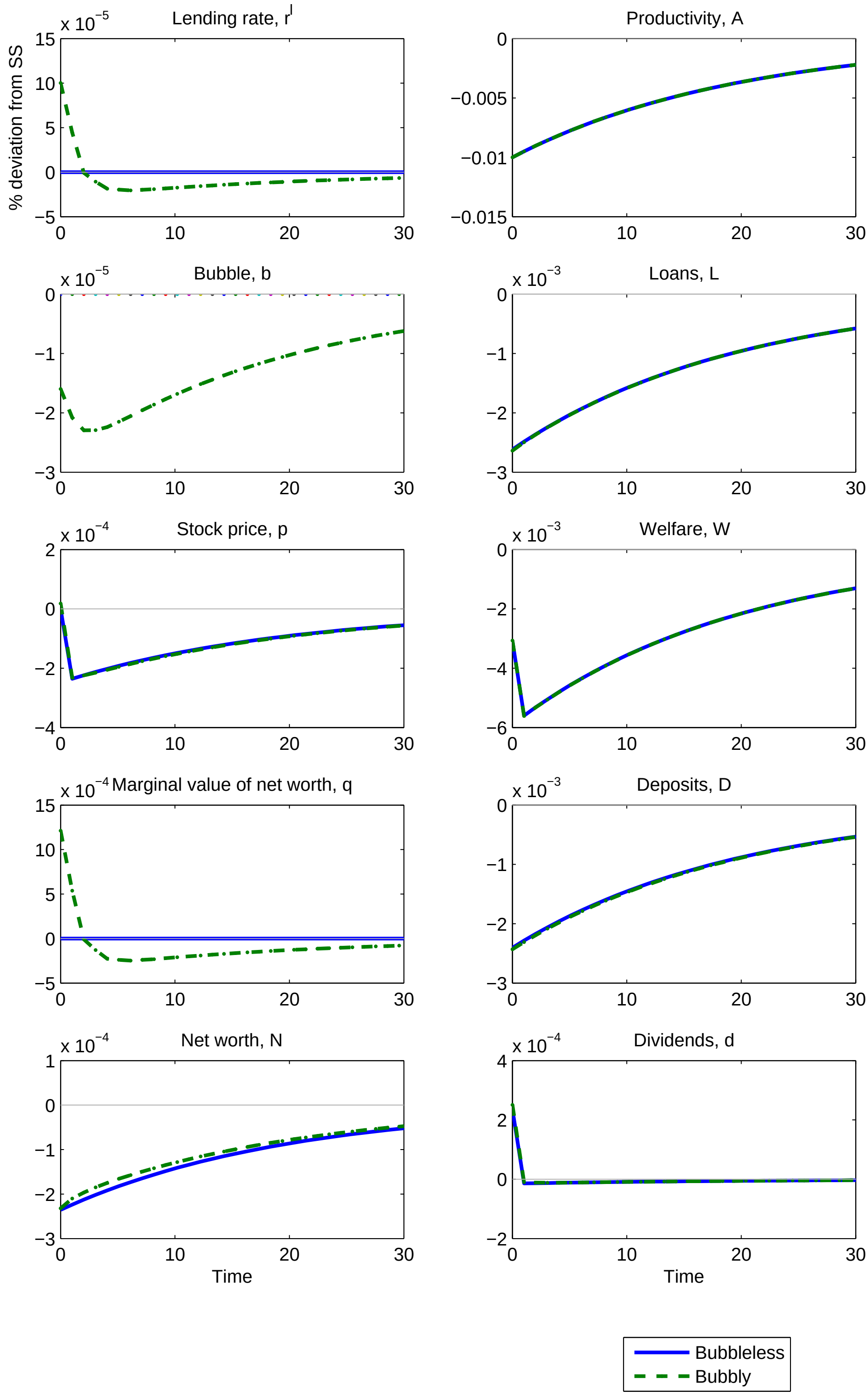
[11] Eigenvalues are reported in Appendix H.

From the bubbleless stationary equilibrium, a negative productivity shock decreases firms profits and thus also the demand for loans. By the balance sheet, the reduction in assets leads to a fall in net worth accumulation, which increases dividends (see equation (3.9)). Moreover, the fall in net worth reduces the ability of banks to raise deposits. The reduction in loans leads to a decrease in production and welfare. Since there is no uncertainty about the bank value, the marginal value of net worth and the lending rate are constant. Finally, the stock price falls following the decrease in net worth.

The impulse response functions from the semi-stationary stochastic bubbly equilibrium are similar to the ones from the bubbleless equilibrium. The main difference lies in the fact that the uncertainty on the burst of the bubble changes the inter-temporal substitution between net worth and dividends. A negative productivity shock that decreases loans demand and decreases net worth raises the marginal value of net worth. Indeed, a fall of net worth below its steady state value raises the incentive to increase net worth, reducing the value of holding investment in the bubble, and thus the bubble growth diminishes. Therefore, net worth from the bubbly equilibrium falls by less than from the bubbleless equilibrium.

In conclusion, impulse response functions from both equilibria show that the effect of a productivity shock are similar. This suggests that the bubble does not amplify the effect of shocks on real economic variables.

Figure 3.7 Negative productivity shock



3.7 Conclusion

In this paper, we develop a stochastic general equilibrium model in infinite horizon with a regulated banking sector where a stochastic banking bubble may arise endogenously. We show that a bubble emerges if agents believe that it exists. Thus, expectations of agents are self-fulfilling. Results suggest that when banks face a capital requirement based on Value-at-Risk, two different equilibria emerge and can coexist: the bubbleless and the bubbly equilibria. The capital requirement based on Value-at-Risk allows the bubble to exist. Alternatively, under a regulatory framework where the capital requirement is based on credit risk only as specified in Basel I, a bubble is explosive and as a consequence cannot exist. The stochastic bubbly equilibrium is characterized by a positive or a negative bubble depending on the capital requirement based on Value-at-Risk. We find a maximum capital requirement under which the bubble is positive. Below this threshold, the stochastic bubbly equilibrium provides larger welfare than the bubbleless equilibrium. Therefore, this result suggests that a change in banking policies might lead to a crisis. This can explain the existence of crisis without any external shocks. We also show that a semi-stationary equilibrium with a positive (resp. negative) stochastic bubble exists if the probability that the bubble collapses is small (resp. high). Consequently, a change in beliefs about the bubble's probability of burst also modifies the equilibrium, from a higher to a lower welfare.

Our model can be extended by the addition of different elements. Risk aversion of households and endogenous labor choice can be considered. However, endogenous labor choice will complicate the model without changing our main results. Risk aversion can be introduced by a quadratic utility function for households and thus, the emergence of bubbles can be studied in this context. One can also add a probability of default on loans repayments in order to model credit risk in the economy and analyze its impact on key macroeconomic variables.

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3.9 Appendix

Appendix A

Here, we show that without capital requirement, each bank chooses to hold the maximum amount of deposits.

Each bank maximization problem without capital requirement is given by

$$V_t\left(N_t, D_t\right) = Max_{\{N_{t+1},D_{t+1}\}}\left[d_t + \beta E_t V_{t+1}(N_{t+1}, D_{t+1})\right],$$

subject to

$$d_t = \left(1 + r_t^l\right) N_t + D_t\left[r_t^l(1-\phi) - r_t\right] - \tau N_t - N_{t+1},$$

$$N_t, D_t \geq 0 \;\text{ for all } t.$$

From the problem described above, we get

$$\begin{aligned} V_t(N_t, D_t) = \\ & Max_{\{N_{t+1},D_{t+1}\}}\left(1 + r_t^l\right) N_t + D_t\left[r_t^l\left(1-\phi\right) - r_t\right] - \tau N_t \\ & - N_{t+1} + \beta E_t V_{t+1}(N_{t+1}, D_{t+1}). \end{aligned}$$

The marginal value from an increase in net worth and deposits are given by

$$\frac{\partial V_t\left(N_t, D_t\right)}{\partial N_{t+1}} = -1 + \beta E_t \frac{\partial V_{t+1}(N_{t+1}, D_{t+1})}{\partial N_{t+1}}, \tag{3.33}$$

and

$$\frac{\partial V_t\left(N_t, D_t\right)}{\partial D_{t+1}} = \beta E_t \frac{\partial V_{t+1}(N_{t+1}, D_{t+1})}{\partial D_{t+1}}.$$

Using the envelop theorem, we get

$$\frac{\partial V_t\left(N_t, D_t\right)}{\partial N_t} = 1 + r_t^l - \tau,$$

and

$$\frac{\partial V_t(N_t, D_t)}{\partial D_t} = r_t^l(1-\phi) - r_t.$$

Banks decide to hold an infinite amount of deposits if $\partial V_t(N_t, D_t)/\partial D_{t+1} > 0$, which is equivalent to

$$r_t^l(1-\phi) - r_t > 0. \tag{3.34}$$

The interior solution for the net worth is given by $\partial V_t(N_t, D_t)/\partial N_{t+1} = 0$. Equation (3.33) becomes

$$1 + r_t^l - \tau = \frac{1}{\beta}. \tag{3.35}$$

From equation (3.35), we get the following lending rate

$$r_t^l = \frac{1}{\beta} - 1 + \tau.$$

Putting (3.33) in (3.34), we get the following condition

$$\tau\beta(1-\phi) > \phi(1-\beta).$$

If the above condition holds, banks always choose the maximum amount of deposits, and consequently the capital requirement regulation always binds.

Appendix B

This appendix presents the proof of Proposition 1. From the bank bubbleless maximization problem, we have

$$V_t^*(N_t) = Max_{\{N_{t+1}\}}\left\{d_t + \beta E_t\left[V_{t+1}^*(N_{t+1})\right]\right\},$$

subject to

$$d_t = \left(1 + r_t^l\right)N_t + D_t\left[r_t^l(1-\phi) - r_t\right] - \tau N_t - N_{t+1},$$

$$D_t = \eta V_t^* (N_t),$$

$$N_t, D_t \geq 0 \quad \text{for all } t.$$

The Bellman equation becomes

$$V_t^* (N_t) = Max_{\{N_{t+1}\}} \left(1 + r_t^l - \tau\right) N_t + \eta V_t (N_t) \left[r_t^l (1-\phi) - r_t\right]$$
$$- N_{t+1} + \beta E_t \left[V_{t+1}^* (N_{t+1})\right].$$

The marginal value from a net worth increase is given by

$$E_t \left[\frac{\partial V_t^* (N_t)}{\partial N_{t+1}}\right] = -1 + \beta E_t \left[\frac{\partial V_{t+1}^* (N_{t+1})}{\partial N_{t+1}}\right].$$

By the envelop theorem,

$$\frac{\partial V_t^* (N_t)}{\partial N_t} = \left(1 + r_t^l - \tau\right) + \eta \frac{\partial V_t^* (N_t)}{\partial N_t} \left[r_t^l (1-\phi) - r_t\right].$$

The interior solution for the net worth is given by $\partial V_t (N_t) / \partial N_{t+1} = 0$. Therefore,

$$E_t \left[\frac{\partial V_{t+1}^* (N_{t+1})}{\partial N_{t+1}}\right] = \frac{1}{\beta}.$$

Since the problem is linear in N, we get

$$V_t^* (N_t) = q_t^* N_t. \tag{3.36}$$

Replacing (3.36) in the maximization problem, the solution is given by the following system:

$$E_t \left(q_{t+1}^*\right) = \frac{1}{\beta},$$
$$q_t = \left(1 + r_t^l - \tau\right) + \eta q_t \left[r_t^l (1-\phi) - r_t\right].$$

Appendix C

This appendix proves Proposition 2. From the bank maximization problem when agents believe in a bubble such that $b_t \neq 0$, we have

$$V_t^B(N_t) = Max_{\{N_{t+1}\}}\left\{d_t + \beta E_t\left[V_{t+1}^B(N_{t+1})\right] + \xi\beta\left\{E_t\left[V_{t+1}^M(N_{t+1})\right] - E_t\left[V_{t+1}^B(N_{t+1})\right]\right\}\right\},$$

subject to

$$d_t = \left(1 + r_t^l\right)N_t + D_t\left[r_t^l(1-\phi) - r_t\right] - \tau N_t - N_{t+1},$$

$$D_t = \eta V_t^B(N_t),$$

$$N_t, D_t \geq 0 \text{ for all } t,$$

where $V_{t+1}^M(N_{t+1})$ is the value of the bank if the bubble bursts in $t+1$ and is defined as $V_{t+1}^*(N_{t+1})$ for the bubbleless maximization problem.

The Bellman equation becomes

$$\begin{aligned} V_t^B(N_t) =& Max_{\{N_{t+1}\}}\left(1 + r_t^l - \tau\right)N_t + \eta V_t(N_t)\left[r_t^l(1-\phi) - r_t\right] - N_{t+1} \\ &+ \beta E_t\left[V_{t+1}^B(N_{t+1})\right] + \xi\beta E_t\left[V_{t+1}^M(N_{t+1}) - V_{t+1}^B(N_{t+1})\right]. \end{aligned}$$

The marginal value from a net worth increase is given by

$$\begin{aligned} E_t\left[\frac{\partial V_t^B(N_t)}{\partial N_{t+1}}\right] =& -1 + \beta E_t\left[\frac{\partial V_{t+1}^B(N_{t+1})}{\partial N_{t+1}}\right] \\ &+ \xi\beta E_t\left[\frac{\partial V_{t+1}^M(N_{t+1})}{\partial N_{t+1}} - \frac{\partial V_{t+1}^B(N_{t+1})}{\partial N_{t+1}}\right]. \end{aligned}$$

By the envelop theorem,

$$\frac{\partial V_t^B(N_t)}{\partial N_t} = \left(1 + r_t^l - \tau\right) + \eta\frac{\partial V_t^B(N_t)}{\partial N_t}\left[r_t^l(1-\phi) - r_t\right].$$

The interior solution for the net worth is given by $\partial V_t^B(N_t)/\partial N_{t+1} = 0$. Therefore,

$$E_t\left[\frac{\partial V_{t+1}^B(N_{t+1})}{\partial N_{t+1}}\right] = \frac{1-\xi\beta E_t\left[\frac{\partial V_{t+1}^M(N_{t+1})}{\partial N_{t+1}}\right]}{(1-\xi)\beta}.$$

Since the problem is linear in N, we get

$$V_t^B(N_t) = q_t^B N_t + b_t. \tag{3.37}$$

Replacing (3.37) in the maximization problem, the solution is given by the following system:

$$\begin{aligned}
E_t\left(q_{t+1}^B\right) &= \frac{1-\xi\beta E_t\left(q_{t+1}^M\right)}{\beta(1-\xi)}, \\
q_t^B &= \left(1+r_t^l-\tau\right)+\eta q_t^B\left[r_t^l(1-\phi)-r_t\right], \\
(1-\xi)\beta E_t(b_{t+1}) &= b_t\left\{1-\eta\left[r_t^l(1-\phi)-r_t\right]\right\}.
\end{aligned}$$

Appendix D

This appendix presents the proof of Proposition 3. We show the condition to ensure that the stochastic bubbly equilibrium until the bubble bursts satisfies the transversality condition. The following transversality condition is required:

$$lim_{t\to\infty} p_t\beta^t = lim_{t\to\infty} E_{t-1}\left[\xi\left(q_t^M N_t\right)+(1-\xi)\left(q_t^B N_t+b_t\right)\right]\beta^t = 0.$$

It is satisfied if

$$lim_{t\to\infty} E_{t-1}\left[\xi\left(q_t^M N_t\right)+(1-\xi)N_t q_t^B\right]\beta^t = lim_{t\to\infty} E_{t-1}(1-\xi)b_t\beta^t = 0.$$

Since the bubble growth rate is

$$\frac{E_t(b_{t+1})}{b_t} = \frac{1}{\beta(1-\xi)}\left\{1-\eta\left[r_t^l(1-\phi)-r_t\right]\right\},$$

the TVC requires that

$$\frac{1}{\beta(1-\xi)}\left\{1-\eta\left[r_t^l(1-\phi)-r_t\right]\right\}<\frac{1}{\beta}.$$

Thus, the condition to allow a bubble to exist is

$$\eta\left[r_t^l(1-\phi)-r_t\right]>\xi.$$

Appendix E

This appendix proves Proposition 4. Here, we prove that the interest rate of loans in the bubbleless stationary equilibrium is negatively correlated with the Value-at-Risk regulation parameter η. Using (3.24), we have that

$$r^{l*}=\frac{r(\eta+\beta)+\beta\tau}{\beta+\eta(1-\phi)}.$$

Therefore,

$$\frac{\partial r^{l*}}{\partial\eta}=\frac{(1-\beta)-[1-\beta(1-\tau)](1-\phi)}{[\beta+\eta(1-\phi)]^2}<0.$$

The numerator is negative if and only if $\tau\beta(1-\phi)>\phi(1-\beta)$, which is always satisfied (see Appendix A).

Appendix F

The stationary bubbleless steady state welfare is given by the consumption such that

$$W=L^{\psi}-\left(1+\frac{\tau}{1+(1-\phi)\frac{D}{N}}\right)L.$$

Therefore, the marginal impact of the lending rate on welfare is

$$\frac{dW}{dr^l}=\psi\frac{dL}{dr^l}L^{\psi-1}-\frac{dL}{dr^l}\left(1+\frac{\tau}{1+(1-\phi)\frac{D}{N}}\right).$$

Thus, $\frac{dW}{dr^l} < 0$ if and only

$$\psi L^{\psi-1} < \left(1 + \frac{\tau}{1+(1-\phi)\frac{D}{N}}\right).$$

Since $L = \left[(1+r^l)/\psi\right]^{\frac{1}{\psi-1}}$, we have that

$$r^l > \frac{\tau}{1+(1-\phi)\frac{D}{N}}. \tag{3.38}$$

In the stationary bubbleless equilibrium, the lending rate is $r^{l*} = \frac{r(\eta+\beta)+\beta\tau}{\beta+\eta(1-\phi)}$. Therefore the condition (3.38) becomes

$$r^{l*} = \frac{r(\eta+\beta)+\beta\tau}{\beta+\eta(1-\phi)} > \frac{\tau}{\beta+(1-\phi)\eta}.$$

It is equivalent to

$$r(\eta+\beta) > 0,$$

which is always verified.

Appendix G

Here, we display the proof of Proposition 8

$$r^{lB} - r^{l*} = \frac{r\eta + 1 - \beta(1-\xi)}{\eta(1-\phi)} - \frac{1-\beta(1-\tau)+\eta r}{\beta+\eta(1-\phi)} > 0.$$

Therefore, $r^{lB} - r^{l*} > 0$ if

$$\eta < \frac{1-\beta(1-\xi)}{(\tau-\xi)(1-\phi)-r} = \bar{\eta}.$$

Therefore, the bubbly lending rate is higher than then bubbleless lending rate if and only if a negative bubble exists. For a positive bubble, we have $r^{lB} - r^{l*} < 0$.

Therefore, it can be shown that the welfare is higher in the presence of a positive bubble. In contrast, it is lower with a negative bubble.

Appendix H

Table 3.3 displays eigenvalues associated with the linearized system around the stationary bubbleless and the semi-stationary bubbly equilibrium.

Table 3.3 Eigenvalue of the bubbly and bubbleless equilibria

bubbly ($b_t > 0$)	bubbleless ($b_t = 0$)
values	values
0	0
0	2.236e-55
0	3.012e-36
0	3.452e-36
1.456e-19	4.408e-19
9.661e-18	1.321e-17
9.161e-17	1.472e-17
0.95	0.95
1.01	1.01
1.038	1.915e+39
Inf	Inf
Inf	Inf
Inf	