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Implications of Banking Regulation for Banking Sector Stability and Welfare

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Résumé

Cette thèse étudie un certain nombre de sujets liés à la réglementation du secteur bancaire. Elle passe d'abord en revue les études empiriques sur le lien entre la réglementation et la stabilité du système bancaire, utilise ensuite un modèle à changement de régime Markovien pour évaluer empiriquement l'impact de la réglementation sur la stabilité du système bancaire et enfin analyse les effets des réglementations bancaires (tels que les restrictions sur la composition du portefeuille et les exigences minimales de fonds propres) sur la croissance et le bien-être.

Le premier chapitre passe en revue les travaux déjà réalisés sur le lien entre la réglementation bancaire et la stabilité du secteur bancaire. Il compile la littérature théorique sur ce lien avant de présenter la littérature empirique. Bien qu'il existe plusieurs types de réglementations, les études se concentrent surtout sur un nombre restreint de règlementations et plus précisément: l'exigence minimale de fonds propres, l'assurance-dépôts, les réserves obligatoires, et les barrières à l'entrée. La prédiction théorique de l'impact de la quasi-totalité des types de réglementations sur la stabilité du secteur bancaire reste encore indéterminée. La raison sous-jacente en est l'existence de nombreux types de faillites de marché dans le secteur bancaire. Par conséquent, une mesure réglementaire peut réussir à prémunir le système bancaire d'une défaillance du marché, mais en même temps contribuer à accroître les autres types de faillites.

Dans le second chapitre nous évaluons empiriquement l'efficacité de la réglementation bancaire en matière de stabilisation. À cette fin, nous construisons d'abord un indice mensuel de la fragilité du système bancaire. Notre indice capte la quasi-totalité des risques que l'on rencontre dans le système bancaire. Nous utilisons ensuite cet indice pour estimer l'effet de la réglementation bancaire sur la stabilité dans le contexte d'un modèle à changement de régime Markovien. Nous dérivons théoriquement les effets marginaux des réglementations sur la probabilité que le système bancaire soit en crise. Nous appliquons ensuite notre méthode au système bancaire Indonésien.

Nos principales conclusions sont que les barrières à l'entrée sont efficaces contre l'instabilité. De plus, ils réduisent la durée des périodes de crises dans le cas où celles-ci finissent par se produire. L'assurance-dépôts stimule les crises bancaires, mais réduit leurs durées. Les réserves obligatoires améliorent la stabilité du système bancaire, tandis que les exigences minimales de fonds propres

ont un effet mixte sur la stabilité du système bancaire.

Dans le troisième chapitre nous analysons le coût en bien-être de la réglementation bancaire. Cette analyse est motivée par le fait que les Accords de Bâle cherchent à promouvoir l'adoption de l'exigence minimale de fonds propres afin d'améliorer la stabilité du secteur bancaire. Malheureusement, ce type de réglementation peut entraver la croissance économique en transférant les fonds destinés aux investissements les plus productifs, mais risqués, vers les investissements les moins productifs. Nous analysons ce problème dans un modèle à générations imbriquées d'accumulation de capital et étudions comment elle affecte la croissance économique, la stabilité du secteur bancaire et le bien-être. Dans ce modèle, une crise bancaire est le résultat d'un choc de productivité, ce qui conduit certaines banques à ne pas être en mesure de s'acquitter de leurs obligations envers les prêteurs. La réglementation bancaire est modélisée comme une contrainte sur la part maximale du portefeuille des banques allouées aux actifs à risque.

Ce modèle nous permet d'évaluer quantitativement le principal arbitrage inhérent à ce type de réglementation bancaire, entre la stabilité du secteur bancaire et la croissance économique. Le modèle implique un niveau optimal de réglementation qui élimine les crises bancaires. Dans le même temps, la réglementation est préjudiciable pour la croissance. Nous constatons que l'effet global du niveau optimal de la réglementation sur la protection sociale est positif lorsque la probabilité d'une crise bancaire est suffisamment élevée, et les agents économiques sont suffisamment averses au risque.

Mots clés: les modèles à changement de régime Markovien, les modèles à générations imbriquées, la croissance économique, l'équilibre concurrentiel, la stabilité bancaire, la réglementation bancaire.

Classification JEL: C25, D50, D94, E44, G21, G28.

Abstract

This dissertation studies a number of topics related to the banking sector regulation. It focuses on the impact of various types of regulation on the banking system stability and also on the implication of some types of regulation for economic dynamic and welfare. In fact, due to numerous market failures present in the banking industry, banks are viewed as fragile. This has led governments to regulate heavily the banking sector, which is nowadays one of the most regulated industries in the world. This dissertation first reviews the theoretical and the empirical literature on the banking system regulation, then uses the Markov-switching model to assess empirically the impact of regulation on the banking system stability, and finally analyzes the growth and welfare effects of banking regulations, such as asset holding restrictions and capital adequacy requirements.

More precisely, the first chapter reviews the work already done on the link between banking regulation and the banking sector stability. It brings together and adds structure to the empirical literature on the link between banking regulation and banking system stability. In addition to clarifying the theoretical underpinnings for studying banking regulation, it points to several directions for future empirical research, necessary to fill the gaps in our understanding of the link between banking regulation and stability. It finds that although there are many types of banking regulation, studies focus mainly on a group of regulations such as the capital adequacy requirement, the deposit insurance, and the reserve requirement. The theoretical prediction of the effect of almost each type of regulation on the banking sector stability is mixed. The key reason behind this is the fact that there are many types of market failures in the banking industry. Therefore, a regulatory measure can succeed to cure a given market failure but at the same time help to increase the other market failures.

In "The Empirics of Banking Regulation", we assess empirically whether banking regulation is effective at preventing banking crises. We use a monthly index of banking system fragility, which captures almost every source of risk in the banking system, to estimate the effect of regulatory measures (entry restriction, reserve requirement, deposit insurance, and capital adequacy requirement) on banking stability in the context of a Markov-switching model. We apply this method to the Indonesian banking system, which has been subject to several regulatory changes over the

last couple of decades and at the same time has experienced a severe systemic crisis. We draw the following findings from this research: (i) entry restriction reduces crisis duration and also the probability of their occurrence; (ii) larger reserve requirements reduce crisis duration, but increase banking instability; (iii) deposit insurance increases banking system stability and reduces crisis duration; (vi) capital adequacy requirement improves stability and reduces the expected duration of banking crises.

Finally, in "The Welfare Cost of Banking Regulation", we are motivated by the fact that the Basel Accords promote the adoption of capital adequacy requirements to increase the banking sector's stability. Unfortunately this type of regulation can hamper economic growth by shifting banks' portfolios from more productive risky investment projects toward less productive but safer projects.

We introduce banking regulation in an overlapping-generations model of capital accumulation and studies how it affects economic growth, banking sector stability, and welfare. In this model, a banking crisis is the outcome of a productivity shock, which leads some banks to be unable to fulfill their obligations toward lenders. Banking regulation is modeled as a constraint on the maximum share of banks' portfolios that can be allocated to risky assets.

This model allows us to evaluate quantitatively the key trade-off inherent to this type of banking regulation, between banking sector stability and economic growth. The model implies an optimal level of regulation which eliminates banking crises. At the same time, regulation is detrimental to growth. We find that the overall effect of the optimal level of regulation on social welfare is positive when the likelihood of a banking crisis is sufficiently high and economic agents are sufficiently risk-averse. We use the model to evaluate whether the proposed Basel Accord regulation might be welfare-improving, given plausible magnitudes for the likelihood of a crisis and agents' risk aversion.

Key words: Markov switching models, overlapping generations models, competitive equilibrium, economic growth, banking stability, banking regulation.

JEL Classification: C25, D50, D94, E44, G21, G28.

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Introduction générale

L'industrie bancaire est l'une des industries les plus réglementées et contrôlées au monde. En fait, il n'existe pas moins de huit types de réglementation bancaire (Voir Mishkin, 2000). Deux principales raisons expliquent ce fait. D'une part, les banques sont perçues comme des institutions fragiles qui ont besoin de l'aide du gouvernement pour évoluer dans un environnement sain et d'autre part, l'instabilité des banques est coûteuse à l'économie toute entière; ceci est dû au rôle central que jouent les banques dans l'intermédiation financière en approvisionnant l'économie en liquidités, et en fournissant l'information économique et financière.

En règle générale, les gouvernements délèguent leur pouvoir de réglementation aux banques centrales. Ces dernières organisent le système réglementaire compte tenu de leur rôle de prêteur en dernier ressort. Depuis la grande vague de libéralisation financière des années 1980, de nouveaux types de règlements ont vu le jour, le plus important étant les Accords de Bâle avec son exigence d'adéquation des fonds propres et ses pratiques de surveillance. Il s'en est aussi suivi au cours des années 1990 une baisse du taux de réserves obligatoires, l'émergence de l'assurance-dépôts, et l'émergence de la supervision bancaire dans un grand nombre d'économies. Ce nouveau cadre réglementaire a été acclamé pour sa contribution à la convergence internationale des techniques de gestion des risques bancaires et pour l'amélioration des normes bancaires dans de nombreux pays. Toutefois leur conception et leur mise en œuvre ont souvent été responsables de la création ou de l'amplification de plusieurs défaillances du marché dans le secteur bancaire.

Beaucoup de travaux théoriques ont été effectués sur la quasi-totalité des types de réglementations existantes mais leurs résultats sont généralement contradictoires, ceci est essentiellement dû au fait qu'il existe plusieurs sources d'instabilité dans le système bancaire. Ainsi, un type de réglementation peut réussir valablement à contrer un certain type de faillite de marché mais en même temps accroître un autre type de faillite de marché. L'exemple le plus illustratif est celui de l'assurance-dépôts qui est efficace pour contrer les crises dues à une faillite de coordination des retraits mais qui malheureusement accroît les problèmes d'aléas moraux en amenant les épargnants à être moins regardant sur le niveau de risque auquel la banque s'expose. Ainsi malgré les progrès récents dans la recherche sur la fragilité bancaire, il n'existe toujours pas de consensus sur la meilleure façon de concevoir et de mettre en œuvre la réglementation bancaire dans ce nouveau contexte de grande liberté bancaire. Il s'ensuit que pour déterminer l'impact des réglementations sur la stabilité du système bancaire, l'analyse empirique semble plus appropriée.

Dans le premier chapitre de cette thèse nous passons en revue et mettons de la structure aux travaux empiriques déjà réalisés sur le lien entre la réglementation bancaire et la stabilité du secteur bancaire. Bien qu'il existe de nombreux types de réglementations bancaires, les études se concentrent surtout sur un groupe de règlementations, plus précisément: la condition d'adéquation des fonds propres, l'assurance-dépôts, les réserves obligatoires, et les barrières à l'entrée. Deux grandes approches sont employées : une approche qui utilise une mesure d'instabilité implicite telle que le taux d'actif risqué dans le portefeuille des banques et la volatilité des profits, et une approche qui utilise une variable muette qui prend la valeur 1 pendant les années de crise et la valeur 0 en dehors.

Ces deux méthodes utilisent des techniques économétriques différentes pour effectuer leurs estimations: la méthode de risque implicite repose très souvent sur les modèles à équations simultanées et les modèles de survie; alors que la méthode de risque explicite repose très souvent sur les modèles de régression logit ou probit.

Jusqu'à présent, ces études ne réussissent pas à fournir un résultat convaincant quant à l'impact de nombreux types de réglementations sur la stabilité bancaire. Par conséquent, au lieu de fournir une solution aux résultats théoriques conflictuels, ces études empiriques en ajoutent à la confusion. D'autre part les études utilisant une mesure implicite d'instabilité ne font pas l'unanimité dans le sens que l'exposition au risque couplé à une bonne technique de gestion de risque n'est en aucun cas un signe d'instabilité. Pour les études utilisant la méthode explicite, les résultats sont généralement peu robustes. Ces études souffrent principalement de biais de sélection qui vient de la méthode utilisée pour construire la variable mesurant l'instabilité bancaire.

Dans le second chapitre nous développons une méthode empirique pour tester l'impact de certains types de réglementations sur la stabilité bancaire et la durée des crises bancaires. Comme nous l'avons constaté dans le premier chapitre, en général, les effets théoriques de presque tous les types de règlementations sont ambiguës et les études empiriques déjà réalisées sur ce sujet présentent des limitations importantes: un biais de sélection et une absence d'évaluation de l'impact de ces règlements sur la durée des crises bancaires.

Le biais de sélection vient de la méthode utilisée pour construire la variable de crise bancaire. En fait, la pluspart des indicateurs de crises bancaires identifient une année de crise en utilisant une combinaison de symptômes observables sur le marché tels que les fusions et l'adoption des mesures d'urgence par le gouvernement ou la Banque Centrale. Nous nous référons à cette approche de datation de crise bancaire, comme approche-événementielle. Cette approche n'identifie les crises que si elles sont suffisamment graves pour déclencher une réaction du marché. En revanche, les crises contenues avec succès par des politiques correctives sont négligées. Par conséquent, les travaux empiriques basés sur ces données souffrent d'un problème de biais de sélection.

Le premier objectif de ce chapitre est de faire face à ce problème de biais de sélection en utilisant une autre méthode d'estimation, le Modèle à Changement de Régime Markovien (MCRM), afin d'évaluer l'effet de différents types de réglementation bancaire sur la stabilité du système bancaire. Le deuxième objectif est d'évaluer l'effet de ces règlements sur la durée des crises.

Pour atteindre ces objectifs, nous calculons dans un premier temps un indice de fragilité du système bancaire, et l'utilisons comme variable dépendante pour estimer la probabilité des crises bancaires. Nous mettons en œuvre un MCRM à trois états: la crise systémique, la tranquillité, et l'expansion. Nous introduisons des mesures de réglementation comme variables explicatives de la probabilité de transition d'un état à un autre pour évaluer leur effet sur l'apparition d'une crise bancaire systémique. Nous ferons référence à cette méthode comme le Modèle à Changement de Régime Markovien avec Probabilités de Transition Variables (MCRM-PTV). Nous dérivons de la MCRM-PTV l'effet marginal de chaque mesure réglementaire sur la probabilité d'être dans l'état de crise systémique. Nous utilisons ensuite cette spécification pour évaluer l'effet des mesures réglementaires sur la durée de crise bancaire. Nous effectuons une analyse de sensibilité: pour cela nous utilisons d'abord un autre indice de fragilité afin de voir si les résultats sont robustes. Nous utilisons également une procédure de Monte Carlo pour vérifier la sensibilité des résultats pour des modèles à deux états. Enfin, nous évaluons l'importance des biais de sélection résolus par le MCRM-PTV.

Nous appliquons notre méthode à une économie de marché émergente, l'Indonésie qui a souffert de crises bancaires au cours de la période 1980-2003 et où il y a eu une certaine dynamique sur les mesures réglementaires au cours de la même période. Nous concentrons notre analyse sur quatre grandes mesures de réglementation: (i) les restrictions à l'entrée, (ii) l'assurance-dépôts, (iii) les réserves obligatoires, et (iv) l'exigence d'adéquation de fonds propres.

Nous constatons que les restrictions à l'entrée sont efficaces contre les crises bancaires et réduisent la durée des crises. Un taux élevé de réserves obligatoires réduit la durée de crise, mais semble accroître la fragilité bancaire. L'assurance-dépôts accroît la stabilité du système bancaire et réduit la durée des crises bancaires. L'exigence d'adéquation de fonds propres améliore la stabilité et réduit la durée de crise bancaire.

Dans le troisième chapitre, nous analysons l'effet de la réglementation bancaire sur le bien-être en supposant que cette réglementation soit efficace en matière de stabilisation. Plus particulièrement nous nous intéressons aux réglementations qui finissent par être une contrainte sur le portefeuille des banques en matière du choix du type d'actifs. En effet, ce type de réglementation peut entraver la croissance économique en transférant les fonds des investissements productifs vers les investissements moins productifs et moins risqués. Bien qu'il existe encore des débats sur l'efficacité de ces types de réglementation bancaire, nous supposons dans ce chapitre que l'exigence adéquation de fonds propres actuellement en vigueur est efficace en matière de stabilisation.

Le principal problème de la réglementation, lorsque l'on étudie son impact sur le bien-être au niveau macro-économique, est d'évaluer l'arbitrage entre assurer la stabilité et promouvoir la croissance économique. En fait, quand un régime de réglementation est efficace, il améliore le bien-être parce qu'il réduit la probabilité de crise bancaire, mais en même temps il entrave la croissance donc, peut réduire le bien-être.

Le présent chapitre vise à fournir un cadre pour étudier cet arbitrage. Ce cadre est un modèle à générations imbriquées dans lequel les banques servent d'intermédiaires financiers et la réglementation bancaire est modélisée comme une contrainte sur le portefeuille des banques.

Notre modèle est construit dans un cadre d'équilibre général. Dans ce modèle, chaque jeune agent a accès à deux types de technologie de production Cobb-Douglas: une technologie risquée, très productive et une technologie sans risque, moins productive. Ces technologies servent à produire deux biens intermédiaires, qui sont utilisés pour produire un bien final par l'intermédiaire d'une technologie de type CES. Les jeunes individus sont des entrepreneurs, tandis que les vieux agents sont des bailleurs de fonds. N'ayant pas une dotation initiale de capitaux, l'entrepreneur a recours aux prêts du secteur bancaire. Les banques transfèrent les ressources des vieux vers les entrepreneurs en prêtant à un taux d'intérêt d'équilibre.

Nous tirons de nombreux résultats intéressants de ce modèle. Tout d'abord, nous montrons que lorsque des chocs de productivité sont idiosyncratiques, l'allocation d'équilibre compétitif est un optimum de premier rang et dans ce cas la réglementation entrave la croissance et maintient l'économie à un niveau de production inférieur à celui de l'économie non réglementée. Deuxièmement, en présence d'un choc non anticipé de productivité, l'existence de fonds propres réglementaires a un effet positif sur la stabilité bancaire. L'intuition derrière ce résultat étant qu'en cas de crise il existe plus de ressources dans une économie réglementée que dans une économie non réglementée.

La règlementation affecte le bien-être social à travers quatre canaux. Le premier canal est son effet sur la proportion d'entrepreneurs impliqués dans le projet risqué. Les deuxième et troisième canaux sont ses effets sur les revenus des entrepreneurs impliqués dans les projets risqués et les entrepreneurs sans risques. Le dernier canal est l'effet de la réglementation sur les intérêts. Certains de ces canaux sont liés à l'effet de stabilisation de la réglementation tandis que d'autres sont liés à l'effet de croissance. L'ampleur du choc, et le comportement des individus face à l'incertitude sont les principaux déterminants de l'importance de l'effet de stabilisation de la réglementation vis à vis de l'effet de croissance. Nous trouvons que l'impact global du niveau optimal de la réglementation sur la protection sociale dépend de manière déterminante de l'ampleur du choc de productivité, sa probabilité, et du niveau d'aversion aux risques des agents économiques.

Chapter 1

Regulation and Banking Stability: A Survey of Empirical Studies

1. Introduction

Banking is one of the most regulated and monitored industries in the world. In fact, there exist no less than eight types of banking regulation.[1] Two main reasons have been pointed out to explain why this is the case. Firstly, is the perception of banks as fragile institutions that need the help of government to evolve in a sound and safe environment; and secondly, banking instability is costly to the entire economy as a result of the key role banks play in financial intermediation by providing liquidity insurance, monitoring services, and providing economic and financial information.

Generally, governments delegate their regulatory power to Central Banks, which organize the regulatory system given their role of the lender of last resort. However, this has not always been the case (see, e.g., Allen and Herring (2001)). In fact, Central Banks were initially founded for different purposes. It is only in the nineteenth century that the focus of Central Banks shifted towards financial stability and their role increasingly came to be to eliminate crises. Moreover, the experience of bank panics during the Great Depression had a profound effect on bank regulation in the US. and in almost all countries in the world. As a result banks became heavily regulated in every country. Furthermore, in some countries the government intervened directly in the financial system to allocate resources. Interest rates were strictly controlled and systemic risk was avoided. Financial stabilization became the objective of banking regulation.

The costs of banking crises were perceived to be so high that they had to be avoided at all costs. Even though intensive regulations were able to eliminate systemic risk associated with banks in the post war period, over time it became increasingly less obvious that heavily regulated banking were optimal. This led to a worldwide wave of financial liberalization. Unfortunately, it also led to the return of financial crises. More importantly, it induced a new generation of regulations.

Since the re-introduction of financial liberalization in the 1980s, new types of regulation have emerged, the most important being the Basel Accords with its capital adequacy requirement and its supervision practices. We also noticed the decline of the level of the reserve requirement, the adoption or the redesign of deposits insurance, and the emergence of banking examination and

[1] see, e.g., Mishkin (2000), Barth, Caprio, and Levine (2004), and Allen and Herring (2001)

supervision in a great number of economies. This new regulatory framework has been praised for the international convergence of banks' risk management standards and for the improvement of these standards in many economies. Their design and implementation have been blamed for increasing several market failures in the banking industry. For example Brimmer (1992) argued that:

"Contrary to expectations,(...) the banking bill which became law in December 1991, will most likely undermine the stability and the efficiency of the banking system in coming years. In the mistaken belief that it was helping to enhance the "safety and soundness" of individual banks—and simultaneously protecting Federal insurance funds—Congress actually established an inflexible regulatory regime which will cut back on the scope of the financial activities in which banks can engage, increase the level and costs of capital requirements, make the money market less efficient, and involve regulators much more extensively in the internal affairs of banking institutions."

Existing banking regulations can be grouped into three broad categories: regulatory measures affecting the bank's balance sheet (capital adequacy requirements, reserve requirements, and asset holding restrictions), regulatory measures affecting the structure of the banking system (separation of the banking and other financial industries like securities, insurance, or real estate (e.g., the Glass-Steagall act of 1933); restrictions on competition), and regulatory measures for banks' owners' and managers' behavior (risk-based deposit insurance premiums, disclosure requirements, bank chartering, and bank examination).

Despite the recent progress in the research on banking fragility, there is still no consensus on how best to design and implement banking regulation in this new context of free banking. According to Santos (2001), this is the result of our lack of understanding of the mechanisms between banking regulation and market failure, and also the interaction of these regulations among them. It is also a consequence of our limited understanding of the implications of those regulations in a general equilibrium framework.

Notwithstanding of these limitations, the research already undertaken has produced some important results, specifically on the link between the type of banking regulation and banking system stability. This paper contributes to this literature by bringing together and adding structure to the contemporary theoretical and empirical literature.

The remainder of the paper is organized as follows. Section 2 presents a brief theoretical review of the link between regulation and banking stability. Section 3 reviews the design of banking regulations. Section 4 assesses the existing methodologies used in the literature. Section 5 reviews the empirical literature of various types of banking regulation. Section 6 presents a proposal for new directions of research on the link between banking regulation and banking system stability, and concludes.

Before proceeding, we should mention several important topics closely related to banking regulation that our article does not deal with, as well as some of the references to these topics. Specifically, our study does not deal with the link between regulation, banking profitability, and/or financial development (see, e.g., Bath, Caprio, and Levine (2004)). It also does not deal with the link between regulation and bank governance (see, e.g., Beck, Demirguç-Kunt, and Levine (2006b)). The last preliminary point is on the selection of countries that we talk about. Most of the available empirical evidence comes from the United States and the group of ten member countries of the Basel committee. One reason for this is the fact that data are generally more easily available for these economies than for others, and another is that a great number of economic researchers is located in these countries.

2. Reviewing the Link Between Regulations and Banks' Stability

In the introduction we argued that one of the key rationales for banking regulation is the prevention of banking crises. Hence, we start our paper with a brief review of the sources of banking instability, and the channels through which regulations can prevent it.

There are two main reasons for banks' failure. A bank can fail because the assets it owns or the credit it has made, have realized an unexpected low return such that the bank no longer has the resources to pay back depositors. A bank can also fail if a sudden rush of withdrawals forces it to sell off assets at a very low price. Let us start with the latter.

A financial crisis can be initiated by a sudden rush of withdrawals; hereafter, a run on a bank. *This sudden rush is generally a result of a coordination failure among the bank's depositors.* In fact, banks are characterized by balance sheets where banks' liabilities (deposits) are generally short-term, while their assets are long-term and illiquid. A run on a bank occurs when the bank's demand for withdrawals by depositors exceeds the short-term value of its assets.

Many reasons have been given in the literature as the trigger of bank runs. The most important is an arbitrary shift in expectations generally called sunspot; see, e.g., Diamond and Dybvig (1983). Another trigger is a shift in expectations due to the release of "bad news" (see, e.g., Morris and Shin (1998, 2000), Goldstein and Pauzner (2000), Chari and Jagannathan (1988)). Finally a productivity shock can trigger a bank run (e.g., Diamond and Rajan (2001a, 2001b), and Chen (1999) and Dasgupta (2000)).

But even if coordination failure can cause the failure of a bank, we need a linkage between *banks in the form of information spillovers or credit exposures to turn a bank run into a systemic* banking crisis, see e.g., Allen and Gale (2000a); Freixas, Parigi, and Rochet (2000).

The coordination failure problem in banking is a type of market failure, which can be solved by a proper identification of unnecessary withdrawals, suspension of withdrawals, and/or the institution of deposit guarantee, which can give incentive to depositors not to join the rush even if others are rushing.

The information spillovers market failure can be mitigated by markets' transparency, which helps to reduce information asymmetry and gives confidence to the other banks' depositors not to join the run occurring in the neighbour bank. Moreover, efficient lender-of-last-resort operations by the Central Bank can provide liquidity into the banking system and mitigate the negative effect of credit exposure and reduce the risk of contagion, see, e.g., Allen and Gale (2000).

A banking crisis can also be initiated by a high level of unexpected non-performing loans in a bank. When this information is known by the depositors, they rush to the bank to get back their deposits before the other depositors. If markets for liquidity are inefficient because of market power or information asymmetries, liquidity problems at healthy banks can turn into solvency problems.

In fact, in this case the bank is forced to sell its long-term assets below their fair value, see, e.g., Allen and Gale (1998), Bernanke and Gertler (1989, 1990), Donaldson (1992), and Kiyotaki and Moore (1997).

In order to mitigate the risk due to non-performing loans, banks can choose to hold an important proportion of their portfolio in safe assets. Regulators can help them to do so by increasing the required capital ratio. Another channel which can be used to mitigate this type of risk is the increase of competition among banks so as to reduce their market power and provide them with an incentive to organize efficiently the interbank lending market.[2]

3. Review of the Design of Banking Regulation

According to Allen and Herring (2001), there are 16 types of banking regulation.There are broadly four goals for these regulations, namely: preventing systemic risk, providing protection for investors, enhancing efficiency, and improving the social welfare. None of the regulations can achieve all of these objectives. Given our interest in banking stability we focus only on regulations put in place to prevent systemic risk. According to this paper there are eight types of regulation which help to achieve stability. These regulations are: (i) the asset restrictions; (ii) the capital adequacy requirement; (iii) the deposit insurance, (iv) the fit and proper entry tests; (v) the interest rate ceilings on deposits, (vi) the liquidity requirement; (vii) the reserve requirements; (viii) the restrictions on services and product lines.

Other studies have also focused on the design of the banking system regulation around the world. Barth, Caprio, and Levine (2001) provide an extensive assessment of the existing regulation and supervision.[3] Mishkin (2000) provides a list of eight types of regulation.[4] Although these

[2] For a detailed review of the theoretical literature on banking instability see Lai (2002).

[3] From Barth, Caprio, and Levine (1998) there are 12 basic types of banking regulation: (i) entry into banking, (ii) ownership, (iii) capital, (iv) activities, (v) external auditing requirements, (vi) internal managements/organizational requirements, (vii) liquidity and diversification requirements, (viii) the deposit requirements, (ix) the accounting /information disclosure requirements, (x) the discipline/problem institutions/exit, and (xi) supervision.

[4] The eight basic regulatory measures pointed out by Mishkin (2000) are: (i) restrictions on asset holdings and activities, (ii) separation of the banking and other financial industries like securities, insurance, or real estate, (iii)

studies do not report the same regulations, they do report many in common.

For a structured presentation of the design of banking regulation let us organize the presentation around the three groups that we presented above.

3.1 Regulations Affecting Bank's Balance Sheet

Among the regulatory measures presented by the above three studies, three measures are aimed at affecting the bank's balance sheet: restrictions on asset holdings, capital adequacy requirements, and reserve and/or liquidity requirements.

a) Restrictions on asset holdings aim at reducing the proportion of some type of risky assets in the portfolios of banks. It is then a constraint on the asset side of the bank's balance sheet. Its theoretical justification is based on the presence of information asymmetries between depositors and the bank manager, which can lead the manager to take too much risk without being disciplined by the withdrawal of deposits. It is a regulation, which has been adopted by many countries around the world. However, findings of Barth, Caprio, and Levine (2004) show that the level of restriction is higher in lower-income countries than in higher-income countries.

b) Capital adequacy requirements ask bank managers and/or owners to keep, in the form of equities, a given proportion of the amount of the risky loans that they have made. It has a direct effect on the composition of the liability size of a bank's balance sheet. More importantly, it aims at providing incentives for banks to hold less risky portfolios. In fact, this regulation can reduce their incentive to provide too many risky loans since in the case of a failure they may lose all their equities, and if their amount of equity is important, it means that they will lose a lot.

There are many types of capital adequacy requirement; their design has also evolved over time. According to Mishkin (2000) bank capital requirements typically take three forms: (i) the first type is based on the so-called leverage ratio, which is the amount of capital divided by the bank's total assets; (ii) the Basel I Accord type where assets and off-balance sheet activities are allocated into four categories, each with a different weight to reflect the degree of credit risk; (iii) the third type

restrictions on competition, (iv) capital requirements, (v) risk-based deposit insurance premiums, (vi) disclosure requirements, (vii) bank chartering, and (viii) bank examination.

is the capital requirement based on the level of market risk taken by banks.

Given the importance of the capital adequacy requirement in the regulatory framework of almost every country in the world today, we found useful to present some insight about the design of the capital adequacy requirement as stated by the Basel II Accord. The risk-weighted capital adequacy requirement is based on the concept of the capital ratio where the numerator represents the amount of capital a bank has available and the denominator is a measure of the risks faced by the bank and is referred to as risk-weighted assets. The resulting capital ratio may be no less than eight percent. The assessment of the risk-weighted assets taken by a bank depends heavily on the technique used to measure it. The Basel II accord specifies the technique that should be used to assess each type of risk. Let us recall that the Basel committee identified three types of risk in the banking industry: credit risk, market risk, and operational risk.

To measure the credit risk the bank can use three approaches: the standardized approach, the foundation internal ratings based (IRB) approach, and the advanced IRB approach: (i) the standardized approach uses only a predetermined risk weight for different types of loans; (ii) the model underlying the internal ratings based approach is the one-factor Gaussian copula model of time to default.[5]

To assess the market risk, Basel II accord proposed the VaR. The market risk capital requirement for banks when they use the internal model-based approach is calculated at any given time as $k * VaR + SRC$, where k is a multiplicative factor and SRC is a specific risk charge. The value at risk, VaR, is the greater of the previous day's value at risk and the average value at risk over the last 60 days. The minimum value of k is 3.

In addition to improving the way banks calculate credit risk capital, Basel II required banks to keep capital for operational risk. The regulators offered three approaches to measure this: the

[5] More precisely, consider a large portfolio of N loans. Let us denote: $WCDR$: the worst-case default rate during the next year that we are 99.9% certain will not be exceeded, PD: the probability of default for each loan in one year, EAD: the exposure at default on each loan (in dollars), LGD: the loss given default, i.e., the proportion of the exposure that is lost in the event of a default. Suppose that the copula correlation between each pair of obligors is ρ. We have $WCDR = N[((N^{-1}(PD) + \sqrt{\rho N^{-1}(0.999)})/(\sqrt{(1-\rho)}))]$. It follows that there is a 99.9% chance that the loss on the portfolio will be less than N times $EAD \times LGD \times WCDR$.

basic indicator approach, the standardized approach, and the advanced measurement approach. The basic indicator approach sets the operational risk capital equal to the bank's average annual gross income over the last three years multiplied by 0.15.

Barth, Caprio, and Levine (2004) found that the stringency of capital requirements is lower for lower-income countries than for higher-income countries. The overall capital stringency is lower in developing countries than in developed countries.

c) Reserve and/or liquidity requirements are a form of regulation which forces banks to maintain, in the form of a reserve, a given proportion of their deposits in an account of the Central Bank, and/or to maintain, in the form of liquidity, a given proportion of deposits in their account. This type of regulation affects the composition of the asset size of the bank's balance sheet. This regulation can mitigate the incentive of a bank's owner and manager to get involved in too risky activities. Besides, the reserve requirement is probably one of the most ancient types of banking regulation. It has been viewed as a form of taxation on banks by governments, since generally these required reserves do not bear interest. Many US economists have argued that a reserve requirement was needed in the US because of the existence of a deposit insurance run by the government. But this is no longer the view of a lot of Central Bank economists in developed economies.. In fact, in the 1990s some countries like Australia, Canada and New Zealand have abandoned the use of this required reserve and even countries which have not removed it, have reduced it substantially and more frequently. Meanwhile, in developing countries the reserve and/or liquidity requirement is still used. Some countries have significantly reduced their reserve requirement and increased the liquidity requirement. More than four-fifth of the countries still maintain a reserve requirement and about one-eighth of the countries has a liquidity requirement.

3.2 Regulations Affecting the Banking Sector Structure

Some regulations have an important impact on the structure of the banking system in a given country. From the previous example of regulations the following can have a significant influence on bank structure: regulations separating banking and non-banking business, and restrictions on entry in the banking industry.

a) Regulations separating banking and non-banking business: some governments restrict banks from involvment in commercial activities, which are considered to be outside the core banking business and, therefore, may be more risky. In the United States there was an even more restrictive policy, which was under application during the period 1933-2003: the Glass-Steagall Act of 1933.[6] We observed from the Barth, Caprio, and Levine (2004) survey that almost every country (except New-Zealand) has at least a restriction on banks' involvement in activities such as: securities, insurance, real estate, and a bank owning non-financial firms. They also found that restrictions imposed on bank activities are greater for lower-income countries than higher-income countries; and that government ownership of banks increases in countries, on average, as one moves from the higher-income level to the lower-income level.

b) Regulation on entry into the banking industry: there are many types of restrictions to the entry into the industry. It ranges from the minimum amount of capital that the owner should provide to the regulatory agencies, to the restriction of foreigners to own or invest in banks. If the goal of the minimum amount of capital needed to enter into the banking sector is mainly to limit competition, the goal of restricting foreign funds is three-fold: to limit competition, to reduce the exposure to capital flight, and to reduce the exchange-rate risk. From Barth, Caprio, and Levine (2004) almost every country has a minimum amount of capital to obtain a licence or a charter for banking activities. Although the entry of foreign funds was prohibited for acquisition, subsidiary, and creation of a branch during the 1980s, according to Barth, Caprio, and Levine (2004) almost no banking system is now restricting foreign funds to invest in banking. Meanwhile, they found that the percentage of entry applications denied is greater for low-income countries than for high-income countries; and that developing countries place more limitations on foreign bank ownership of domestic banks and foreign bank entry through branching than developed countries.

[6]The Glass-Steagall Act of 1933 forces banks to be separated from other financial industries such as securities, insurance or real estate.

3.3 Regulations Affecting the Managers' and/or Owners' Behavior

Since the theoretical literature has pointed out many market failures which can lead managers to take too much risk or to take improper actions without being disciplined by a free well-functioning financial market, many regulations have been designed to deal with this issue: the risk-based deposit insurance, disclosure requirements, bank chartering, and bank examination.

a) Deposit insurance was first introduced in the US after the Great Depression and has since been adopted by many countries. In their survey of 2001 Barth, Caprio, and Levine observed that at least 77 countries were applying it while Demirgüç-Kunt, Kane, and Laeven (2006) found that 87 countries were applying it by the end of 2003. Its aim is to reduce the likelihood of bank runs and panics in the banking system. However, complete insurance is likely to introduce moral hazard into the banking system and therefore increase its fragility. That is why a new type of deposit insurance has emerged, namely risk-based deposit insurance premiums. If the deposit insurance premium, provided by the government, is priced appropriately to reflect the amount of risk taken by a bank, it will solve the moral hazard issue.[7] Barth, Caprio, and Levine (2004) found that developing countries are almost three times as likely as developed countries not to have an explicit deposit insurance scheme.

b) Disclosure requirements aim at mitigating the asymmetry of information available in the banking industry. Generally, regulators require that banks adhere to certain standard accounting principles and disclose a wide range of information that helps the market assess the quality of a bank's portfolio and the degree of the bank's exposure to risk. This type of regulation is widely used by high-income countries and less by developing countries. For example, Barth, Caprio, and Levine (2004) point out that the percentage of banks rated by international credit rating agencies is seven times greater for high-income countries as compared to low-income countries.

c) Bank chartering aims at preventing dishonest people and overly ambitious entrepreneurs from engaging in highly speculative activities. In fact, chartering proposal for new banks are screened

[7] Risk-based deposit insurance premiums are theoretically appealing but in practice they have not worked very well mainly because it is hard to accurately determine the amount of risk a bank is actually taking

to prevent dishonest and speculative people from controlling banks. Almost every country has this type of regulation.

d) Bank examination, or supervision, or monitoring helps to limit moral hazard incentives for excessive risk taking. Since it is not enough to have regulations which encourage less risk taking, banks must be monitored to see if they are complying with these regulations. This type of regulation improves the quality of the financial information given to the public by bank owners and managers and can also serve to enforce the existing regulations. Barth, Caprio, and Levine (2004) found that the degree of private monitoring increases as one compares lower-income countries to higher-income countries and that the tenure of supervisors is less in developing countries than in developed countries.

4. Review of Empirical Methodologies

The empirical analysis of the link between regulation and stability of the banking system had so far taken two main directions. The first direction is to compute, using a measure of risk assessment, the risk taken by the banks during a period under which a given type of regulation was under implementation and to see if the dynamic of the risk is associated with the given regulation. We will refer to this method as the implicit-risk method. This method is generally applied on bank-level data in a given economy or on bank-level data of a group of economies.

The second direction is to talk about banking fragility in a given economy. The risk measure here takes the form of a dummy variable which takes the value 1 if a banking system is assumed to be in a systemic banking crisis situation during a given year, and 0 if not. Under this method cross-country data and discrete regression model are widely employed.

4.1 Implicit Risk Method

A least three classes of econometric models use the implicit measure of risk to assess the impact of regulation on banking stability. These classes are: the simultaneous equation model, which is generally used to study the impact of capital adequacy requirement on bank's risk, the discrete regression model which is mainly used in studies using the rate recorded by credit rating agencies, and the survival and hazard models used to model the probability of a bank's failure.

4.1.1 Simultaneous Equation Model

The simultaneous equation model was introduced by Shrieves and Dahl (1992) to analyze adjustments in capital ratio and risk following the imposition of capital adequacy requirement in the US banking system.[8] The key ingredient of this model is that observed changes in bank capital ratios and portfolio risk levels can be decomposed into two components, a discretionary adjustment, and a change caused by an exogenously determined random shock, such that

$$\begin{cases} \Delta CAP_{jt} & = & \Delta^d CAP_{jt} + E_{jt} \\ \Delta RISK_{jt} & = & \Delta^d RISK_{jt} + U_{jt} \end{cases}$$

where ΔCAP_{jt} and $\Delta RISK_{jt}$ are observed changes in capital ratios and risk levels for bank j in period t, $\Delta^d CAP$ and $\Delta^d RISK$ represent discretionary adjustments in capital ratios and risk levels, and E and U are exogenous shocks. Recognizing that banks may not be able to adjust their desired capital ratios and risk levels instantaneously, the discretionary changes in capital and risk are modeled using a partial adjustment framework.

$$\begin{cases} \Delta CAP_{jt} & = & \mu(CAP^*_{jt} - CAP_{j,t-1}) + E_{jt} \\ \Delta RISK_{jt} & = & \beta(RISK^*_{jt} - RISK_{j,t-1}) + U_{jt} \end{cases}$$

Thus, observed changes in bank capital ratios and portfolio risk in period t are functions of the target capital ratio CAP^*_{jt} and target risk level $RISK^*_{jt}$, the lagged capital ratio CAP_{t-1} and risk levels $RISK_{t-1}$ and any random shocks.

The target capital ratio level is not observable, but is assumed to depend upon some set of observable variables, including the changes in portfolio risk ($\Delta RISK_{jt}$), while the exogenous shock that could affect bank capital ratios is the regulatory pressure. Also, the target risk level is not observable, but is assumed to depend on a set of observable variables including the changes in portfolio risk (ΔCAP_{jt}), while the exogenous shock that could affect bank capital ratios is the

[8] It has since then been used by a great number of authors e.g., Jacques and Nigro (1997), Rime (2000), and Nachane et al. (2000).

regulatory pressure. This assumption helps to recognize the possible simultaneous relationship between capital and risk.[9]

To complete the empirical estimation of the simultaneous equation system one must provide a measure of the bank capital and a measure of the portfolio risk of banks. In the literature, portfolio risk is measured in two ways: using the ratio of total risk weighted assets to total assets, and using the gross non-performing loans as percentage of total assets (see, e.g., Avery and Berger (1991), Berger (1995), and Shrieves and Dahl (1992)). The literature also uses two definitions of a bank's capital ratio: the ratio of capital to total assets (see, e.g. Shrieves and Dahl (1992), and the ratio of capital to risk-weighted assets (see, e.g. Jacques and Nigro (1997), Aggarwal and Jacques (1998) and Ediz et al. (1998)).

In this literature also, the regulatory pressure is a cornerstone of the hypotheses involving minimum capital standards; hence, it should be captured. Generally, the regulation pressure (REG) is a binary variable.

Let us denote by $OTHERS$ the other variables affecting the banking capital and the bank's risk. The model can be broadly set as

$$\begin{cases} \Delta CAP_{jt} = \mu_0 + \mu_1 REG_{jt} + \mu_2 OTHERS_{jt} + \mu_3 \Delta RISK_{jt} + \mu 4 CAP_{jt-1} + u_{jt} \\ \Delta RISK_{jt} = \beta_0 + \beta_1 REG_{jt} + \beta_2 OTHERS_{jt} + \beta_3 \Delta CAP_{jt} + \beta 4 RISK_{jt-1} + v_{jt} \end{cases}$$

where u_{jt} and v_{jt} are error terms. This model is generally estimated using a two or a three-stage least-square procedure. Authors using the three-stage method argue that it allows them to take into account the simultaneity of banks' adjustments in capital and risk and to get estimates that are asymptotically more efficient than under the two-stage technique.

4.1.2 Methodology with the Credit Rating

Some authors working on bank level data use the rate of commercial banks provided by the international rating risk agencies as their measure of risk. Typically these agencies rate banks'

[9]Shrieves and Dahl (1992) argued that a positive relationship between changes in capital and risk may signify, among other possibilities, the unintended impact of minimum regulatory capital requirements or even managerial risk aversion. Jacques and Nigro (1997) argued that a negative relationship may result because of methodological flaws in the capital standards.

financial strength on a $N - point$ scale, ranging from E to $A+$. Since these rates form a limited dependent variable, the appropriate econometric model used to assess the impact of regulation on the banking system stability here is an ordered probit or logit. Specifically, the regression equation estimated is:

$$RAT_{ij} = \beta_0 + \beta_1 REG_j + \beta_2 BKC_{ij} + \beta_3 INS_j + \beta_4 MEV_j + u_{ij}$$

where the subscript i denotes the country and the subscript j denotes the bank; with RAT for rating, REG for regulation, BKC for banking characteristics, INS for institutions, MEV for macroeconomic variables.[10]

4.1.3 Survival Model

Some authors use the probability of bank failure as their measure of risk or fragility. They then study the impact of regulation on this probability of failure. In the literature survival econometric model of Kaplan-Meier is generally used.[11]

4.2 Explicit-Instability Method

So far in the literature, we have reported two econometric methodologies used to study the link between banking regulation and banking instability when the dependent variable is the explicit dummy variable of banking crisis. The most frequent one is the Demirguç-Kunt and Detragiache (1998), hereafter $DKD98$ method, which consists of using a discrete regression model in the context of panel data. More precisely, $DKD98$ built a model similar to this:

Let P_{it}^* denotes an unobservable variable representing the probability that the banking system of country i suffers a systemic crisis at time t, and P_{it} - a dummy variable which takes the value 1 when country i suffers a systemic banking crisis at time t and 0 otherwise. The probability of a systemic banking crisis is modelled as follows:

$$\begin{cases} P_{it} = 1 & if \quad P_{it}^* > C \\ P_{it} = 0 & if \quad P_{it}^* \leq C \end{cases}$$

[10] See Demirgüç-Kunt, Detragiache, and Tressel (2006) for more details.

[11] See, e.g., Erlend and Baumann (2006), and Sheldon (2006) for more details

With

$$P_{it}^{*} = \beta' X_{it} + \varepsilon_{it}$$

and where X_{it} represents the matrix of all exogenous variables; i the country index; t the time index, and C a threshold value of the banking crisis probability.

The impact of each regulation on the banking system stability can be assessed by augmenting the above benchmark model of banking crises with variables capturing some characteristics of the banking regulation. Let us denote by L_{it} the matrix of variables representing the regulatory measures in country i at time t. The reduced form equation can be given by

$$P_{it}^{*} = \beta' X_{it} + \theta' L_{it} + \varepsilon_{it}.$$

If θ is significant and negative, then regulation reduces the probability of the banking system being in a systemic crisis.

This model is estimated using the logit regression model in the context of panel data. The sign of the estimated coefficients for each exogenous variable shows how an increase of that explanatory variable increases or decreases the probability of a crisis. However, as is well known for a binary model, the estimated coefficients cannot represent the magnitude of the effect of a marginal change in the exogenous variable on the likelihood of a banking crisis. Each coefficient instead reflects the effect of a change in a given explanatory variable on $ln(P_{it}/(1 - P_{it}))$, so that the magnitude of the effect on the probability of a crisis depends on the slope of the cumulative distribution function at $\beta' X_{it} + \theta' L_{it}$: it follows that the magnitude of the change in the probability of a banking crisis depends on the initial values of all the exogenous variables and their coefficients. Hence, after the estimation of the logit model, the following step is to compute the marginal coefficient estimates which are evaluated at the sample mean. These estimates represent the magnitude of the link between each exogenous variable and the probability of a systemic banking crisis evaluated at the sample mean.

The literature tends to use the logit instead of the panel-logit to estimate this model because the former is always convergent and the latter may not be.

The second method consists of using the discrete regression model but in the context of cross-section data. More precisely, Barth, Caprio, and Levine (2004) use the cross-section data over a five-year period time. Their dependent variable, which is the dummy variable for a crisis, is defined as follows: if a country has suffered a systemic banking crisis during the five-year period, the dummy variable takes on the value 1; if not it is 0. The regulatory variables are taken from a survey, and the macroeconomic control variables are the average of this variable over the five-year period. They then use a simple logit model to assess the impact of each regulatory measure on the banking instability.

5. Review of Empirical Studies

We will carry out our empirical review with respect to the above groups. Let us first start with the implicit-method.

5.1 Empirical Studies Using the Implicit-Risk Method

A great number of theoretical and empirical studies have been carried out on the impact of the capital adequacy requirement on the banking stability or the risk-taking behavior of bank managers in developed economies over the last decade. A lot of research has been done on the US banking system. Generally, these works use individual bank-level data and compute a measure of risk taken by each bank. Let us first present the work already done for the US banking system before presenting the work for other economies.

5.1.1 Capital Standard and Stability in the US Banking System

The capital standard was first introduced in the US banking system in 1981.[12] Even before the introduction of the Basel I accord on capital requirement, many theoretical studies have been carried out on this regulation regarding the risk-taking behavior of bank owners and managers.

[12]This was even before the introduction of the Basel I accord which was adopted by the G10 countries in 1988.

The most important studies were Koehn and Santomero (1980) and Kim and Santomero (1988). The message of this theoretical work was that capital standard may not be effective under various sets of conditions. Since then a lot of economists have carried out empirical studies on the US banking system to test this theoretical conclusion.

The first empirical work for the US banking system is the paper of Furlong (1988). He used the data of 98 large US bank holding companies from 1975 to 1986. He defined the risk taken by banks as the volatility of underlying asset values. He computed this by inverting the call option pricing formula, and found that asset risk measured in this way doubled during the period 1981-86 in the part of his sample in which banks were under capital requirements, compared with the earlier period. However, banks which were well-capitalized in 1981 before the introduction of capital requirement experienced the same rise in volatility as those which were not. He then argued that these findings do not support the view that an increase in capital adequacy requirement leads banks to increase their risky-assets.

As noted by Jackson et al. (1999), his interpretation is true only if one assumes that the level of bank capital in 1981 was representing the desired or the equilibrium capital level. In this case Furlong's findings would be inconsistent with the Kim and Santomero's theoretical findings since well-capitalised banks would not have been subjected to any additional constraint.[13] But, it is possible that, through the effects of capital requirements on market discipline, the introduction of fixed capital standards led to an increase in target capital rates for both highly capitalised and weakly capitalised banks. In this event, Furlong's findings might be seen as consistent with Kim and Santomero's findings.

This work has been criticized for not controlling for many variables which could have affected risk-taking behavior during that sample period. Also, it hasn't taken into account the endogeneity of capital ratio and risk. This has motivated the emergence of a new set of studies. Shrieves

[13]i.e., although capital requirements with differentiated weights will probably give banks an incentive to shift towards lowly-weighted asset categories, for any category of assets which bear the same proportional capital charge, banks will shift towards the more risky assets in the category, which will end up increasing risk-taking behaviour in the banking system.

and Dahl (1992) built a simultaneous equation model to take into account the fact that changes in both capital and risk have endogenous as well as exogenous components, and to focus on the determination of discretionary changes in risk which are induced by either endogenous or exogenous changes in capital. They then investigated the relationship between changes in risk and capital in a large sample of US banks over the period 1983-1987, and found a positive association between changes in risk and capital.[14] In fact, their results established that risk exposure and capital levels are simultaneously related, and that the majority of banks mitigate the effects of increases in capital levels by increasing asset risk posture, and vice versa. They argued that the fact that these relationships were present even in banks which were in excess of the minimum regulatory requirements for capital adequacy, supports the conclusion that a positive association between risk and capital in such banks is not strictly the result of regulatory influence, but rather reflects the view that risk-taking behavior tends to be constrained by bank owners' and/or managers' private incentives. Their findings suggest then that capital standard tends to increase the risk in the US banking system.

A partial conclusion at this stage is, that taking into account the endogenous part of an increase in capital and risk can make a huge difference to the results. But this conclusion will not be entirely fair, since the sample period and banks are slightly different and the measures used to assess risks in banks are also different. Besides, when Jacques and Nigro used the same empirical methodology on a different sample period, they obtained a different result. In fact, Jacques and Nigro (1997) studied the impact of risk-based capital standards on capital ratio and risk is the US banks under the period 1990-91 and found that changes in the capital ratio and risk are negatively related, i.e., an increase in the level of capital reduces the risk taken by US banks.[15]

[14]Where risk is measured using the gross non-performing loans as percentage of total assets, and bank's capital ratio is the ratio of capital to total assets.

[15]The conflicting empirical findings on the effect of capital standard on banking stability is confirmed by the study of Haubrich and Watchel (1993) which found that the implementation of the Basle risk standards caused poorly-capitalised banks to reconfigure their portfolios away from high-risk and towards low-risk assets, and which runs contrary to that of Hancock and Wilcox (1992) who found out that, banks that had less capital than required by the risk-based standards, shifted their portfolios towards high-risk assets.

The implicit-risk method failed then to close the debate about the effectivity of capital standard for banking stability in the US banking system. To end this subsection, let us review the Dahl and Spivey (1995) paper which provides an indirect way of assessing the importance of capital standard on banking stability. They used US bank data over the period 1980-88 to assess the likelihood and timing of bank recovery from undercapitalization. They noted that there appears to be only a limited capacity for banks to change positions of undercapitalisation by growth limitations or dividend restrictions, and that the impact of profitability on recovery is greater the longer a bank remains undercapitalised. Hence, the design of the capital requirement has important implications not only for optimal capital levels, but also for the level of risk and the safety and soundness of the banking system as a whole.

5.1.2 Capital Standard and Stability in Other Countries' Banking Systems

Outside of the US, studies on the impact of capital adequacy requirement on banking stability using the implicit-risk method are scarce. So far, we have found two studies on the Switzerland banking system (Rime (2000), and Sheldon (2001)), a study on the group of ten member countries of the Basel committee (Sheldon (1996)) and a study on the Indian banking system (Nachane et al. (2000)).

Using a modified version of the Shrieves and Dahl (1992), Rime (2001) built a simultaneous equations model to analyze adjustments in capital and risk in Swiss banks and found that regulatory pressure to implement capital adequacy requirement induced banks to increase their capital ratio but did not affect the level of risk. In his study, risk is measured by the ratio of risk-weighted earnings to total assets. He argued that his findings indicate that for Swiss banks, an increase in available capital through retained earnings or equity issues is less costly than a downward adjustment in the risk of the portfolio, and that a rationale for this can be the absence of a developed market for asset-backed securities in Switzerland. However, this runs contrary to the result found by Sheldon (2001) on banks that operated in Switzerland during the period 1987-99. He estimated the impact of the capital standard on the probability of banks' failure and found that over this period the capital adequacy requirement succeeded in increasing the banks' safety, although it decreased the profitability of banks, and finally that the level of adequacy requirement was too high from a welfare point of view. As in the case of the US banking system the difference in results can be due to sample periods and the methodology used.

Nachane et al. (2000) provided an empirical assessment of the impact of capital adequacy requirement on the risk-taking behavior of India's commercial banks. Their study examined 27 Indian public sector banks using year-end data for 1998. Their measures of risk were: the ratio of risk-weighted assets to total assets and the ratio of gross non-performing loans to total assets. They found that banks adjusted their capital ratios significantly, but their risk positions adjusted relatively slowly to the respective target levels. They argued that this suggests that changes in capital and risk are negatively related.

Sheldon (1996) performed an analysis of the equity and asset volatilities of 219 banks from the group of ten member countries of the Basel committee over the period 1987 to 1994. He found that bank asset volatility in the US banks rose and that this was the case both for banks which increased their capital ratios and for those which did not. In Japan, asset volatility fell, although most banks raised their capital ratios. He concluded that he found little evidence that the implementation of the Basel guidelines had a risk-increasing impact on bank portfolios.

5.1.3 Other Regulations and Banking Stability

In the literature of implicit-risk there are few studies about the impact of other types of regulation on banking stability. There is a study of Horiuchi (1999) about the safety-net in the Japanese banking system, two other studies on safety-net in cross-section analysis, and two studies using a broad notion of regulation.

We have found one study of the Japanese government safety-net and its links with stability. It is the paper of Horiuchi (1999) which examines how the Japanese government safety-net mechanism generated fragility in the banking system during the 1990s. He found that even though the Japanese safety net protected depositors from losses associated with bank failures, it did not implement prudential regulations to prevent moral hazard associated with it. The later translated into the systemic banking crisis that Japan experienced during that period. This study therefore associated deposit insurance with banking crises in Japan.

Cull, Senbet and Sorge (2005) found a similar result using the volatility of credit to the private sector as the proxy for risk in a cross-country analysis. More precisely, they found that the decision to introduce deposit insurance increases the volatility of credit to the private sector in countries with weak institutions. Demirgüç-Kunt and Huizinga (2004) also found a similar result about the association of deposit insurance with banking fragility. They used bank-level data to study the effect of deposit insurance on market discipline of banks. They focused on the disciplinary role of interest rates and deposit growth and found that market discipline is stronger in countries with better institutions, but that the presence of generously designed deposit insurance is able to reduce its effect significantly, leading to banking system fragility. Nier and Baumann (2006) found the same result using bank-based data that *"government safety nets result in lower capital buffers and that stronger market discipline resulting from uninsured liabilities and disclosure results in larger capital buffers, all else equal,"*. In other words, the deposit insurance is less important for banking stability than market-discipline.[16]

Some studies used a broad notion of regulation. These defined an index of banking regulation as a weighted average of many types of regulation. For example, Gonzalez (2005) provided a channel through which banking regulation affects banking stability: charter value. The study used a panel database of 251 banks in 36 countries to analyze the impact of bank regulations on bank charter value and risk-taking. He found, after controlling for the presence of deposit insurance and for the quality of a country's contracting environment, that regulatory restrictions increase banks' risk-taking incentives by reducing their charter value. More precisely, banks in countries with stricter regulation have a lower charter value, which increases their incentives to follow risky policies. In

[16]This result about a positive association of deposit insurance and banking instability was found as a byproduct of their research on market discipline. Nier and Baumann (2006) found, using a cross-country panel data set consisting of observations on 729 individual banks from 32 countries over the years 1993 to 2003, that competition leads to greater risk.

other words, there is a negative relationship between regulatory restrictions and the stability of banking systems. He also found that the deposit insurance can have a positive effect on stability if it is exogenous, but if it is endogenous, it is not relevant for stabilization purposes. Gonzalez used non-performing loans to total loans and bank stock price volatility as the measure of risk in banks.

Also, viewing bank concentration as a symptom of regulatory restriction, Evrensel (2007) applied non-parametric and parametric methods of survival analysis to study the impact of bank concentration on banking crises. The empirical results suggest that concentration in the banking sector increases the survival time. In other words, it reduces the probability of bank failure. Another result is that the $G10$ and $non - G10$ countries constitute two distinct groups of countries, where the $non - G10$ countries have a higher incidence of bank crises.[17] The parametric survival time regressions confirmed the possibility that the effects of the covariates on bank crises may have different dynamics in the $G10$ and $non - G10$ countries. The study states that the different dynamics associated with banking crises in developed and developing countries seem to be related to the absence of competitive forces in the economic and political environment.

Demirgüç-Kunt, Detragiache, and Tressel (2006) studied whether compliance with the Basel Core Principles for effective banking supervision (BCP) improves bank soundness. They argued that BCP compliance assessments provide a unique source of information about the quality of bank supervision and regulation around the world. They found a significant and positive relationship between bank soundness (measured with Moody's financial strength ratings) and compliance with principles related to information provision. Specifically, they found that countries, which require banks to report their financial data regularly and accurately to regulators and market participants, have sounder banks. They found similar results when the soundness was measured through $z - scores$ yields. They interpreted their findings as evidence that transparency makes supervisory processes effective, strengthening market discipline, and that it is the most important element of the core principles.

[17] The G10 refers to the group of eleven countries member of the Basel Committee on Banking Supervision. More precisely, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States.

The general result found in the implicit-risk literature about the relationship between capital standard and stability is that the previous implementation of capital requirement before the Basel II Accord had not shown convincingly that it has any effect in fighting risk-taking in the banking sector. This had motivated regulators to introduce the Basel II capital standard. So far no empirical assessment of the impact of the Basel II Accord on risk-taking in banking have been found in the literature. It will take some time to be able to carry out a good study on this new accord. This time may even be longer than usual, since the introduction of Basel II in the US has been coupled with a banking crisis.[18] A key issue one should take into account should be the endogenous part of the level of the capital ratio.

Apart from the capital standard, other types of regulation have not been scrutinized by many authors. Their findings however show that regulation directly affecting the bank manager's and/or owner's behavior (excluding full deposit insurance) seems effective for stabilization purpose. However, one cannot conclude strongly whether the empirical findings presented in this section are robust, since we have only a few studies. Therefore, these regulations need additional empirical scrutiny.

However, the implicit-risk method will always bring controversy as some would argue that the measure of the risk which is taken into account is not the one which matters for stability.

5.2 Explicit-Risk Method

A recent and growing literature of the empirical studies on banking regulation and stability using an explicit measure of banking instability departs from the work of $DKD98$. These studies use cross-country data on banking regulation and banking crises to assess, using a discrete variable regression model such as the logit or the probit model, if a given regulatory measure has successfully contained or reduced the probability of the occurrence of a banking crisis in a given set of economies. Some studies use all countries with available data, while others focus on a group of countries such as developing countries, developed countries, etc.

[18]This crisis caused by the subprime loans for housing cannot be accounted for as a consequence of Basel II; more reasonably, it can be viewed as an evidence of the weakness of the Basel I Accord on capital standard.

Generally, these studies are motivated by the conflicting theoretical results of the effect of regulation on the banking system stability. However, the most important reason for the increase in empirical research on regulation and stability seems to be the availability of data. Since 1998, a group of researchers at the World Bank : Barth, Caprio, Levine, and others have developed a comprehensive survey of the banking regulation practices around the world. From the first survey in 1998-1999 to the third survey in 2007, the number of countries covered has increased significantly from 100 to almost every country in the world. The number of questions and types of regulation practices covered by these surveys have also increased over this period. They have also assembled a database on banking crises.

Many studies have used these datasets to answer different types of questions, ranging from the effect of entry restriction on banking stability, to the effect of deposit insurance, capital adequacy requirement, and a broad range of criteria in banking regulation.

5.2.1 Banking Entry Restriction

A key question which has earned empirical scrutiny is whether {a lower level of} entry restriction into the banking system is likely to increase the stability of the banking sector. Beck, Demirguc-Kunt, and Levine (2006) provided an empirical answer to this question. They used data for 69 countries from 1980 to 1997, and applied the $DKD98$ discrete regression model. They found that crises are less likely in economies with more concentrated banking systems. Moreover, the data showed that regulations that thwart competition are linked with greater banking system fragility. Furthermore, Barth, Caprio, and Levine (2004) found that the likelihood of systemic banking crisis is positively associated with greater limitations on foreign bank entry; and they found no evidence of positive association between domestic entry restrictions and banking stability.

But before all this research Demirguc-Kunt and Detragiache (1998) have provided the first empirical assessment of the link between lower entry restriction in banking and financial fragility using a dummy variable of banking crises. Their study used a panel of data of 53 countries over the period 1980-1995. They found that banking crises were more likely to occur in countries with more liberalized financial systems. They pointed out that the financial liberalization's impact on a fragile banking sector is weaker in countries with strong institutions–especially where there is respect for the rule of law, a low level of corruption, and good contract enforcement. They also found that even in the presence of macroeconomic stabilization, less entry restriction is likely to be linked with the occurrence of banking crises in countries where institutions to ensure legal behaviour, contract enforcement, and effective prudential regulation and supervision are not fully developed.

Conversely, Noy (2004) found a different result when studying the effect of liberalization on banking stability. He examined the hypothesis that insufficient prudential supervision of the banking sector after the removal of entry restriction results in excessive risk-taking by financial intermediaries and a subsequent crisis. The paper evaluated the empirical validity of this hypothesis using a panel-probit model of the occurrence of banking crises controlling for macro-economic, institutional and political variables. It concluded that such a development is, at worst, only a medium run threat to the health of the banking sector. He found that a more direct danger is the loss of monopoly power that liberalization typically entails.

5.2.2 Capital Standard

So far we have found in the literature only one study of the impact of capital standard on banking stability using the explicit-risk method. Barth, Caprio, and Levine (2004) found a significant negative relationship between higher ratio of capital requirement and non-performing loans. However, when they used the explicit dummy variable for banking crises, they found some specifications in which capital requirement entered with a negative and significant coefficient. They interpreted this result as evidence that the relationship between capital adequacy requirement and banking stability is not very robust.

5.2.3 Deposit Insurance

Before the important empirical research of Demirguc-Kunt and Detragiache (2002), hereafter $DKD02$, there was a large body of theoretical literature on deposit insurance and its association to fragility. However, there was a large divergence in the results of these studies too. $DKD02$ used cross-country panel data on 61 countries over the period 1980-1997 and found that explicit deposit insurance tends to increase the likelihood of banking crises, the more so where bank interest rates are deregulated and the institutional environment is weak. They also found that the negative effect of deposit insurance on banks' stability is stronger the more extensive is the coverage offered to depositors, where the scheme is funded, and where it is run by the government. Barth, Caprio, and Levine (2004) found a positive association between the generosity of the deposit insurance scheme and the bank fragility. Their relationship was robust to alterations in the control variables. This was consistent with the view that deposit insurance not only substantially aggravates moral hazard but also produces deleterious effects on banking stability.

However this result has not been found to be robust by Arteta and Eichengreen (2006). In fact, they assessed the link between banking fragility and deposit insurance using a sample of 75 emerging market economies over the period 1975-1997 and found no significant effect of deposit insurance on the probability of the banking system being in a systemic crisis. They argued that what led to this difference was that they had more data on deposit insurance on emerging market than $DKD02$.

5.2.4 Overall Banking Regulation

Using the above databases some studies such as: Barth, Caprio, and Levine (2000, 2004, 2006), and Barth, Gan, and Nolle (2006) have assessed the stabilization effect of existing banking regulations.

In a book entitled "Rethinking Banking Regulation: Till Angels Govern" based on the World Bank survey, Barth, Caprio, and Levine (2006) assessed the importance of each type of regulatory policy on the stabilization of the banking system. They provided empirical results for a range of regulations. They found that regulation is not effective for stability, and for a long range of criteria. They argued for paying closer attention to the foundations of the financial sector, and that without good information and adequate incentives, market participants will not be able to effectively monitor banks. These findings are the summary of findings already done in one of their previous works: Barth, Caprio, and Levine (2004). In this work they used their database on bank regulation and supervision covering 107 countries to assess the relationship between specific regulatory and supervisory practices and banking-sector development, efficiency, and fragility. More precisely, they examined the effect on banking stability of regulations such as: restrictions on bank activities; entry restriction; capital adequacy requirement; deposit insurance system design features; supervisory power, independence, and resources; loan classification stringency, provisioning standards, and diversification guidelines; regulations fostering information disclosure and private-sector monitoring of banks; and government ownership. They found that regulatory measures that rely excessively on direct government restriction on bank activities is not good for stability and can even create fragility. More precisely, they found that the relationship between capital adequacy requirement and banking stability is not robust. They also found that regulatory policies that rely on guidelines that force accurate information disclosure, empower private-sector corporate control of banks, and foster incentives for private agents to exert corporate control, worked best to promote stability.

They argued that their findings do not mean that regulations which have not been proven effective have no role in strengthening the banking sector. Rather, their interpretation is that it suggested a supporting role for regulation, one in which the regulators' job is to verify that the information being disclosed by banks is accurate, and to penalize banks that disclose false, misleading or inadequate information.

Furthermore, Shimpalee and Breuer (2006) found, using cross-section data on twin banking crises and controlling for institutional factors, mixed evidence that deposit insurance, the removal of capital controls, a lack of central bank independence, and financial liberalization increase the chance of banking crises.[19] Using cross-country data on bank ownership, regulation and supervision, Barth, Caprio, and Levine (2000) investigated the link between bank ownership and regulation on banking fragility. They found that the tighter the restrictions placed on this activity (a bank is not permitted to do securities, insurance and real estate activities), on average, the more inefficient are banks and the greater the likelihood of a banking crisis. The likelihood of a banking crisis is also

[19]Their dataset consists of over 30 countries covering 13 institutional factors for the period 1984-2002.

greater, on average, the tighter the restrictions placed on bank ownership of non-financial firms. They also found that restricting the mixing of banking and commerce is associated with greater financial fragility. Whereas restricting non-financial firms from owning commercial banks is not associated with financial fragility, restricting banks from owning non-financial firms is positively associated with bank instability. Finally, countries that restrict banks from owning non-financial firms have a robustly higher probability of suffering a major banking crisis.

It follows from the empirical studies, using explicit measures of banking crises, that regulations affecting a bank's balance sheet or the banking sector structure are generally at least not effective for stabilization purposes, and can even increase the fragility of the banking system. Conversely, regulation affecting a bank managers' and/or owners' behavior is effective. The importance of taking the institutional factors into account has emerged as these factors are often linked with instability.

6. Summary and Conclusion

The empirical literature on banking regulation has so far tried to solve the theoretically conflicting results on banking regulatios and banking stability. It has taken two main directions in respect of the stability measure which is used in the study. The so called implicit-stability method uses an implicit measure of risk such as: the ratio of non-performing loan on the total asset, bank stock price volatility, and the ratio of risk-weighted assets to total assets; while the explicit-stability method uses the occurrence of a systemic banking crisis in a given economy as the measure of instability.

These two methods differ also in terms of econometric techniques that they use for their estimations. The implicit-stability method relies mainly on a simultaneous equation model, and on a survival and/or hazard model; while the explicit-stability method relies on a discrete regression model such as logit or probit in the context of panel data.

So far, many studies have been done on the US banking system but only few on other banking systems. Most importantly, many works focus on a given type of regulation, generally on the capital adequacy requirement, deposit insurance, entry restriction, and supervision practices in the banking sector. So far, also these studies have failed to provide a convincing result about the impact of many types of regulation on banking stability. No regulation assessed so far had been found by all the empirical studies done on it to present the same result about its effect on stability. Hence, instead of providing a solution of the conflicting theoretical findings, empirical studies add confusion to them.

These conflicting results are mostly due to the methodologies used. In fact, even for studies using the implicit-instability technique, the results on banking regulation and instability vary from studies using simultaneous equation models to those using hazard or survival models. They vary also in the function of the control variable used to account for the characteristics of the banking system, and finally on the sample periods or sample countries. The difference between the simultaneous equations model and the others may be that the former takes into account the endogeneity effect of some types of regulation.

For studies using a cross-section dummy variable of systemic banking crises as the measure of the banking stability, the result is generally not robust, showing that regulations such as entry restriction and capital requirement have no significant effect on stability. These studies suffer mainly from selection bias, which comes from the method used to build the banking crisis variable. In fact, as pointed out by von-Hagen and Ho (2007), all datasets on the banking crises variable identify a crisis year using a combination of market events such as closures, merges, runs on financial institutions, and government emergency measures such as a freeze. Hence, they identify crises only when they are severe enough to trigger market events. In contrast, crises successfully contained by corrective policies are neglected.

There is a need to find a good measure of banking stability in order to assess the importance of regulation on stability. The measure of banking instability can be constructed using banking system indicators which are positively correlated to banking crises, such as the growth of credit to the private sector, and the growth of banks' deposits.[20] Thereafter, one can use methods such as

[20]See, e.g., Demirgüç-Kunt, Detragiache, and Gupta (2007)

the Markov-switching model, suitable for modelling changes in the state of a variable, to detect banking crises episodes.

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Chapter 2

The Empirics of Banking Regulation

1. Introduction

Banks have always been viewed as fragile institutions that need government help to evolve in a safe and sound environment. Market failures such as incomplete markets, moral hazard between banks' owners and depositors, and negative externalities (like contagion) have been pointed out to explain this fragility. These have motivated government regulatory agencies or central banks to introduce several types of regulatory measures, such as entry barriers, reserve requirements, and capital adequacy requirements.

Generally, the theoretical effect of any given regulation is mixed. For example, full deposit insurance helps the banking system to avoid bank panics (see, e.g., Diamond and Dybvig (1983)). In fact, it provides insurance to depositors that they will in any case obtain their deposits. However, as all authors acknowledge, it increases the moral hazard issue in the banking industry. Therefore, the general equilibrium result of deposit insurance is not as straightforward as one would have thought (see, e.g., Matutes and Vives (1996)).[1] For almost every type of regulation the general equilibrium result is not straightforward on theoretical grounds (see, e.g., Allen and Gale (2003, 2004), Morrison and White (2005)). It follows then that the question of the effectiveness of banking regulation is of first-order empirical importance.

A fair amount of empirical work has already been done on the impact of banking regulation on banking system stability. Barth, Caprio and Levine (2004) assessed the impact of all available regulatory measures across the world on banking stability. More specifically, Demirgüç-Kunt and Detriagache (2002) focused on the effect of deposit insurance on banking system stability, while Beck, Demirgüç-Kunt and Levine (2006) focused on the impact of banking concentration. All these studies use discrete regression models such as the logit model. Although this is an important attempt to test empirically the effect of regulation on banking system stability, it presents some important limitations: a selection bias and a lack of assessment of the impact of these regulations on banking crisis duration.

[1]Matutes and Vives found that deposit insurance has ambiguous welfare effects in a framework where the market structure of the banking industry is endogenous.

The selection bias comes from the method used to build the banking crisis variable. In fact, available banking crisis indicators identify a crisis year using a combination of market events such as closures, mergers, runs on financial institutions, and government emergency measures. After Von Hagen and Ho (2007), we refer to this approach of dating banking crisis episodes as the event-based approach.[2] This approach identifies crises only when they are severe enough to trigger market events. In contrast, crises successfully contained by corrective policies are neglected. Hence, empirical work based on the event-based approach suffers from a selection bias.

The first goal of this paper is to deal with this selection bias problem by using an alternative estimation method, the Markov-switching regression model (MSM), to assess the effect of various types of banking regulation on banking system stability.[3] The second goal is to assess the effect of these regulations on crisis duration.

To achieve these goals, we first compute an index of banking system fragility and use it as the dependent variable to estimate the probability of banking crises. Secondly, we implement a three-state Markov-switching model, where the three states are: the systemic crisis state, the tranquil state, and the booming state. We introduce regulatory measures as explanatory variables of the probability of transition from one state to another to assess their effect on the occurrence of a systemic banking crisis. We will refer to this method as the Time-Varying Probability of Transition Markov-Switching Model, hereafter TVPT-MSM. We derive from the TVPT-MSM the marginal effect of each regulatory measure on the probability of being in the systemic banking crisis state. Thirdly, we use this specification to assess the effect of regulatory measures on banking crisis duration. Fourthly, we carry out a sensitivity analysis: we first use an alternative index to see if the results are robust; we also use a Monte Carlo procedure to check the sensitivity of the results to having less than two states and to having state-dependent standard deviations. Finally, we assess the importance of selection bias resolved by the TVPT-MSM.

We applied our methodology to an emerging market economy, Indonesia, which has suffered

[2]On this issue of selection bias see von-Hagen and Ho (2007).

[3]In fact, as pointed out by Diebold, Lee and Weinbach (2003), the Markov-switching model is useful because of its ability to capture occasional but recurrent regime shifts in a simple dynamic econometric model.

from banking crises during the period 1980-2003, and where there have been some dynamics on the regulatory measures during the same period. We focus our analysis on four major regulatory measures: (i) entry restriction; the removal of entry restriction is assumed by many authors such as Allen and Herring (2001) to have contributed to the reappearance of systemic banking crisis; (ii) deposit insurance, which is supposed to reduce instability by providing liquidity, therefore reducing the possibility of bank runs. However, it has been found by many authors to increase the moral hazard problem in the banking industry; (iii) reserve requirements, which most economists viewed as a tax on the banking system that can lead to greater instability in the banking system; and (iv) the capital adequacy requirement, which is promoted by the Basel Accords and is supposed to be effective in reducing the probability of a banking crisis.

We find that reducing entry restriction increases the duration of a crisis and the probability of being in the banking crisis state. The reserve requirement reduces crisis duration but seems to increase banking fragility. Deposit insurance increases the stability of the Indonesian banking system and reduces the duration of banking crises. The capital adequacy requirement improves stability and reduces the expected duration of banking crises. This later result is obtained when we control for the level of entry barrier.

Our paper builds on the previous literature of banking crisis indices and the Markov-switching regression. The paper most closely related to ours is by Ho (2004), who also applied the MSM to the research on banking crises. It uses a basic two-state Markov-switching model to detect episodes of banking crises. However, his paper does not apply the MSM framework to study the effect of banking regulations on the banking system stability, which is the main feature we are interested in. The papers by Hawkins and Klau (2000), Kibritçioglu (2003), and Von-Hagen and Ho (2007) are related in that they build banking system fragility indices, and use them to identify episodes of a banking crisis.[4] The objective of this method is to construct an index that can reflect the vulnerability or the fragility of the banking system (i.e., periods in which the index exceeds a given threshold are defined as banking crisis episodes).

[4]These authors follow the approach taken by Eichengreen, Rose and Wyplosz (1994, 1995, and 1996) for the foreign currency market and currency crises.

The remainder of this paper is organized as follows. Section 2 presents the TVPT-MSM and its estimation strategy. Section 3 analyzes the Indonesian banking system. Section 4 assesses empirically the effect of banking regulations on the occurrence and the duration of banking crises. Section 5 carries out a sensitivity analysis. Section 6 assesses the selection bias. We conclude in section 7.

2. The Model and the Estimation Strategy

To estimate a Markov-switching model we need an indicator that we will use to assess the state of the banking activity. Therefore, in this section, we first present an index of banking system fragility, before presenting the TVPT-MSM.

2.1 The Banking System Fragility Index

The idea behind the banking system fragility index (hereafter $BSFI$), introduced by Kibritçioglu (2003), is that all banks are potentially exposed to three major types of economic and financial risk: (i) liquidity risk (i.e., bank runs), (ii) credit risk (i.e., rising of non-performing loans), and (iii) exchange-rate risk (i.e., bank's increasing unhedged foreign currency liabilities).[5] The $BSFI$ uses the bank deposit growth as a proxy for liquidity risk, the bank credit to the domestic private sector growth as a proxy for credit risk, and the bank foreign liabilities growth as a proxy for exchange-rate risk. Formally, the $BSFI$ is computed as follows:

$$\begin{aligned} BSFI_t &= \frac{NDEP_t + NCPS_t + NFL_t}{3} \text{ with} && (1)\\ NDEP_t &= \frac{DEP_t - \mu_{dep}}{\sigma_{dep}} \text{ while } DEP_t = \frac{LDEP_t - LDEP_{t-12}}{LDEP_{t-12}}, && (2)\\ NCPS_t &= \frac{CPS_t - \mu_{cps}}{\sigma_{cps}} \text{ while } CPS_t = \frac{LCPS_t - LCPS_{t-12}}{LCPS_{t-12}}, \text{ and} && (3)\\ NFL_t &= \frac{FL_t - \mu_{fl}}{\sigma_{fl}} \text{ while } FL_t = \frac{LFL_t - LFL_{t-12}}{LFL_{t-12}}. && (4) \end{aligned}$$

[5] Demirgüç-Kunt, Detragiache and Gupta (2006) have found in a panel of countries, which have suffered from systemic banking crises during the last two decades, that in crises years, one observes an important decrease in the growth rate of banks' deposits and of credit to the private sector.

where $\mu_{(.)}$ and $\sigma_{(.)}$ stand for the arithmetic average and for the standard deviation of these three variables, respectively. $LCPS_t$ denotes the banking system's total real claims on the private sector; LFL_t denotes the bank's total real foreign liabilities; and $LDEP_t$ denotes the total deposits of banks. One should notice that nominal series are deflated by using the corresponding domestic consumer price index.

2.2 The Markov-Switching Model

In this subsection we present and provide the estimation method of our econometric model.

2.2.1 The Model Setup

We adapt the Garcia and Perron (1996) MSM to assess the state of the banking activity. To ease the presentation, we present only the model with three states (which happen to be more appropriate for our data), although we have studied the other specifications. These three states are : (i) the systemic crisis state with a mean μ_1 and variance σ_1^2, (ii) the tranquil state with a mean μ_2 and variance σ_2^2, and (iii) the booming state with a mean μ_3 and a variance σ_3^2.[6] Let y be a banking system fragility index (as provided in the above subsection). We assume that the index's dynamics are only determined by its mean and its variance. We set up the model as follows:

$$y_t = \mu_{s_t} + e_{s_t} \tag{5}$$

where $e_{s_t} \sim iid\ N(0, \sigma_{s_t}^2)$,

$$\begin{aligned} \mu_{s_t} &= \mu_1 s_{1t} + \mu_2 s_{2t} + \mu_3 s_{3t}, \\ \sigma_{s_t}^2 &= \sigma_1^2 s_{1t} + \sigma_2^2 s_{2t} + \sigma_3^2 s_{3t}, \end{aligned}$$

and $s_{jt} = 1$, if $s_t = j$, and $s_{jt} = 0$, otherwise, for $j = 1, 2, 3$. The stochastic process on s_t can be summarized by the transition matrix $p_{ij,t} = Pr[s_t = j | s_{t-1} = i, Z_t]$, with $\sum_{j=1}^{3} p_{ij,t} = 1$. Z_t is the

[6] Hawkins and Klau (2000), and Kibritçioglu (2003) argue that banking crises are generally preceded by a period of high increase of credit to the private sector and/or high increase of deposits and/or high increase of foreign liabilities. Some studies even labelled the booming state as the pre-crisis state.

vector of N exogenous variables which can affect the transition probability of the banking crisis. It is a vector of real numbers. The $(3X3)$ transition matrix P_t at time t is given by

$$P_t = \begin{bmatrix} p_{11,t} & p_{21,t} & p_{31,t} \\ p_{12,t} & p_{22,t} & p_{32,t} \\ p_{13,t} & p_{23,t} & p_{33,t} \end{bmatrix}. \tag{6}$$

We assess the effect of regulations on banking crises by assuming that the transition probability from one state to another is affected by regulatory measures taken by the government such as the entry barrier, the reserve requirement, the deposit insurance, and the capital adequacy requirement.[7] Formally, we assume that for $i = 1, 2, 3$ and all t,

$$p_{ij,t} = \frac{\exp(\lambda_{ij,0} + \sum_{k=1}^{N} \lambda_{ij,k} Z_{kt})}{1 + \exp(\lambda_{i1,0} + \sum_{k=1}^{N} \lambda_{i1,k} Z_{kt}) + \exp(\lambda_{i2,0} + \sum_{k=1}^{N} \lambda_{i2,k} Z_{kt})} \tag{7}$$

for $j = 1, 2$; while,

$$p_{i3,t} = \frac{1}{1 + \exp(\lambda_{i1,0} + \sum_{k=1}^{N} \lambda_{i1,k} Z_{kt}) + \exp(\lambda_{i2,0} + \sum_{k=1}^{N} \lambda_{i2,k} Z_{kt})} \tag{8}$$

Note that the model specification with constant probability of transition is a special case of the above model where Z_t is the null matrix.

This model is well suited to account for selection bias since it uses a measure of banking system activity more robust to prompt and corrective action, and also because the Markov-switching model is an endogenous regime switching model that, according to Maddala (1986), is a good framework for a self-selection model. The $TVPT - MSM$ is also suitable to account for endogeneity bias since the states of nature and the effect of regulation on the occurrence of these states are jointly estimated. In other words, the $TVPT - MSM$ is a type of a simultaneous equations models.

2.2.2 The Estimation Method for the TVPT-MSM

We jointly estimate the parameters in equation (5) and the transition probability parameters in equation (7) by maximum likelihood.[8] For this purpose, we first derive the likelihood of the

[7] See Filardo (1994) for a deeper assessment of a Markov-switching model with time varying probability of transition.

[8] In the MSM literature there are some other estimation techniques for the TVPT-MSM. For example Diebold, Lee, and Weibach (1994) proposed the EM algorithm to estimate a related model and Filardo and Gordon (1993)

model. The conditional joint-density distribution, f, summarizes the information in the data and links explicitly the transition probabilities to the estimation method.

If the sequence of states $\{s_t\}$ from 0 to T were known, it would be possible to write the joint conditional log likelihood function of the sequence $\{y_t\}$ as

$$\ln\left[f(y_T,...,y_0|s_T,...,s_0,Z_T,...,Z_0)\right] = -\frac{T}{2}\ln 2\pi - \sum_{t=2}^{T}\left\{\ln(\sigma_{s_t}) + \frac{\{y_t - \mu_{s_t}\}^2}{2\sigma_{s_t}^2}\right\}. \tag{9}$$

Since s_t is not observed, but only y_t from time 0 to T, we adapt the two-step method of Kim and Nelson (1999) to determine the log likelihood function. (See details in appendix A).

2.3 Estimating the Marginal Effect of Regulation on Banking Stability

When the regulatory measures are included in the probability of transition, the result obtained from the standard Markov-switching estimation is the estimated value of the parameters defining the transition probabilities. Since many parameters are involved in the computation of these probabilities of transition, the direct estimates of these parameters do not tell us the full story about the effect of each regulatory measure on the transition probability. More importantly, it does not provide an assessment of each regulatory variable on the probability of the banking system being in a given state. In other words, to obtain the effect of a regulatory measure (z_l) on the banking stability one should compute the marginal effect of each regulation on the probability of the banking system being in the systemic crisis state. We derive the result in the proposition below, but first present a lemma that will help in the derivation.

Lemma *Let z_{lt} be a time series variable, if z_{lt} is a continuous variable, the marginal effect of z_{lt}*

used a Gibbs Sampler to estimate the same type of model.

on $p_{ij,t}$ for $i = 1, 2, 3$ is given by:

$$\begin{aligned} \frac{\partial p_{ij,t}}{\partial z_{lt}} &= \frac{g(\lambda_{ij})\left[\lambda_{ij,l} + (\lambda_{ij,l} - \lambda_{i1,l})\, g(\lambda_{i1}) + (\lambda_{ij,l} - \lambda_{i2,l})\, g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}, \qquad (10) \\ \text{for } j &= 1, 2; \text{and}; \\ \frac{\partial p_{i3,t}}{\partial z_{lt}} &= \frac{-\left[\lambda_{i1,l} g(\lambda_{i1}) + \lambda_{i2,l} g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}, \qquad (11) \\ \text{with } g(\lambda_{ij}) &= \exp(\lambda_{ij,0} + \sum_{k=1}^{N} \lambda_{ij,k} z_{kt}). \end{aligned}$$

Let z_{lt} be a dummy variable, the marginal effect of z_{lt} on $p_{ij,t}$ is given by

$$\Delta p_{ij,t} = \left[p_{ij,t}(z_{-lt}, 1) - p_{ij,t}(z_{-lt}, 0)\right]; \qquad (12)$$

where z_{-lt} is the matrix Z_t without z_{lt}.

Proof. These results are straightforward from a partial differentiation of (7) and (8). See details in appendix A. ■

Proposition *The marginal effect of any exogenous continuous time series variable z_{lt} on the probability of the banking system to be in state $s_t = 1$ is given by:*

$$\frac{\partial \Pr(s_t = 1)}{\partial z_{lt}} = \sum_{i=1}^{3} \frac{g(\lambda_{ij})\left[\lambda_{i1,l} + (\lambda_{i1,l} - \lambda_{i2,l})\, g(\lambda_{i2})\right] \Pr(s_{t-1} = i)}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}. \qquad (13)$$

The marginal effect of any exogenous dummy variable z_{lt} on the probability of the banking system to be in state $s_t = 1$ is given by:

$$\Delta_l \left[\Pr(s_t = 1)\right] = \sum_{i=1}^{3} \left[p_{i1,t}(z_{-lt}, 1) - p_{i1,t}(z_{-lt}, 0)\right]\left[Pr(s_{t-1} = i)\right]. \qquad (14)$$

Proof. The idea of this proof is to compute the unconditional probability of state $s_t = 1$, and then derive it with respect to z_{lt}. Details are available in appendix A. ■

We know that a given continuous variable z_k has a positive effect on the banking system stabilization if it has a positive effect on $Pr(s_t = 1)$. i.e., at any time t, $\frac{\partial Pr(s_t=1)}{\partial z_{kt}} \geq 0$. Using the above proposition, this is achieved when for all i

$$\lambda_{i1,k} \geq 0, \text{ and } \lambda_{i1,k} \geq \lambda_{i2,k}. \tag{15}$$

In other words, the regulatory measure (z_k) increases the probability of the banking system to get into a systemic banking crisis when (15) is met. Conversely, if for all i

$$\lambda_{i1,k} \leq 0, \text{ and } \lambda_{i1,k} \leq \lambda_{i2,k} \tag{16}$$

the regulatory measure (z_k) reduces the probability of the banking system to suffer a systemic banking crisis.

The other combinations of parameters are difficult to handle analytically, but fortunately with the above proposition we can compute the marginal effect of each explanatory variable at its mean. To do this we follow the literature of the discrete variable model, which computes the marginal effect at the mean of the explanatory variable.We then use the delta method to compute the standard error of this marginal effect.

2.4 Effect of Regulation on Banking Crisis Duration

A heuristic idea of the effect of a regulatory measure (z_k) on the crisis duration is given by the sign of $\frac{\partial p_{11,t}}{\partial z_{kt}}$. From the above lemma $\frac{\partial p_{11,t}}{\partial z_{kt}} \geq 0$ if

$$\lambda_{11,k} \leq 0, \text{ and } \lambda_{11,k} \leq \lambda_{12,k}. \tag{17}$$

It follows that the regulatory measure z_k reduces the probability of remaining in state 1, (i.e., remaining in the banking crisis state) if condition (17) is met. This can be viewed as a positive effect on the banking crisis duration.

However, to assess properly the expected duration of a given state j, at each time t, we keep in mind that the adoption of any type of regulation is assumed to be exogenous and that its adoption is not predictable. We will then consider that the expected duration at a given point in time is based on the transition probability observed at that time. More precisely, the expected duration of a given state j, at time t, conditional on the inferred state (crisis state, tranquil state or booming state, respectively) is given by:

$$
\begin{aligned}
E_t(D_j) &= \sum_{d=1}^{\infty} d \Pr(D_j = d | y_{t-1}, Z_t) \qquad (18) \\
&= \sum_{d=1}^{\infty} d \left[\Pr(S_{t+d} \neq j | S_{t+d-1} = j, Z_t) \prod_{i=1}^{d-1} \Pr(S_{t+i} = j | S_{t+i-1} = j, Z_t) \right] \\
&= \sum_{d=1}^{\infty} d \left[(1 - \Pr(S_{t+d} = j | S_{t+d-1} = j, Z_t)) \prod_{i=1}^{d-1} \Pr(S_{t+i} = j | S_{t+i-1} = j, Z_t) \right]. \qquad (19)
\end{aligned}
$$

Since for all i

$$\Pr(S_{t+i} = j | S_{t+i-1} = j, Z_t) = \Pr(S_t = j | S_{t-1} = j, Z_t), \qquad (20)$$

the expected duration is similar to the case of absence of constant probability of transition. In fact, substituting (20) in (19) yields

$$E_t(D_j) = \frac{1}{1 - \Pr(S_t = j | S_{t-1} = j, Z_t)}. \qquad (21)$$

3. The Data

We now apply our estimation strategy to the Indonesian banking system. We will first present the background of the banking activity in Indonesia during the period 1980-2003, before describing the data used in our empirical investigation.

3.1 The Background of the Indonesian Banking System

The Indonesian banking system has experienced some important structural developments during the 1980-2003 period. One can distinguish four stages of this development: (i) the ceiling period (1980 – 1983) where interest rate ceilings were applied; (ii) the growth period (1983 – 1988), which was a consequence of the deregulation reform of June 1983 that removed the interest rate ceiling; (iii) the acceleration period (1988 – 1991) where the extensive banking liberalization reform starting in October 1988 was being implemented gradually; the bank reforms in October 1988 led to a rapid growth in the number of banks as well as total assets. Within two years Bank Indonesia granted licenses to 73 new commercial banks and 301 commercial banks' branches; and (iv) the consolidation (1991 – 2003) in which prudential banking principles were introduced, including capital adequacy requirement. In February 1991, prudential banking principles were introduced, and banks were urged to merge or consolidate.[9]

The Indonesian banking system experienced two episodes of banking crises over the 1980-2003 period: the **1994 episode,** which was labelled by Caprio et al. (2003) as a non-systemic crisis, and the **1997-2002 episode,** which was recorded by Caprio et al. (2003) as a systemic crisis. During the 1994 episode, the non-performing assets equalled more than 14 percent of banking system assets, with more than 70 percent in state banks. The recapitalization costs for five state banks amounted to nearly two percent of GDP, (see, Caprio and Klingebiel (1996, 2002)).

At the end of the 1997-2002 episode, Bank Indonesia had closed 70 banks and nationalized 13, out of a total of 237. The non-performing loans (NPLs) for the banking system were estimated at 65 – 75 percent of total loans at the peak of the crisis and fell to about 12 percent in February 2002. At the peak of the crisis, the share of NPLs was 70 percent, while the share of insolvent banks' assets was 35 percent (see, Caprio et al (2003)). From November 1997 to 2000, there were six major rounds of intervention taken by the authorities, including both "open bank" resolutions and bank closures: (i) the closure of 16 small banks in November 1997; (ii) intervention into 54 banks in February 1998; (iii) the take-over of seven banks and closure of another seven in April 1998; (iv) the closure of four banks previously taken over in April 1998 and August 1998; and (v) the closure of 38 banks together with a take-over of seven banks and joint recapitalization of seven banks in March 1999; and (vi) a recapitalization of six state-owned banks and 12 regional banks during 1999-2000.

The Indonesian banking regulations have changed over the period of study. The reserve requirement was in place before 1980; it was reduced from 15 percent to two percent during 1983-1984 and remained at this level until 1998 when it was increased to *five* percent. The first act of bank-

[9]See e.g. Batunanggar (2002) and Enoch et al. (2001) for details about the evolution of the Indonesian banking system during this period.

ing liberalization was introduced in June 1983; entry barrier was abolished in October 1988. The capital adequacy requirement was effective in 1992 and has since then been modified frequently. An explicit deposit insurance was introduced in 1998.[10]

3.2 Data Sources

Before proceeding let us recall that the index of banking system fragility is given by

$$BSFI_t = \frac{NDEP_t + NCPS_t + NFL_t}{3}$$

where $NDEP$, $NCPS$ and NFL are centralized and normalized values of $LDEP$, $LCPS$, and LFL respectively.

We use the International Financial Statistics (IFS) database of the International Monetary Fund (IMF). More precisely, $LCPS$ is taken from IFS's line $22D$, LFL is taken from line $26C$, $LDEP$ is considered as the sum of lines 24 and 25 in the IFS. We deflated nominal series by using the corresponding domestic consumer price index (CPI) taken from IFS line 64. The dummy variable for explicit deposit insurance is taken from Demirgüç-Kunt, Kane and Laeven (2006). The reserve requirement is taken from Van't Dack (1999), and Barth, Caprio and Levine (2004). The capital adequacy requirement is taken from the Indonesian Bank Act 2003. The entry restriction variable is constructed based on Abdullah and Santoso (2000) and Batunanggar (2002).

3.3 Banking System Fragility Index

Figure 1 shows the $BSFI$ index for Indonesia. It presents three phases: a phase with higher index value consisting of two periods (1988-1990, and 1996-1997), a phase with the index value around zero over two periods (1980-1987, and 1991-1996), and a phase with lower index value for one period (1998-2003).

[INSERT FIGURE 1 HERE]

[10]There exists a full blanket guarantee in Indonesia since 1998 (see, Demirgüç-Kunt, Kane, and Leaven (2006) p.64).

The two higher value periods are driven by different causes. The 1988-1997 period was a consequence of the introduction of the first major package of removal of entry restrictions. In fact, in October 1988, the government introduced a new legislation that allowed the private sector to create and manage banks. This legislation stimulated the banking activity through the credit channel, since newly created banks provided new loans to the private sector, which in turn translated into new deposits. The Indonesian banking system took approximately two years to return to the normal trend in its activities. By contrast, the 1996-1997 period was driven by an increase of credit to the private sector due to an increase of foreign capital in the Indonesian banking system. It was also a consequence of the 1994 regulation removing the ceiling on the maximum share of investment a foreign investor can withdraw, and also the 1996 regulation allowing mutual funds to be 100 percent foreign-owned.

[INSERT FIGURE 2 HERE]

The two medium-value periods are periods with smooth dynamics in the banking activity. In those periods there is no important change in regulation, nor in the banking system structure. Figure 2 (b) shows that during these periods the annual growth rate of credit to the private sector and bank deposits are stable around 20 percent.

The lower index phase is a consequence of the Asian financial crisis, which followed the collapse of the Thailand currency during the second semester of 1997. As we can see in figure 2 (a) and (b), the dynamics of the three banking indicators changed dramatically in 1997, that is a change in the level and in the trend. We guess that these three phases characterize the states of the Indonesian banking activities during the sample period of 1980-2003. INSERT FIGURE 3 HERE] Figure 3 compares the episodes of crises obtained with the MSM on the BSFI index and the episodes provided by Caprio et al. (2003). The episode of 1997-2002 matches perfectly, there is a crisis in 1992 not reported by Caprio et al.

4. Results

The econometric methods assess the degree to which $TVPT - MSM$ characterize banking crises, and assess the impact of regulatory measures. Tables 1 and 2 contain the estimates and the tests of banking regulation. The estimates of interest are the state-dependent means in each state, μ_1, μ_2, and μ_3, and the coefficient of transition probabilities $\lambda_{ij,k}$. More specifically, from the proposition in section 2 we know that these coefficients provide straightforward results on the impact of a given regulatory measure only if condition (15) or (16) is verified.

[INSERT TABLE 1 and TABLE 2 HERE]

The first panel of Table 1 presents the mean, and the following panels present the effect of regulatory measures on the probability of the banking system to be in a given state.

Column (1) presents the estimated parameters without regulation, column (2) the estimates of specification with entry restriction, column (3) the estimates with reserve requirement, column (4) the estimates with deposit insurance, column (5) the estimates with capital adequacy requirement, column (6) the estimates with deposit insurance and reserve requirement, column (7) the estimates with entry restriction and capital adequacy requirement, and finally column (8) presents the estimates of the specification with all these regulatory variables.

We obtain that all three states are significantly different from one another, since the confidence intervals at 95 percent on their means do not coincide. Also we obtain that the mean of the crisis state is negative, while the mean of the tranquil state is around 0 and the mean of the booming state is strictly positive, suggesting that the states are in fact representing periods of contraction, normal activity, and expansion in the banking sector.

Furthermore, the mean of the crisis state is close to -0.86 and its variance is 0.22, a significantly larger number than the estimated variance in the tranquil state. The MSM succeeded in capturing the fact that in July 1997 the Indonesian banking system was in a state of crisis. As we explained in section 3 describing the Indonesian banking system, the banking crisis which started in the second semester of 1997 was characterized by a huge decrease in the growth of credit to the private sector, banking deposits, and foreign liabilities.

Besides, the estimated mean of the tranquil state is around 0.11 for each of our estimations, which is an indication that during the tranquil period, the weighted average of growth rates of credit to private sector, banking deposits and foreign liabilities was slightly positive. In other words, the tranquil period is characterized by a slight positive growth rate in banking activity. Its estimated variance of 0.07 is lower than the variance in the other states. This was expected as tranquil states tend to be periods of less volatility; generally, there are periods of business as usual, i.e., no external shocks nor changes in the banking industry.

Finally, the estimated mean of the booming state is around 1.9 with a variance of 0.7. This value is high compared to the expected maximum value of 3 at a 99 percent confidence level. It means also that in booming periods the weighted average of credit to the private sector, banking deposits, and foreign liabilities grows very fast. In fact, the two periods of fast growth of the Indonesian banking sector were characterized by sudden and very high increase of banking deposits and credit to the private sector.

4.1 Impact of Regulation on Banking Stability

[INSERT TABLE 3 HERE]

Entry Restriction: The estimated parameters provided in Table 2 do not verify neither condition (15) nor condition (16). Hence, the only way to assess the impact of entry restriction on stability is by using the marginal effect results developed in section 2. Table 3 shows that this marginal effect is estimated at -0.111 and it is significantly different from zero, i.e., entry restriction reduced the fragility of the Indonesian banking system. In fact, the crisis of 1997 was preceded by a period of removal of entry restriction. Specifically, in 1994 a regulatory bill allowed foreign investors to withdraw without limit their deposits in the banking system, and in 1996 Indonesian regulation allowed mutual funds to be 100 percent owned by foreigners. When we control for the level of capital requirement the result remains unchanged. This supports the view of Allen and Herring (2001) that entry restriction is associated with banking instability. More precisely, Allen and Herring link the re-appearance of systemic banking crisis in the 1980s to the reduction and/or removal of entry restriction in many banking systems. [11]

Reserve Requirement: Like for entry restriction, the estimated parameters do not satisfy the conditions derived from the proposition. We then refer to Table 3, where the marginal effect of an increase in the reserve requirement level on the probability of the banking system to be in the systemic crisis state is computed. The estimated coefficient is -0.135 and it is significant at the 10 percent level. In other words, an increase in the reserve requirement by 1 point reduces the probability of being in the crisis state by 0.135 point. This does not come as a surprise since during the period $1984 - 1998$ the level of the reserve requirement in Indonesia was very low, at 2 percent. It was increased in 1998 to 5 percent as the aftermath of the 1997 systemic banking crisis. It was also raised at a time when the government was putting in place its explicit and universal deposit insurance. This may not be a coincidence, since the deposit insurance regulation literature emphasizes the need of reserve requirement to reduce the moral hazard problem associated with the existence of an explicit deposit guarantee.[12] It is then important to control for this. When we control for the existence of an explicit guarantee for banking deposits, we observe that the sign of this elasticity is different. The elasticity is now positive and equal to 0.155 and it is significant at the one percent level. In other words, when we control for the existence of deposit insurance, the reserve requirement is actually positively associated with banking instability.

This second result is more appropriate. In fact, the first estimation can be viewed as an estimation with an omitted variable, which means that the parameters estimated in this context are biased and inconsistent. Finally, we do not worry about multicollinearity as the coefficient of correlation between deposit insurance and reserve requirement is small (-0.11).

Deposit Insurance: Table 3 shows that the marginal effect of deposit insurance on the probability of the Indonesian banking system to be in a crisis is equal to -0.033, i.e., the introduction of deposit insurance reduces instability. When we control for the level of reserve requirement the result becomes even stronger. The new elasticity is -0.043 and it is significant at a 5 percent

[11] This also conforms with an earlier empirical work of Demirgüç-Kunt and Detragiache (1998), which found a positive link between less entry restriction in the banking activity and banking fragility.

[12] See e.g., Bryant (1980) for a theoretical rationale.

level. In other words, the Diamond and Dydvig (1983) view on the effect of deposit insurance for stabilization purposes seems to find supporting evidence here. It is then the converse of the empirical result of Demirgüç-Kunt and Detragiache (2002) who found that the moral hazard effect of deposit insurance is dominant. Like in the previous paragraph, the second specification is more appropriate.

Capital Adequacy Requirement: The estimated parameters for the capital adequacy requirement in the TVPT-MSM specification do not satisfy any of the sufficient conditions (15) and (16); hence we should refer to Table 3. It shows that the marginal effect of the capital adequacy requirement is equal to 0.198 but it is not significantly different from zero. Therefore, without control it has no impact on Indonesian banking stability. But we know that capital adequacy requirement was introduced in Indonesia following the removal of entry restriction on domestic private investors in 1988. When we control for the level of entry restriction, we obtain that instead the capital adequacy requirement has reduced the probability to be in the banking crisis state by -0.033 and it is significant at 5 percent.[13]

There is, however, a negative correlation between entry restriction and the other regulatory measures that we have studied. This correlation is close to -0.48 for reserve requirement, -0.55 for deposit insurance, and -0.67 for capital adequacy requirement. This can be a source of multicollinearity. However, we have controlled for multicollinearity by dropping 2.5 percent, and 5 percent of the sample data, and we have found that the result remained almost the same. Therefore, we concluded that multicollinearity was not an important issue.

4.2 Expected Duration

Another goal of this paper is to study the expected duration of the systemic crisis state. The three-state MSM with constant probabilities of transition shows that the expected duration of banking crises is equal to 42 months. As we can see in Figure 4, the expected duration is affected by banking regulations. More precisely, the presence of deposit insurance tends to reduce crisis

[13]This result does not confirm the Kim and Santomero (1988), and Blum (1999) view that capital adequacy requirement increases the risk taking behavior in the banking industry.

duration. An increase of the capital adequacy requirement tends also to reduce crisis duration. An increase in the reserve requirement reduces crisis duration, while entry restriction increases crisis duration. [14]

[INSERT FIGURE 4 and TABLE 4 HERE]

4.3 Disentangling the TVPT-MSM Contribution from the MSM Contribution

In this subsection we want to see if the results obtained so far about the link between the type of regulation and banking stability would have been obtained by implementing a simple three-state MSM model, and use its filtered probabilities to estimate with a simple OLS regression the effect of each regulation on the stability of the banking system. We will refer to this method as the $MSM - OLS$ regression. [15] In Table 5, we report the results obtained from the $MSM - OLS$ regression.

[INSERT TABLE 5 HERE]

Deposit insurance appears to have a positive and significant effect on the probability of the banking system to be in the systemic crisis period. When we control for other regulatory measures, this effect is equal to 0.82; with macroeconomic variables the new number is 0.81.

The effect of a reserve requirement, when we control with the entire set of major regulatory variables, is equal to 0.95 and is 0.81 when we add key macroeconomic variables. The capital adequacy requirement has a negative and significant effect on the probability of the banking system to be in the crisis state. In fact, when we control with the other regulatory variables, this effect is equal to -0.78; while it is equal to -0.32 when we control with other macroeconomic variables. Finally, the effect of entry restriction is significant and negative even when we control with other regulatory measures.

Let us now assess the difference between the two methods. Deposit insurance increases the probability of being in a crisis in the $MSM - OLS$ regression but not in the $TVPT - MSM$.

[14] A policy implication which can be derived from this finding is that there is a need to design regulatory measures that can improve the crisis duration, and not only to prevent its occurrence.

[15] The $MSM - OLS$ is very tractable and allows the introduction of many control variables.

This difference can be explained by the fact that deposit insurance was put in place in 1998, a crisis year. Therefore, the $MSM - OLS$ perceives a positive correlation between its presence and the occurrence of the banking crisis even though the crisis preceded it. The $MSM - OLS$ shows a higher impact of the capital adequacy requirement for stabilization purposes than the $TVPT - MSM$. A rationale behind this is that just after the beginning of the banking crisis in 1997, the Indonesian government has reduced the rate of its capital adequacy requirement and then started to increase it slowly. Hence, the $MSM - OLS$ perceives a stronger link between the reduction of the capital adequacy requirement and the presence of banking crises. The result on entry restriction is not too different. In the $TVPT - MSM$, reserve requirements have a less positive impact on banking stability than in the $MSM - OLS$. More generally, the marginal effects produced by the $TVPT - MSM$ tend to be less important in magnitude.

5. Robustness

In this section, we verify the robustness of our results. First, we assess the impact of banking regulation using another index of banking crisis, and then we verify whether we used the appropriate number of states.

5.1 Sensitivity to the Index

In the BSFI, each type of risk is weighted equally. This can be a source of misidentification as it tends to give each type of risk the same importance in causing banking crises. We modify the $BSFI$ to take into account this issue and we rename the new index as the banking system crisis index (hereafter the $BSCI$). We use the weighting procedure of the monetary condition index (MCI) literature (see, e.g., Duguay (1994), and Lin (1999)), but instead of running a free regression we estimate a constrained regression. More precisely, we assume that a banking crisis can be determined by a number of macroeconomic and financial variables: economic growth (hereafter Gy_t), interest rate changes (hereafter Gr_t), variation in the banking reserves ratio (hereafter $G\gamma_t$), exchange rate fluctuations (hereafter Ge_t), growth of the credit to the private sector, rate of growth of bank deposits and growth of foreign liabilities.

The new weights w_c, w_d, and w_f for the credit to the private sector, the banks' deposits, and the foreign liability respectively, are obtained using a constrained ordered logit model. In each period the country is either experiencing a systemic banking crisis, a small banking crisis or no crisis. Accordingly, our dependent variable takes the value 2 if there is no crisis, 1 if there is a small crisis and 0 if there is a systemic banking crisis.

The probability that a crisis occurs at a given time t is assumed to be a function of a vector of n explanatory variables X_t. Let P_t denote a variable that takes the value of 0 when a banking crisis occurs, 1 if a minor banking crisis occurs and 2 when there is no banking crisis at time t.[16] β is a vector of n unknown coefficients and $F(\beta' X_t)$ is the cumulative probability distribution function taken at $\beta' X_t$. The log-likelihood function of the model is given by

$$LogL = \sum_{t=1}^{T} I_{0t} \ln(F(-\beta' X_t)) + I_{1t} \ln\left[F(C - \beta' X_t) - F(-\beta' X_t)\right] + I_{2t} \ln\left[1 - F(C - \beta' X_t)\right],$$

where $I_{it} = 1$ if $P_t = i, 0$ if not; for $i = 0, 1, 2$; and where X_t represents the matrix of all exogenous variables, N the number of countries, T the number of years in the sample and C a threshold value. We assume here that

$$\begin{aligned} P_t &= \theta_0 + \theta_1 G y_t + \theta_2 G r_t + \theta_3 G \gamma_t + \theta_4 G e_t + \ldots \\ & w_c NCPS_t + w_d NDEP_t + w_f NFL_t + \varepsilon_t, \end{aligned} \tag{22}$$

and that there exist three real numbers a, b, c, such that

$$\begin{aligned} w_c &= exp(a)/exp(a) + exp(b) + exp(c), \\ w_b &= exp(b)/exp(a) + exp(b) + exp(c), \\ w_f &= exp(c)/exp(a) + exp(b) + exp(c). \end{aligned}$$

The $BSCI$ index is then computed as:

[16] Although this variable does not provide the crisis date with certainty, we assume that it contains sufficient information to help us compute the weight of each type of risk in introducing banking crisis.

$$BSCI_t = w_c NCPS_t + w_d NDEP_t + w_f NFL_t. \tag{23}$$

To obtain the index with the Indonesian data, we complete our previous dataset so as to be able to compute Gy, $Gr, G\gamma$ and Ge.[17] The variable for banking crises is obtained from Caprio et al. (2003). For Indonesia the estimate of the reduced form model presented in (22) is given by:

$$\begin{aligned} P_t &= -0.06 + 6.58Gy_t - 1.50Gr_t + 0.44G\gamma_t - 4.78Ge_t + \ldots \\ &\quad (-0.20) \quad (8.45) \quad (-4.61) \quad (1.11) \quad (-1.77)\ldots \\ &\quad 0.8049NCPS_t + 0.195NDEP_t + [7.04E-8]NFL_t \\ &\quad (2.02) \qquad (1.98) \qquad (0.77) \end{aligned}$$

The student $t-$statistics are in parentheses. We obtain from the above estimation that $w_c = 0.8049$, $w_d = 0.195$, and $w_f = 7.04E - 08$. We observe that the weight for the credit to the private sector is greater than the weight of bank deposits. More importantly, the weight for foreign liability is practically zero. This may be due to the fact that the Indonesian banking crisis was introduced by non-performing loans. In fact, in mid-1997 most domestic firms could not service their liabilities to international and domestic banks.[18] This later translated into a severe liquidity problem arising from increased burdens of firms servicing external debts, and was exacerbated by mass withdrawal of deposits.

[INSERT FIGURE 5 HERE]

Figure 5 presents the new index. We observe that the graph of the $BSCI$ is similar to the graph of the $BSFI$. We can then guess that we should obtain the same results.

[INSERT TABLE 6, TABLE 7 and TABLE 8 HERE]

[17] To compute G_e we use the data on exchange rate available from IFS's line AF. To compute Gr we use the nominal interest rate from IFS's line 60B. To compute Gy we use the information on the real GDP growth available in the World Development Indicator (WDI) 2006. To compute $G\gamma$ we use the demand deposits from (IFS line 24), the time and saving deposits (IFS line 25), the foreign liabilities (IFS line 26C) of deposit money banks and the credit from monetary authorities (IFS line 26G).

[18] See e.g., Enoch et al. (2001) for a better description of the state of the Indonesian banking system during that period.

Table 6 and Table 7 provide the raw parameters while Table 6 provides the marginal effect of each regulatory measure on the probability of the banking system to go into crisis. We observe that the results are fundamentally the same for each type of regulation. The results differ slightly on the crisis duration. In fact, the expected crisis duration is 42 months for the $BSFI$ index while it is 21 months for the $BSCI$; but the impact of each type of regulation on the expected duration is exactly the same.

[INSERT FIGURE 6 HERE]

5.2 Sensitivity to the MSM Specification

In this subsection we verify that the three-state specification with different variances for each state is the appropriate model. We compare this specification with the two-state specification and with the three-state specification but with constant variance. Our choice of model is based on the likelihood ratio (LR) test. The distribution of the LR statistic between constant variance and state-varying variance is the standard χ^2. But it is no longer the case between the two-state and the three-state specification.[19] This is due to the fact that under the null of a $Q-1-$state model, the parameters describing the Q^{th} state are unidentified. To solve this problem we follow Coe (2002) in performing a Monte Carlo experiment to generate empirical critical values for the sample test statistic. For each index, we first run a two-state MSM. We then use its estimated parameters to generate an artificial index. We use this index to estimate both the two-state model and the three-state model by the maximum likelihood method. Finally, we calculate the likelihood ratio test statistic. Let us denote by ML_i the maximum likelihood of the $i-$state model. The test statistic is given by

$$LR_2 = -2\left[Log(ML_2) - Log(ML_3)\right]. \tag{24}$$

We generate this index randomly one thousand times, and follow this procedure the same number of times to obtain the empirical distribution of the test statistic. In Table 9 we report the critical values of these test statistics.

[19]In fact, from Garcia (1998) we know that the LR test statistic in this context does not possess the standard distribution.

[INSERT TABLE 9 and 10 HERE]

Let's now implement the test. The test statistics (obtained in Table 10) show that the value of the likelihood ratio test is above the critical *one* percent values presented in Table 9. It follows that on the basis of this test the three-state specification should be chosen instead of the two-state. The same result holds with the $BSCI$ index.

6. Assessing the Selection Bias

We now assess the selection bias in the existing work. For this purpose we compare our estimates to estimates obtained with the logit method used in the previous literature. Since the previous works were conducted mostly with cross-country data, we first develop another discrete regression model to have specific coefficients on Indonesia.

6.1 The Ordered Logit Model (OLM)

We estimate the probability of a banking crisis using an ordered logit model. In each period the country is either experiencing a systemic banking crisis, a small banking crisis or no crisis. Accordingly, our dependent variable takes the value 2 if there is no crisis, 1 if there is a small crisis and 0 if there is a systemic banking crisis.

The probability that a crisis occurs at a given time t is assumed to be a function of a vector of n explanatory variables X_t. Let P_t denote a variable that takes the value of 0 when a banking crisis occurs, 1 when a minor banking crisis occurs and 2 when no banking crisis occurs at time t. β is a vector of n unknown coefficients and $F(\beta' X_t)$ is the cumulative probability distribution function taken at $\beta' X_t$. The log-likelihood function of the model is given by

$$LogL = \sum_{t=1}^{T} I_{0t} \ln(F(-\beta' X_t)) + I_{1t} \ln\left[F(C - \beta' X_t) - F(-\beta' X_t)\right] + I_{2t} \ln\left[1 - F(C - \beta' X_t)\right],$$

where $I_{it} = 1$ if $P_t = i, 0$ if not; for $i = 0, 1, 2$; and where X_t represents the matrix of all exogenous variables, N the number of countries, T the number of years in the sample and C a threshold value. We then use the estimated parameters to compute the marginal effect of each regulatory measure on the probability of the banking system to be in a systemic crisis.

[INSERT TABLE 11 HERE]

In Table 11 we report the results using the ordered logit model. The banking crisis variable is given by Caprio et al. (2003). We observe that deposit insurance appears to have a positive and significant marginal effect on the probability for the banking system to be in the systemic crisis period. When we control with other regulatory measures, this marginal effect is equal to 0.69. The reserve requirement has no marginal significant effect on the probability of the banking system to be in the systemic crisis period. The marginal effect of the capital adequacy requirement is not significantly different from zero when we control for other regulatory measures. Finally, the marginal effect of entry restriction is significant and negative even when we control for the existence of capital adequacy requirement.

6.2 Results of the Previous Work

[INSERT TABLE 12 HERE]

Table 12 shows that previous works link deposit insurance to instability. We found that in the Indonesian case if we used the OLM or the $MSM - OLS$ we still have the same result. But the result is different if we use the $TVPT - MSM$. In the later case deposit insurance improves banking stability. Hence, the selection bias is not the only issue to deal with. This suggests that the simultaneity bias due to the adoption of full deposit insurance during the crisis is better taken into account by the $TVPT - MSM$ than by the other models.

Previous studies found a non-significant link between the capital requirement and banking fragility.[20] But, with Indonesia, we obtain a significant negative link at 10 percent. When we used the OLM, the link is also significant and negative, but lower than the coefficient of the event-based method. We can then infer a negative selection bias. But even here the magnitude of the $TVPT - MSM$ coefficient is significantly different from the $MSM - OLS$ coefficient. We guess that this is due to the simultaneity bias. In fact, the Indonesian government reduced the level of

[20]For example, Barth et al. (2004) found a negative coefficient of the capital adequacy requirement varies from -1.201 to -1.026 when they are significant and not significant in some of their specifications; while Beck et al. (2006) found a non significant term for the link between capital adequacy requirement and banking crisis.

the capital adequacy requirement during the crisis and started to increase it as the situation was improving. The $TVPT - MSM$ is more able to take this feature into account.

Entry restriction has been linked to stability by the previous studies. We obtain the same result here and no significant bias.

Concerning the reserve requirement, studies using event-based data found mixed results on the link between it and instability. This is not the case with the $MSM - OLS$. Instead, we found a positive and significant link between higher reserve requirement and instability. Therefore, the selection bias is positive. As in the previous case we found that the simultaneity bias is also important.

7. Conclusion

The first goal of this research was to provide an estimation strategy that was less subject to selection bias and to use it to assess empirically the effect of banking regulations on the banking system stability. The second goal was to assess the effect of each type of regulation on crisis duration. To this end, we developed a three-state Markov-switching regression model. Specifically, we introduced four major regulations (entry restriction, deposit insurance, reserve requirement, and capital adequacy requirement) as explanatory variables of the probability of transition of one state to another in order to assess the effect of these regulations on the occurrence and the duration of systemic banking crises.

Given that the time-varying probability of transition TVPT-MSM does not provide a straightforward measure of the marginal effect of exogenous variables on the probability of the system to be in a given state, we derived analytically the marginal effect of each exogenous variable on the probability of the system to be in a given state. This is our theoretical contribution to the MSM literature. We then applied our strategy to the Indonesian banking system, which has suffered from systemic banking crises during the last two decades and where there has been some dynamics on the regulatory measures during the same period.

We found that: (i) entry restriction reduces crisis duration and the probability of being in the crisis state. This result is consistent with other results available in the banking crisis literature linking banking crises and an easing in entry restrictions; (ii) reserve requirements increase banking fragility; but this result is obtained only when we take into account the existence of deposit insurance. At the same time reserve requirements tend to reduce banking crisis duration; (iii) the deposit insurance increases the stability of the Indonesian banking system and reduces the banking crisis duration. This result is different from the Demirgüç-Kunt and Detragiache (2002) result about the link between the existence of explicit deposit insurance and banking fragility, and it raises a flag about the importance of the simultaneity bias in this type of studies; (iv) the capital adequacy requirement improves stability and reduces the expected duration of a banking crisis; this result is obtained when we control for the level of entry restrictions.

We have also provided an idea of the selection bias present in the previous literature. We found that studies using the event-based method present a positive selection bias on deposit insurance and reserve requirements, a negative selection bias on capital adequacy requirement but no selection bias on entry restriction.

It then appears that the $TVPT - MSM$ can improve our understanding of the impact of regulation on banking activities by allowing us to work on a given country, taking into account the selection bias as well as the simultaneity bias. In fact, in the $TVPT - MSM$, the states of nature and the effect of regulation on the occurrence of each state are jointly estimated. In other words, the $TVPT - MSM$ is a type of a simultaneous equation model. Finally, it helps to provide an assessment of the impact of regulatory measures on the expected duration of crises. However, it presents an important limitation. It is less tractable when the number of exogenous variables explaining the probability of transition is important. In fact, in a three-state $TVPT - MSM$ the introduction of an additional variable leads to the estimation of six new parameters. This makes the convergence of the maximum likelihood estimation technique more difficult to achieve and complicates the estimation process.

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8. Appendix

8.1 Appendix A

Application of the Kim and Nelson Method on the the TVPT-MSM

Let us set $\psi_t = \{\psi_{t-1}, y_t, Z_t\}$.

Step 1. We consider the joint density of y_t *and the unobserved* s_t *variable, which is the product of the conditional and marginal densities:* $f(y_t, s_t|\psi_{t-1}) = f(y_t|s_t, \psi_{t-1})f(s_t|\psi_{t-1})$.

Step 2. To obtain the marginal density of y_t*, we integrate the* s_t *variable out of the above joint density by summing over all possible values of* s_t*:*

$$\begin{aligned} f(y_t|\psi_{t-1}) &= \sum_{s_t=1}^{3} f(y_t, s_t|\psi_{t-1}) \\ &= \sum_{s_t=1}^{3} f(y_t|s_t, \psi_{t-1}) f(s_t|\psi_{t-1}) \\ &= \sum_{i=1}^{3} f(y_t|s_t = i, \psi_{t-1}) \Pr(s_t = i|\psi_{t-1}) \end{aligned}$$

The log likelihood function is then given by

$$\ln L = \sum_{t=0}^{T} \ln \left\{ \sum_{i=1}^{3} f(y_t|s_t = i, \psi_{t-1}) \Pr(s_t = i|\psi_{t-1}) \right\}. \tag{25}$$

The marginal density given above can be interpreted as a weighted average of the conditional densities given $s_t = 1, s_t = 2,$ *and* $s_t = 3$*, respectively.*

We adopt the following filter for the calculation of the weighting terms :

Step 1. Given $Pr[s_{t-1} = i|\psi_{t-1}]$*,* $i = 1, 2, 3$*, at the beginning of time* t *or the* $t-th$ *iteration, the weighting terms* $Pr[s_t = j|\psi_{t-1}]$*,* $j = 1, 2, 3$ *are calculated as*

$$\begin{aligned} Pr[s_t &= j|\psi_{t-1}] = \sum_{i=1}^{3} \Pr[s_t = j, s_{t-1} = i|\psi_{t-1}] \\ &= \sum_{i=1}^{3} \Pr[s_t = j|s_{t-1} = i, Z_{t-1}] \Pr[s_{t-1} = i|\psi_{t-1}], \end{aligned}$$

where $Pr[s_t = j|s_{t-1} = i, Z_{t-1}], i = 1, 2, 3,\ j = 1, 2, 3$ *are the transition probabilities.*

Step 2. Once y_t is observed at the end on time t, or at the end of the $t-th$ iteration, we update the probability term as follows:

$$\begin{aligned} Pr[s_t &= j|\psi_t] = Pr[s_t = j|y_t, \psi_{t-1}, y_t, Z_t] \\ &= \frac{f(s_t = j, y_t|\psi_{t-1}, Z_t)}{f(y_t|\psi_{t-1}, Z_t)} \\ &= \frac{f(y_t|s_t = j, \psi_{t-1}, Z_t)\,\Pr[s_t = j|\psi_{t-1}, Z_t]}{\sum_{i=1}^{3} f(y_t|s_t = i, \psi_{t-1}, Z_t)\,\Pr[s_t = i|\psi_{t-1}, Z_t]}. \end{aligned}$$

The above two steps may be iterated to get $Pr[s_t = j|\psi_t]$, $t = 1, 2, ..., T$. To start the above filter at time $t = 1$, however, we need $Pr[s_0|\psi_0]$. We can employ the method of Kim and Nelson to obtain the steady-state or unconditional probabilities

$$\pi = \begin{bmatrix} \Pr[s_0 = 1|\psi_0] \\ \Pr[s_0 = 2|\psi_0] \\ \Pr[s_0 = 3|\psi_0] \end{bmatrix}$$

of s_t to start with. Where π is the last column of the matrix $(A'A)^{-1}A'$ with

$$A = \begin{bmatrix} 1 - p_{11,0} & -p_{21,0} & -p_{31,0} \\ -p_{12,0} & 1 - p_{22,0} & -p_{32,0} \\ -p_{13,0} & -p_{23,0} & 1 - p_{33,0} \\ 1 & 1 & 1 \end{bmatrix}$$

By now, it is clear that the log likelihood function in (25), is a function of $\mu_1, \mu_2, \mu_3, \sigma_1^2, \sigma_2^2, \sigma_3^2, \{\lambda_{ij,k}\}$ $i = 1, 2, 3$; $j = 1, 2$; $k = 0, 1, ..., N$.

Proof of the Lemma PROOF. *Let z_{lt} be a time series variable. Let us set*

$$g(\lambda_{ij}) = \exp(\lambda_{ij,0} + \sum_{k=1}^{N} \lambda_{ij,k} Z_{kt}). \tag{26}$$

With this notation for $i = 1, 2, 3$;

$$p_{ij,t} = \frac{g(\lambda_{ij})}{1 + g(\lambda_{i1}) + g(\lambda_{i2})}$$

for $j = 1, 2$*; and*

$$p_{i3,t} = \frac{1}{1 + g(\lambda_{i1}) + g(\lambda_{i2})}. \tag{27}$$

If z_{lt} *is a continuous variable, its marginal effect on* $p_{ij,t}$ *can be computed as:*

$$\frac{\partial p_{ij,t}}{\partial z_{lt}} = \frac{g_l(\lambda_{ij})\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right] - g(\lambda_{i1})\left[g_l(\lambda_{i1}) + g_l(\lambda_{i2})\right]}{\left(1 + g(\lambda_{i1}) + g(\lambda_{i2})\right)^2} \tag{28}$$

Besides, direct derivation of (26) in respect with z_{lt} *yields,*

$$g_l(\lambda_{ij}) = \lambda_{ij,l}\, g(\lambda_{ij}). \tag{29}$$

Substituting (29) in (28) yields

$$\frac{\partial p_{ij,t}}{\partial z_{lt}} = \frac{\lambda_{ij,l}\, g(\lambda_{ij})\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right] - g(\lambda_{i1})\left[\lambda_{i1,l}\, g(\lambda_{i1}) + \lambda_{i2,l}\, g_l(\lambda_{i2})\right]}{\left(1 + g(\lambda_{i1}) + g(\lambda_{i2})\right)^2} \tag{30}$$

Developing and regrouping the right hand side of equation (30) gives

$$\frac{\partial p_{ij,t}}{\partial z_{lt}} = \frac{g(\lambda_{ij})\left[\lambda_{ij,l} + (\lambda_{ij,l} - \lambda_{i1,l})\, g(\lambda_{i1}) + (\lambda_{ij,l} - \lambda_{i2,l})\, g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}$$

Let us now compute $\frac{\partial p_{i3,t}}{\partial z_{lt}}$ *for* $i = 1, 2, 3$*. A direct differentiation of (27) yields*

$$\frac{\partial p_{i3,t}}{\partial z_{lt}} = \frac{-\left[g_l(\lambda_{i1}) + g_l(\lambda_{i2})\right]}{\left(1 + g(\lambda_{i1}) + g(\lambda_{i2})\right)^2}. \tag{31}$$

Substituting (29) in (31) yields

$$\frac{\partial p_{i3,t}}{\partial z_{lt}} = \frac{-\left[\lambda_{i1,l}\, g(\lambda_{i1}) + \lambda_{i2,l}\, g(\lambda_{i2})\right]}{\left(1 + g(\lambda_{i1}) + g(\lambda_{i2})\right)^2}.$$

For dummy variable taking the value 1 or 0, the marginal effect is obtained by computing $p_{ij,t} = \left[p_{ij,t}(z_{-lt}, 1) - p_{ij,t}(z_{-lt}, 0)\right]$*; where* z_{-lt} *is the matrix* Z_t *without* z_{lt}*.* ■

Proof of the Proposition PROOF. *We know that* $\pi_t = P_t \pi_{t-1}$*, and since*

$$\pi_t \equiv \begin{bmatrix} Pr(s_t = 1) \\ Pr(s_t = 2) \\ Pr(s_t = 3) \end{bmatrix},$$

it follows that we can rewrite it as

$$\begin{bmatrix} Pr(s_t=1) \\ Pr(s_t=2) \\ Pr(s_t=3) \end{bmatrix} = \begin{bmatrix} p_{11,t} & p_{21,t} & p_{31,t} \\ p_{12,t} & p_{22,t} & p_{32,t} \\ p_{13,t} & p_{23,t} & p_{33,t} \end{bmatrix} \begin{bmatrix} Pr(s_{t-1}=1) \\ Pr(s_{t-1}=2) \\ Pr(s_{t-1}=3) \end{bmatrix}. \tag{32}$$

This implies that

$$Pr(s_t = 1) = p_{11,t}Pr(s_{t-1}=1) + p_{21,t}Pr(s_{t-1}=2) + p_{31,t}Pr(s_{t-1}=3) \tag{33}$$

$$Pr(s_t = 2) = p_{12,t}Pr(s_{t-1}=1) + p_{22,t}Pr(s_{t-1}=2) + p_{32,t}Pr(s_{t-1}=3) \tag{34}$$

$$Pr(s_t = 3) = p_{13,t}Pr(s_{t-1}=1) + p_{23,t}Pr(s_{t-1}=2) + p_{33,t}Pr(s_{t-1}=3). \tag{35}$$

They can be regrouped in the following general form

$$Pr(s_t = j) = \sum_{i=1}^{3} p_{ij,t} Pr(s_{t-1} = i).$$

It is obvious that $Pr(s_{t-1} = i)$ is not a function of z_{lt}. Hence, if z_{lt} is a continuous variable

$$\frac{\partial \Pr(s_t = j)}{\partial z_{lt}} = \sum_{i=1}^{3} \left(\frac{\partial p_{ij,t}}{\partial z_{lt}}\right) Pr(s_{t-1} = i). \tag{36}$$

Substituting (10) or (11) in equation (36) gives

$$\frac{\partial \Pr(s_t = j)}{\partial z_{lt}} = \sum_{i=1}^{3} \left(\frac{g(\lambda_{ij})\left[\lambda_{ij,l} + (\lambda_{ij,l} - \lambda_{i1,l})\, g(\lambda_{i1}) + (\lambda_{ij,l} - \lambda_{i2,l})\, g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}\right) Pr(s_{t-1} = i)$$

for $j = 1, 2$; and

$$\frac{\partial \Pr(s_t = 3)}{\partial z_{lt}} = \sum_{i=1}^{3} \left(\frac{-\left[\lambda_{i1,l} g(\lambda_{i1}) + \lambda_{i2,l} g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}\right) Pr(s_{t-1} = i).$$

More precisely,

$$\frac{\partial \Pr(s_t = 1)}{\partial z_{lt}} = \sum_{i=1}^{3} \left(\frac{g(\lambda_{1j})\left[\lambda_{1j,l} + (\lambda_{i1,l} - \lambda_{i2,l})\, g(\lambda_{i2})\right]}{\left[1 + g(\lambda_{i1}) + g(\lambda_{i2})\right]^2}\right) Pr(s_{t-1} = i).$$

And if z_{lt} is a dummy variable, its marginal effect on the probability of being in a given state j is given by

$$\Delta_l \left[\Pr(s_t = j)\right] = \sum_{i=1}^{3} \Delta_l p_{ij,t} \left[Pr(s_{t-1} = i)\right]. \tag{37}$$

More precisely,

$$\Delta_l \left[\Pr(s_t = 1)\right] = \sum_{i=1}^{3} \left[p_{i1,t}(z_{-lt}, 1) - p_{i1,t}(z_{-lt}, 0)\right] \left[Pr(s_{t-1} = i)\right].$$

■

8.2 Appendix B: Tables and Figures

Table 1: BSFI: Estimates and Tests of the Statistical Significance of Banking Regulation.

Para.	No Reg. (1)	Regulation: En. Res. (2)	Res. Req. (3)	Dep. Ins. (4)	Cap. Req. (5)	Dep.-Ins. Res.-Req. (6)	En. Res. & Cap.-Req. (7)	All Reg. (8)
μ_1	-0.862***	-0.852***	-0.864***	-0.859***	-0.859***	-0.862***	-0.855***	-0.839***
	(0.062)	(0.075)	(0.053)	(0.047)	(0.054)	(0.049)	(0.050)	(0.054)
μ_2	0.104***	0.103***	0.081***	0.102***	0.109**	0.099***	0.101***	0.108***
	(0.024)	(0.022)	(0.027)	(0.021)	(0.021)	(0.022)	(0.023)	(0.020)
μ_3	1.734***	1.753***	1.533***	1.732***	1.990***	1.706***	1.907***	1.986***
	(0.236)	(0.224)	(0.305)	(0.221)	(0.201)	(0.248)	(0.238)	(0.197)
σ_1^2	0.226***	0.215***	0.214***	0.216***	0.218***	0.216***	0.201***	0.233***
	(0.037)	(0.033)	(0.029)	(0.031)	(0.034)	(0.029)	(0.029)	(0.031)
σ_2^2	0.071***	0.073***	0.063***	0.073***	0.075***	0.070***	0.063***	0.075***
	(0.008)	(0.007)	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
σ_3^2	0.916***	0.889***	0.896***	0.917***	0.685***	0.876***	0.831***	0.691***
	(0.271)	(0.291)	(0.252)	(0.195)	(0.233)	(0.218)	(0.275)	(0.233)
$\lambda_{11,0}$	12.357	13.646***	16.940**	12.844***	70.312***	18.253**	14.211**	18.542**
	(14.701)	(2.500)	(6.645)	(0.508)	(24.297)	(8.869)	(5.565)	(7.611)
$\lambda_{12,0}$	7.257	2.452	10.787*	0.684	47.483***	2.569	-0.442	-12.249**
	(14.720)	(10.432)	(6.146)	(0.967)	(17.047)	(1.885)	(0.712)	(5.158)
$\lambda_{21,0}$	-9.294	-15.721***	-30.587*	-11.531***	-97.505***	-14.290*	-27.311**	-24.628**
	(18.247)	(3.986)	(17.577)	(1.241)	(35.989)	(8.066)	(13.867)	(10.317)
$\lambda_{22,0}$	4.525***	3.179***	2.089	4.342***	4.971***	3.349***	-2.504**	0.381**
	(0.762)	(0.972)	(1.384)	(0.625)	(1.049)	(0.829)	(1.147)	(0.171)
$\lambda_{31,0}$	-3.465***	-2.911	-3.514***	-3.232***	-7.618***	-3.249***	3.709	4.318**
	(1.083)	(6.882)	(1.152)	(0.632)	(2.026)	(0.967)	(4.940)	(1.921)
$\lambda_{32,0}$	-2.751***	7.882	-2.824***	-2.939***	-10.301***	-2.812***	18.314***	17.728**
	(0.885)	(16.694)	(0.828)	(0.242)	(3.421)	(0.723)	(6.207)	(7.319)
L	-131.565	-125.532	-124.841	-125.617	-122.081	-120.006	-119.101	-113.232

Standard deviation in parentheses; * means significant at ten percent,
** significant at five percent, and *** significant at one percent.
L is the value of the log likelihood function.

Table 2: BSFI: Estimates and Tests of the Statistical Significance of Banking Regulation (Cont.)

Para.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\lambda_{11,1}$		-1.984					50.709***	2.040***
		(7.200)					(17.592)	(0.778)
$\lambda_{12,1}$		-5.004*					51.735***	8.069***
		(2.940)					(17.078)	(3.347)
$\lambda_{21,1}$		1.197					7.278**	24.173**
		(1.292)					(3.417)	(9.879)
$\lambda_{22,1}$		0.870**					1.034	-15.450**
		(0.418)					(0.738)	(6.322)
$\lambda_{31,1}$		-0.321					-7.828	0.397**
		(6.222)					(5.449)	(0.162)
$\lambda_{32,1}$		-10.698					-21.400***	2.981**
		(16.769)					(6.611)	(1.245)
$\lambda_{11,2}$			2.308*			3.6771*		-5.671**
			(1.268)			(2.182)		(2.416)
$\lambda_{12,2}$			9.779*			5.958**		10.887**
			(5.609)			(2.978)		(4.495)
$\lambda_{21,2}$			4.278			5.308**		7.771***
			(2.783)			(2.615)		(3.156)
$\lambda_{22,2}$			7.544*			23.119*		12.896**
			(4.556)			(14.071)		(5.407)
$\lambda_{31,2}$			-1.532			5.846**		2.214**
			(1.703)			(2.923)		(0.894)
$\lambda_{32,2}$			12.831			4.329*		1.058**
			(8.413)			(2.422)		(0.425)
$\lambda_{11,3}$				2.979***		8.041**		-1.739**
				(0.559)		(3.239)		(0.833)
$\lambda_{12,3}$				6.371***		13.753*		10.877**
				(0.155)		(7.274)		(4.404)
$\lambda_{21,3}$				-3.862**		-2.948		4.485***
				(1.567)		(2.024)		(1.897)
$\lambda_{22,3}$				11.777***		18.863*		-0.125***
				(1.500)		(9.705)		(0.128)
$\lambda_{31,3}$				-2.579**		0.422		-5.389**
				(1.086)		(1.058)		(2.277)
$\lambda_{32,3}$				5.031***		7.356		-18.800**
				(1.067)		(4.564)		(7.710)
$\lambda_{11,4}$					-62.916***		0.203	0.611*
					(23.724)		(1.102)	(0.231)
$\lambda_{12,4}$					91.886***		6.451**	2.448***
					(34.190)		(3.063)	(1.101)
$\lambda_{21,4}$					-17.636**		8.227**	-0.161
					(6.823)		(2.541)	(0.157)
$\lambda_{22,4}$					-17.761		-1.477	-1.963**
					(16.069)		(1.233)	(0.926)
$\lambda_{31,4}$					87.750***		19.642*	13.026**
					(32.376)		(11.092)	(5.463)
$\lambda_{32,4}$					138.019***		20.479*	14.339**
					(51.971)		(11.042)	(5.976)

Standard deviation in parentheses;* means significant at ten percent,
** significant at five percent, and *** significant at one percent.

Table 3: BSFI: Impact of Regulation on Stability.

Regulatory Measures	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Deposit Insurance (a)	-0.033*				-0.044**		-0.069**
	(0.018)				(0.021)		(0.030)
Capital Requirement		0.198				-0.342**	-0.195*
		(0.657)				(0.172)	(0.111)
Entry Restriction			-0.111*			-0.104**	-0.133**
			(0.07)			(0.042)	(0.051)
Reserve Requirement				-0.135*	0.152***		0.065**
				(0.079)	(0.051)		(0.026)
Log-Likelihood	-125.62	-122.08	-125.53	-124.84	-120.01	-119.10	-113.23
Nb. of Obs.	288	288	288	288	288	288	288

Standard deviation in parentheses; * means significant at ten percent,

** significant at five percent, and *** significant at one percent. 1

(a) means that we computed the difference of moving from the absence of deposit insurance to its presence.

Table 4: BSFI: Impact of Regulation on the Probability of Remaining in the Crisis State

Regulation Measures	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Deposit Insurance	-0.015				-0.041		-0.069
Capital Requirement		-0.033				-0.035	-0.028
Entry Restriction			-0.038			-0.014	-0.030
Reserve Requirement				-0.023	-0.016		-0.071

Table 5: BSFI: Effect of Regulation on the Probability to be in the Crisis State.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep.-Ins.	0.974***				0.971***		0.952***	0.961***
	(0.010)				(0.011)		(0.029)	(0.044)
Cap.-Req.		5.659***				-2.344***	0.617***	-0.074*
		(0.413)				(0.916)	(0.378)	(0.335)
En.-Res.			-0.310***			-0.396***	0.006	-0.020
			(0.020)			(0.390)	(0.024)	(0.024)
Res.-Req.				-1.125***	-0.224**		-0.067	-0.219
				(0.260)	(0.099)		(0.233)	(0.237)
Gy								-0.008
								(0.0298)
Ge								-0.071***
								(0.0113)
Gr								0.149***
								(0.0155)
Cons.	0.023**	-0.007	-0.281***	0.326***	0.035***	0.901***	-0.006	0.084*
	(0.009)	(0.018)	(0.029)	(0.035)	(0.015)	(0.094)	(0.047)	(0.051)
Nb. of Obs.	288	288	288	288	288	288	288	288
F (7,280)	9391.99	187.75	292.58	18.66	618.73	143.63	18849.92	3706.76
Prob¿7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-Squared	0.919	0.276	0.519	0.017	0.919	0.534	0.931	0.950
Root MSE	0.126	0.376	0.306	0.438	0.126	0.302	0.117	0.100

Standard deviation in parentheses; * means significant at ten percent, ** significant at five percent, and *** significant at one percent.

Table 6: BSCI: Estimates and Tests of the Statistical Significance of Banking Regulation.

Para.	No Reg.	Regulation						
		En. Res.	Res. Req.	Dep. Ins.	Cap. Req.	Dep.-Ins. Res.-Req.	En.-Res. & Cap.-Req.	All Reg.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
μ_1	-1.601***	-0.853***	-1.598***	-0.699***	-1.524***	-1.139***	-0.850***	-1.607***
	(0.147)	(0.006)	(0.145)	(0.001)	(0.150)	(0.0003)	(0.139)	(0.118)
μ_2	0.150***	0.162***	0.150***	0.061**	0.153***	0.172***	0.141***	-0.104***
	(0.0247)	(0.023)	(0.025)	(0.026)	(0.024)	(0.026)	(0.020)	(0.017)
μ_3	1.822***	1.815***	1.817***	1.052***	1.743***	1.783***	1.822***	0.643***
	(0.183)	(0.171)	(0.177)	(0.113)	(0.172)	(0.216)	(0.232)	(0.052)
σ_1^2	0.723***	1.180***	0.725***	1.425***	0.763***	0.959***	0.133***	0.773***
	(0.152)	(0.220)	(0.154)	(0.280)	(0.167)	(0.159)	(0.022)	(0.114)
σ_2^2	0.115***	0.110***	0.115***	0.072***	0.110***	0.109***	0.0566***	0.032***
	(0.012)	(0.011)	(0.012)	(0.008)	(0.011)	(0.017)	(0.007)	(0.005)
σ_3^2	0.438***	0.442***	0.440***	0.490***	0.482***	0.479**	2.094***	0.376***
	(0.153)	(0.145)	(0.148)	(0.108)	(0.155)	(0.202)	(0.439)	(0.046)
$\lambda_{11,0}$	10.496	13.554	57.631	12.466	30.968***	7.055***	63.861	6.159***
	(11.705)	(22.279)	(50.427)	(50.351)	(10.128)	(0.953)	(35.105)	(1.274)
$\lambda_{12,0}$	7.519	11.036	51.975	0.868	17.670***	0.080	51.468**	4.166***
	(11.831)	(22.359)	(48.196)	(1.242)	(5.970)	(0.934)	(29.552)	(1.488)
$\lambda_{21,0}$	-0.049	1.212	-1.328	-0.618	-0.738	-10.232***	-67.566**	-1.755*
	(0.865)	(1.582)	(1.576)	(1.579)	(1.983)	(1.054)	(39.614)	(0.937)
$\lambda_{22,0}$	4.705***	4.629***	2.830**	4.364***	4.967***	4.298***	0.929***	4.690***
	(0.607)	(11.922)	(1.319)	(0.919)	(0.933)	(0.766)	(2.316)	(0.800)
$\lambda_{31,0}$	-10.573	-7.911	-59.226	-15.909	-35.501***	-2.907***	26.360**	-1.088
	(12.558)	(11.922)	(53.223)	(12.526)	(5.942)	(1.006)	(16.981)	(1.360)
$\lambda_{32,0}$	-2.177***	4.294	-2.190***	-2.923***	-13.882***	-2.802***	-5.329***	-3.231**
	(0.715)	(11.956)	(0.713)	(0.933)	(5.454)	(0.623)	(1.642)	(1.448)
L	-181.581	-169.952	-173.371	-171.104	-170.221	-151.013	-145.854	-135.435

Standard deviation in parentheses; * means significant at ten percent,
** significant at five percent, and *** significant at one percent.
L is the value of the log likelihood function.

Table 7: BSCI: Estimates and Tests of the Statistical Significance of Banking Regulation (Cont.).

Para.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\lambda_{11,1}$		0.353					-14.084*	2.513*
		(6.431)					(8.321)	(1.321)
$\lambda_{12,1}$		4.867					-82.717*	2.264*
		(6.648)					(48.622)	(1.196)
$\lambda_{21,1}$		1.357					8.829	3.799*
		(1.256)					(6.007)	(1.216)
$\lambda_{22,1}$		0.0426					0.874	0.513
		(0.699)					(0.959)	(1.028)
$\lambda_{31,1}$		6.714					-31.665*	-9.341**
		(9.850)					(18.153)	(3.214)
$\lambda_{32,1}$		6.401**					1.841***	-5.985**
		(11.876)					(0.882)	(2.176)
$\lambda_{11,2}$			-17.199***			0.488		0.128
			(6.284)			(1.004)		(1.029)
$\lambda_{12,2}$			49.233			0.674		1.713*
			(41.94)			(1.006)		(1.045)
$\lambda_{21,2}$			54.693**			-0.062		1.142
			(21.494)			(0.999)		(1.038)
$\lambda_{22,2}$			67.219			2.615**		1.248
			(50.218)			(1.232)		(1.078)
$\lambda_{31,2}$			22.085			0.356		-0.201
			(17.617)			(1.000)		(1.061)
$\lambda_{32,2}$			-1.026			0.227		-1.741
			(2.215)			(0.999)		(1.357)
$\lambda_{11,3}$				0.057		1.213		8.806
				(26.983)		(0.897)		(1.713)
$\lambda_{12,3}$				8.647		4.348***		3.826*
				(10.483)		(1.069)		(0.707)
$\lambda_{21,3}$				5.640**		-1.475		-1.864**
				(2.685)		(0.997)		(0.684)
$\lambda_{22,3}$				3.978		3.297***		-1.131*
				(7.995)		(1.059)		(0.453)
$\lambda_{31,3}$				-4.178		-0.625		-2.469
				(4.861)		(1.007)		(0.899)
$\lambda_{32,3}$				-14.994**		-4.457***		-0.007
				(6.372)		(1.023)		(0.657)
$\lambda_{11,4}$					-53.057**		-32.288*	0.913
					(21.619)		(19.949)	(1.027)
$\lambda_{12,4}$					58.619**		47.484*	0.293
					(22.803)		(28.699)	(1.029)
$\lambda_{21,4}$					11.107		-6.844*	-0.975
					(25.403)		(4.391)	(1.121)
$\lambda_{22,4}$					-5.924		30.573*	3.055**
					(14.531)		(21.511)	(1.181)
$\lambda_{31,4}$					-0.147		30.573*	1.587
					(1.004)		(18.305)	(1.124)
$\lambda_{32,4}$					250.121**		3.650*	0.188
					(110.898)		(2.887)	(1.033)

Standard deviation in parentheses; * means significant at ten percent,
** significant at five percent, and *** significant at one percent.

Table 8: BSCI: Impact of Regulation on Stability.

Regulatory Measures	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Deposit Insurance /a	-0.023*				-0.058**		-0.046**
	(0.013)				(0.026)		(0.021)
Capital Requirement		0.090				-0.021**	-0.015*
		(0.214)				(0.011)	(0.009)
Entry Restriction			-0.109*			-0.125*	-0.081*
			(0.058)			(0.067)	(0.045)
Reserve Requirement				-0.104	0.088*		0.037*
				(0.083)	(0.046)		(0.021)
Log-Likelihood	-171.10	-170.22	-169.95	-173.37	-151.01	-145.85	-135.43
Nb. Obs.	288	288	288	288	288	288	288

Standard deviation in parentheses; * means significant at ten percent,

** significant at five percent, and *** significant at one percent.

/a means that we computed the difference of moving from no regulation to regulation

Table 9: Critical Value of the Test Statistics.

Index	10% critical value	5% critical value	1% critical value
BSFI	9.626	11.735	17.008
BSCI	9.417	15.368	18.395

Table 10: Comparing the Two-State and the Three-State Specification.

Log	BSFI			BSCI		
	Two-State	Three-State Con.-Var.	Three-State	Two-State	Three-State Con.-Var.	Three-State
	(1)	(2)	(3)	(1)	(2)	(3)
Likelihood	-211.66	-150.96	-131.56	-284.22	-204.92	-181.58
LR_{12}	121.39			158.61		
LR_{23}		38.80			46.68	
LR_{13}			160.19			205.28

Table 11: Effect of Regulation on the Probability of the Banking Crisis. Ordered Logit Model.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
NCPS	-0.400***	-0.172***	-0.086***	-0.156***	-0.068	-0.089**
	(0.079)	(0.036)	(0.032)	(0.030)	(0.085)	(0.037)
NDEP	-0.008	-0.094***	-0.002	-0.189***	-0.005	-0.004
	(0.048)	(0.026)	(0.016)	(0.033)	(0.010)	(0.016)
NFL	0.173***	0.062**	0.036***	0.051	0.030	0.037
	(0.046)	(0.033)	(0.0137)	(0.043)	(0.038)	(0.016)
Dep.-Ins. /a	0.727***				0.693***	
	(0.090)				(0.134)	
Cap.-Req.		2.133***				-0.111
		(0.547)				(0.560)
En.-Res.			-0.116			-0.115**
			(0.034)			(0.056)
Res.-Req.				-0.947***	-2.072	
				(0.315)	(1.306)	
Nb. Obs.	288	288	288	288	288	288
Wald Chi2(4)	127.81	114.57	229.51	74.75	112.81	229.56
Prob¿chi2	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.52	0.48	0.55	0.44	0.54	0.55
Log Pseudolikelihood	-99.69	-109.26	-93.54	-116.37	-96.35	-74.61
Predict, Outcome	0.159	0.082	0.0348	0.097	0.027	0.026

/a means that we computed the difference on moving from non regulation to regulation

Standard deviation in parentheses;* means significant at ten percent,

** significant at five percent, and *** significant at one percent.

Table 12: Comparing the Marginal Effect.

	DD02	BDL	BCL	DD98	OLM	MSM_OLS	TVPT-MSM
Dep.-Ins.	0.696*	0.004*	0.719***		0.693***	0.952***	-0.069**
	(0.397)	(0.0022)	(0.000)		(0.139)	(0.029)	(0.030)
Cap.-Req.		-0.0016	-0.749		-0.111*	-0.617*	-0.195*
		(0.0027)	(0.471)		(0.560)	(0.378)	(0.111)
En.-Res.		0.0345/i***	-0.279	1.761/i/b***	-0.115***	-0.067	-0.133**
		(0.0127)	(0.495)	(0.634)	(0.056)	(0.233)	(0.051)
Res.-Req.		0.0003			-2.072	0.006	0.065*
		(0.0003)			(1.306)	(0.047)	(0.026)

/b This is not the marginal effect on the probability to be in crisis but instead the effect of ln[p/(1-p)]

/i The study used a variable capture less entry restriction

Standard deviation in parentheses;* means significant at ten percent,

** significant at five percent, and *** significant at one percent.

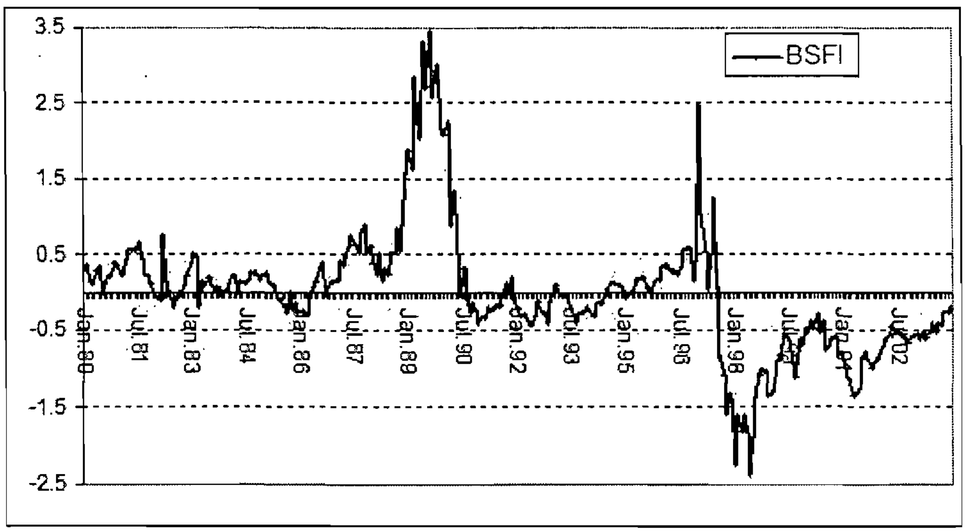
DD98: Demirgüç-Kunt and Detragiache 1998

DD02:Demirgüç-Kunt and Detragiache 2002

BDL: Beck, Demirgüç-Kunt, and Levine (2006)

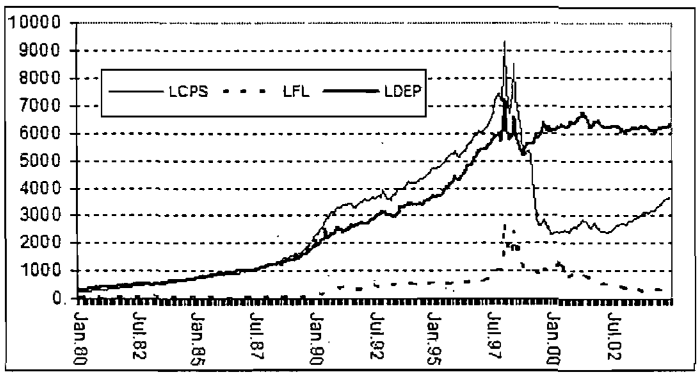
BCL: Barth, Caprio and Levive (2006)

Figure 1: Banking System Fragility Index

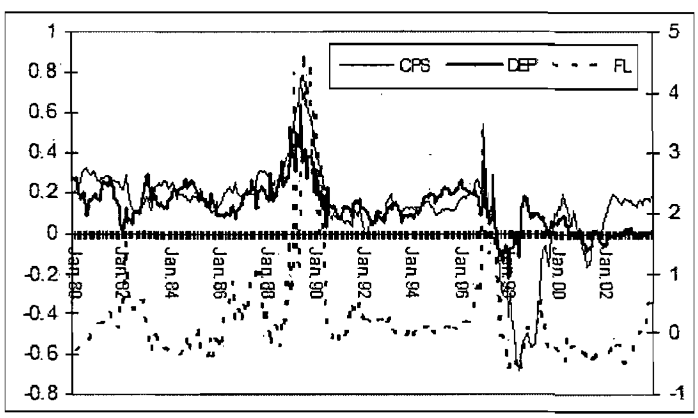


Source: Author computation based on IFS data

Figure 2: Banking System Indicators



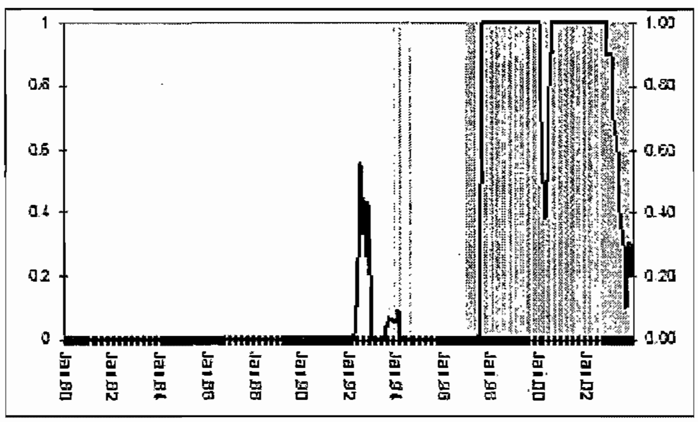
(a) Level in the 2000 local currency



(b) Growth rate in percentage

Source: Author computation based on IFS data

Figure 3: BSFI: Inferred Probability of the Systemic Crisis State

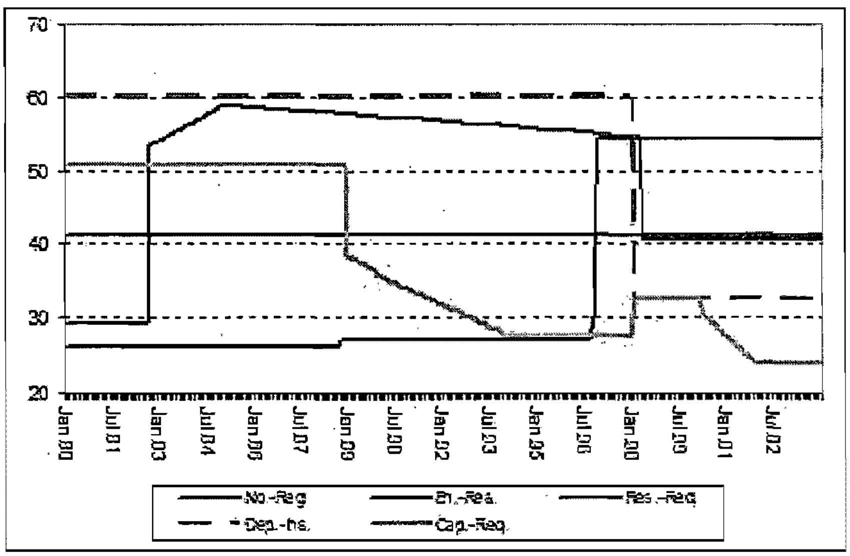


Blue line is the filtered Probability of a crisis

Shadow ranges are the épisodes of crises

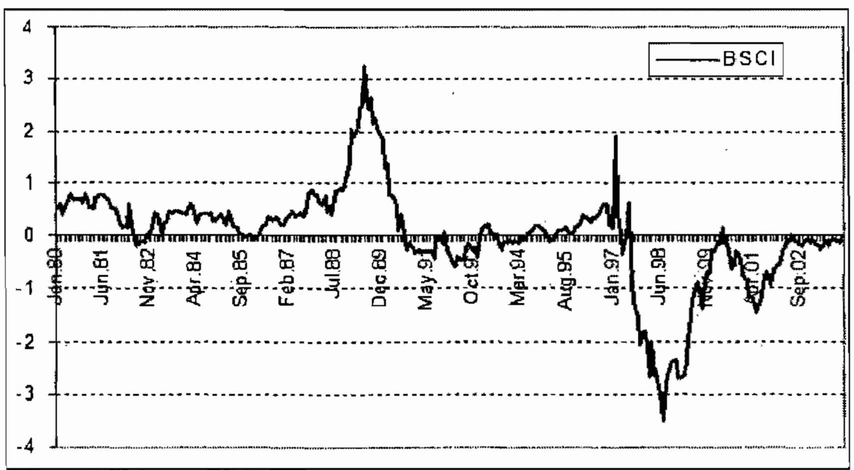
Source: Author computation based on IFS data and Caprio et al. (2003)

Figure 4: BSFI: Expected Duration



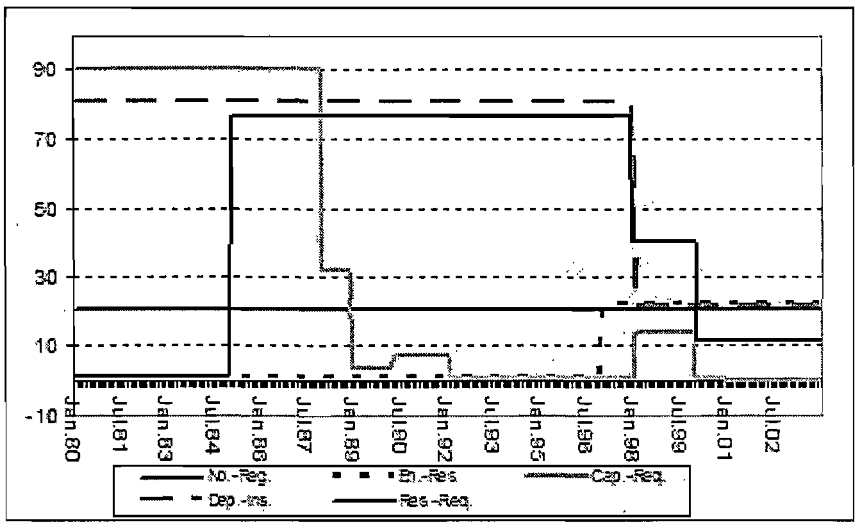
Source: Author computation based on IFS data

Figure 5: Banking System Crisis Index



Source: Author computation based on IFS data

Figure 6: BSCI: Expected Duration



Number of months on the vertical axis

Source: Author computation based on IFS data

Chapter 3

The Welfare Cost of Banking Regulation

1. Introduction

As pointed out by Freixas and Rochet (1997), the usual justification for banking regulation is to increase banking system stability. Specifically, the Basel committee established a list of "best practices" for the regulation and supervision of banks. This has been adopted by many countries in the belief that it will improve the stability of their banking systems and promote financial development. This accord has three pillars, the most important being capital adequacy requirements, which aim to provide incentives for banks to hold less risky portfolios.[1] Unfortunately, this regulation can hamper economic growth by shifting banks' portfolios from more productive risky investment projects toward less productive safe projects.

There is now a fair amount of theoretical and empirical work on the effects of capital adequacy requirements on the stability of the banking system. Some studies of these requirements, as implemented under the Basel I Accord, argue that they can end up by increasing the fragility of the banking system (see, e.g., Kim and Santomero (1984) and Blum (1999)), but others argue that they may be effective in improving banking system stability (see, e.g., Dewatripont and Tirole (1994), Berger, Herring, and Szegö (1995), Freixas and Rochet (1997), Gale (2004)). An empirical assessment of this issue by Barth, Caprio, and Levine (2004) shows that the link between capital requirements and stability was not robust under the experience of the Basel I Accord. The Basel II Accord attempts to account for that by improving the assessment of the risk-weighted assets uses to compute the capital adequacy ratio. We assume in this paper that this improvement makes capital adequacy requirements effective for banking system stability. There are also a number of papers on the optimality of capital adequacy requirements (see, e.g., Hellman, Murdock, and Stiglitz (2000) Allen and Gale (2003), Gale (2003, 2004), which is an extension of Allen and Gale (2004), and Gale and Özgür (2004)). Finally, there is a paper by Van Den Heuvel (2008), which studies the welfare cost of bank capital requirements through its effect on liquidity in the context of a neo-classical growth model.

[1] As pointed out by Bank for International Settlements (2003), the new Basel Accord consists of three pillars: (1) minimum capital requirement, (2) supervisory review of capital adequacy, and (3) public disclosure.

These welfare assessment ignore the fact that changes to banks' portfolio composition have a significant impact on growth, since they are structural shifts, i.e., moving capital from risky assets toward safe investments. The main issue of regulation, when studying its impact on welfare at the macroeconomic level, is to assess the trade-off between ensuring stability and promoting economic growth. In fact, when a regulatory scheme is effective, it improves welfare because it reduces the probability of banking crisis, but at the same time it hampers growth—therefore, it can then be welfare reducing.

This paper aims at providing a framework to study this trade-off. It is an overlapping-generations model in which banks served as financial intermediaries and banking regulation is modeled as a constraint on banks' portfolios. In fact, Dewatripont and Tirole (1994), and Gale (2004), argue that equity capital reduces incentives for excessive risk taking. Consequently, banks hold less risky portfolios. Therefore, capital requirements and portfolio restrictions end up having the same effect on the riskiness of banks' portfolios: They reduce the amount of the risky assets a bank can hold.

Our model is built in a general equilibrium framework. In the setup, each young individual has access to two types of Cobb-Douglas production technology: a risky, highly productive technology and a risk-free, less productive one. The outcome of the risky production process is stochastic and i.i.d. These technologies serve to produce two intermediate goods, which are used to produce a final good via a CES technology. When young, individuals are entrepreneurs, while elders become lenders. Not having an initial endowment of capital, the entrepreneur borrows from the lender through a competitive banking sector. We assume that banks can observe the state of nature, but lenders cannot. This provides a rationale for the existence of banks. These banks transfer resources from elders to entrepreneurs by borrowing from the former at the equilibrium rental rate and lending to entrepreneurs using optimal lending contracts.

We derive many interesting results from this model. First, we show that when productivity shocks are idiosyncratic, the competitive economy can achieve the first-best allocation. We then verify that regulation hampers growth and maintains the economy at a lower level of production than that of the unregulated banking economy. Second, in the presence of an unanticipated aggregate productivity shock, the introduction of capital adequacy requirements has a positive effect on banking stability. In fact, in this case, bankruptcy can occur in the unregulated economy, but adequate banking regulation can eliminate this bankruptcy outcome by providing more available resources when the shock occurs.

Regulation affects social welfare through four channels. The first channel is its effect on the proportion of entrepreneurs involved in the risky project: We will refer to this as the *weight channel*. The second and the third channels are its effects on risky and risk-free entrepreneurs' incomes. We will refer to them as *type 1 and type 2 income channels*, respectively. The last channel is the effect of regulation on interest, we will refer to it as the *interest channel*. Some of these channels are related to the stabilization effect of regulation while others are related to the growth effect. The magnitude of the shock, and the behavior of individuals toward uncertainty, are key determinants of the importance of the stabilization effect of regulation.

We find that the overall impact of the optimal level of regulation on social welfare depends critically on the magnitude of the productivity shock, its probability, and whether economic agents are sufficiently risk-averse. In fact, the stabilization effect deriving from tighter regulation dominates the growth effect in these cases.

The rest of the paper is organized as follows. The model is described in section 2. In the third section, we investigate the effect of regulation on growth in the basic model. In section 4, we study the welfare implications of regulation in an economy with an aggregate, unanticipated shock. Section 5 provides a quantitative assessment, and section 6 considers extensions to the basic framework. Concluding remarks are contained in section 7. Proofs of the various propositions are collected in an Appendix.

2. Model

In this section we consider a simple extension to the standard OLG model, in which banks serve as financial intermediaries and banking regulation is modeled as a constraint on banks' portfolios. This model is a suitable framework for investigating the effects of banking regulation on key macroeconomic variables and for assessing its social welfare implications.

2.1 Preferences and Endowments

The economy consists of a continuum of banks, firms, and individuals. Individuals live for two periods. When young, an individual is called an entrepreneur, and when old becomes a lender. The population is constant and normalized to one. Each individual of generation $t \geq 1$ is endowed with two types of technology when young, but can implement only one, and no technology when old. Each member of generation t has preferences over consumption streams given by

$$U(c_t^y, c_t^o) = E[u(c_t^y) + \beta u(c_t^o)], \tag{1}$$

where c_t^y and c_t^o are the consumptions of a young respectively of a old of generation t, and u is strictly increasing, strictly concave, twice continuously differentiable and satisfies Inada's conditions, and β is a time-preference parameter. Each member of the initial old generation is endowed with an equal share of the aggregate capital stock k_0 and enjoys only last period consumption i.e., $U(c_0^o) = u(c_0^o)$.

2.2 Production and Investment

There are two types of technology, a high-return risky technology $y_{1t} = z_t f(k_{1t})$, and a low-return safe technology $y_{2t} = f(k_{2t})$, where k denotes physical capital, z_t is an independent and identically distributed random variable with discrete probability distribution $Prob(z_t = z_j) = \pi_j$, with $j \in \{h, l\}$ and $z_h \geq z_l,$. We assume that the mean of z_t is $\overline{z}$ and that it is greater than one.[2] Let us denote π_h by π. These technologies serve to produce two intermediate goods. We assume that f is C^2 and satisfies $f(0) = 0$, $f' > 0$, $f'' < 0$, $\lim_{k \longrightarrow 0} f'(k) = \infty$, and $\lim_{k \longrightarrow \infty} f'(k) = 0$. The assumption $f'' < 0$ is one way of providing a positive revenue to entrepreneurs. The random variable z_t determines the quality of the risky investment.

There are a large number of competitive firms, which produce the final good using these two

[2]This is one way of making the risky technology more productive than the risk-free technology.

intermediate goods as inputs according to the production function

$$Y_t = F(Y_{1t}, Y_{2t}) = [\gamma Y_{1t}^{\sigma} + (1-\gamma) Y_{2t}^{\sigma}]^{\frac{1}{\sigma}}, \tag{2}$$

where Y_{1t} denotes the risky input and Y_{2t} denotes the risk-free input at time t. Let us recall that γ is the distribution parameter. It helps to explain the relative factor shares, so it is in $[0,1]$. σ, in $(-\infty, 1]$, is the substitution parameter—it helps in the derivation of the elasticity of substitution. Assuming a CES production function for the final good is one way of taking into account the fact that, in any economy in which one sector receives a shock, other sectors may also be in trouble.

Capital is durable, and is the only way for young agents to save. One unit of consumption placed into investment in period t yields one unit of capital in period $t+1$.

2.3 Banks

We assume that there is free entry into banking activity. This leads to a competitive banking sector. Therefore, some banks will be specialized in the risky technology and others in the risk-free one. In fact, if we suppose that this is not the case, then banks can remove resources from one type of entrepreneur and give them to others. In this case, a new bank can enter the market, specialize in the technology of the "exploited" entrepreneurs, provide a greater amount of transfer to them, and thus capture the entire market and make a positive profit.[3]

The old generation invests in the bank that promises to pay the highest interest rate. This drives all banks to promise the same interest rate to each lender. Banks behave as follows. They collect savings from the old cohort (with a promise to give them some level of consumption good in the next period) and lend to entrepreneurs.

Before presenting the problem of a bank formed in period t, we introduce some notation. p_1 is the price of the risky intermediate good, while p_2 is the price of the risk-free intermediate good. Lending contracts are set according to the type of technology: $(k_{1t}, \tau_{1t}(z_t))$ for the risky technology

[3]We can also obtain this result by assuming that each type of project requires specialized evaluation and monitoring. These evaluations can only be performed via two types of technology with a large fixed cost. Because of this fixed cost, each bank can have access only to one type of evaluation technology, these technologies are not accessible to individuals.

and (k_{2t}, τ_{2t}) for the risk-free, where τ_{it} is the transfer provided to an entrepreneur implementing technology i at time t. This may be a function of the idiosyncratic shock if the entrepreneur implements the risky investment. The optimal contract for those operating the risky technology $(k_{1t}, \tau_{1t}(z_t))$ solves the following optimization problem:

$$\max_{(k_{1t},\tau_{1t}(z_t))} E_t\left[v(\tau_{1t}(z_t), r_{t+1})\right] \tag{3}$$

subject to the zero-profit constraint,

$$\pi\tau_{1t}(z_h) + (1-\pi)\tau_{1t}(z_l) + r_t k_{1t} = p_1 \overline{z} f\left(k_{1t}\right),$$

where $v(\tau_{it}, r_{t+1})$ is the indirect utility function of each individual and is given by

$$v(\tau_{it}(z_t), r_{t+1}) = u\left(\tau_{it}(z_t) - s\left(\tau_{it}(z_t), r_{t+1}\right)\right) + \beta E_t\left[u\left((1+r_{t+1})s\left(\tau_{it}(z_t), r_{t+1}\right)\right)\right], \tag{4}$$

where the optimal savings function $s\left(\tau_{it}(z_t), r_{t+1}\right)$ is given by

$$s\left(\tau_{it}(z_t), r_{t+1}\right) = \arg\max_{s}\left\{u\left[\tau_{it}(z_t) - s\right] + \beta E_t\left(u\left[(1+r_{t+1})s\right]\right)\right\}. \tag{5}$$

Before describing the objective function, we describe the constraint. It states that entrepreneurs' transfers plus the interest payment received by lenders is equal to banks' resources, which are the nominal value of inputs produced by entrepreneurs, i.e., the quantity produced times the price of each unit of input. The objective function describes the expected utility of an individual implementing the risky technology at time t.

The optimal contract for those operating the risk-free technology (k_{2t}, τ_{2t}) solves the optimization problem:

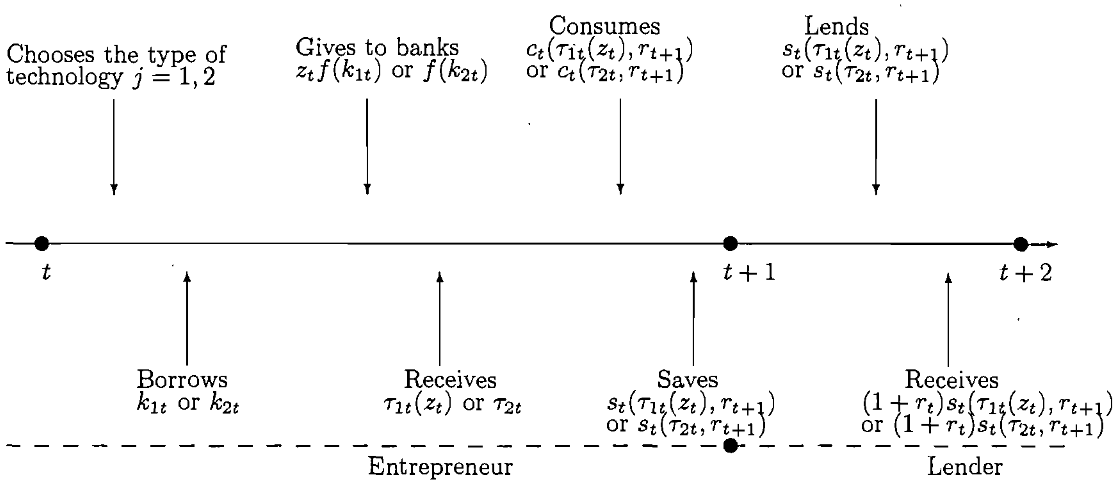
$$\max_{(k_{2t},\tau_{2t})} v(\tau_{2t}, r_{t+1}) \tag{6}$$

subject to the zero-profit constraint,

$$\tau_{2t} + r_t k_{2t} = p_2 f\left(k_{2t}\right).$$

This problem can be interpreted in the same way as the one above.

Figure 7: Timing of Events for an Individual Born at Time t



2.4 Individuals

At time t, each entrepreneur chooses between two types of technology. Then it borrows from banks an amount of capital according to the type of technology chosen. It produces intermediate goods and gives them to banks. Banks sell the intermediate goods to firms producing the consumption good. After production takes place, lenders receive the interest payment and their capital. They sell their capital and obtain the consumption good. Therefore, each old agent has $(1 + r_t)$ units of consumption good for each unit of capital owned at the beginning of the period. They consume all their goods and exit the economy. The entrepreneur receives a transfer and consumes and saves according to the transfer and the anticipated interest rate. Figure 7 describes the timing of events for an individual born at time t.

We resolve this problem recursively using indirect utility. To simplify derivation of our model we make some further assumptions. We assume that u is a power utility function of the form

$$u(c) = \frac{c^{1-\rho} - 1}{1 - \rho}. \tag{7}$$

With this assumption, we obtain (as in Castro, Clementi, and MacDonald (2004)) that $v(\tau_{it}(z_t), r_{t+1})$ is strictly increasing, strictly concave, and a linear translation of a log-separable function of $\tau_{it}(z_t)$.

In the remainder of the paper, we assume that final goods and input markets open at any time

t. As a benchmark, we investigate the properties of banking regulation in the simple model given above.

3. Economy without Banking Crisis

In the above model, productivity shocks are idiosyncratic, so at the aggregate level there is no uncertainty. Although there is no market failure that can provide a rationale for bank regulation, it has been introduced in order to assess its effects on growth. In the remainder of this section we characterize the evolution of this economy in an unregulated banking environment, and then explore how the paths of variables such as capital and output change in response to the introduction of regulation.

3.1 Unregulated Banking

Before characterizing the economy, let us define a competitive equilibrium.

Definition 1. *Given k_0 units of capital in period $t = 0$, a sequential market equilibrium is defined by the consumption level of the initial old generation c_0^o, the consumption allocation for entrepreneurs who choose the risky technology (hereafter type 1 entrepreneurs) $\{c_{1t}^y(z_t), c_{1t}^o(z_t)\}_{t=0}^{\infty}$, the consumption allocation for those who choose the risk-free technology (hereafter type 2 entrepreneurs) $\{c_{2t}^y, c_{2t}^o\}_{t=0}^{\infty}$, aggregate capital $\{k_{t+1}\}_{t=0}^{\infty}$, the proportion of the type 1 entrepreneurs $\{n_t\}_{t=0}^{\infty}$, contracts $\{(k_{1t}, \tau_{1t}(z_t))\}_{t=0}^{\infty}$, for those operating the risky technology, and $\{(k_{2t}, \tau_{2t})\}_{t=0}^{\infty}$ for type 2 entrepreneurs, allocation $\{Y_t, Y_{1t}, Y_{2t}\}_{t=0}^{\infty}$ for firms, and sequences of prices $\{r_t, p_{1t}, p_{2t}\}_{t=0}^{\infty}$, such that for all $t \geq 0$:*

1. *consumers optimize, i.e., $c_0 = k_0(1 + r_0)$, for $t > 0$ and for $i = 1, 2$, $c_{it}^y(z_t) = \tau_{it}(z_t) - s(\tau_{it}(z_t), r_{t+1})$* and *$c_{it}^o(z_t) = (1 + r_{t+1})s(\tau_{it}(z_t), r_{t+1})$;*
2. *contracts are optimal, i.e., they solve the banks' problem;*
3. *ex ante, entrepreneurs are indifferent between technologies, i.e.,*

$$E\left[v(\tau_{1t}(z_t), r_{t+1})\right] = v(\tau_{2t}, r_{t+1});$$

4. *firms optimize, i.e.,* $\{Y_t, Y_{1t}, Y_{2t}\}_{t=0}^{\infty}$ *solves the firms' problem* ;

5. *aggregate capital stock equals supply, i.e.,*

$$n_{t+1}k_{1t+1} + (1 - n_{t+1})k_{2t+1} = n_t\left[\pi s_{1t}(z_h) + (1-\pi)s_{1t}(z_l)\right] + (1 - n_t)s_{2t};$$

6. *the risky input market clears, i.e.,* $Y_{1t} = n_t\overline{z}f(k_{1t})$;

7. *the risk-free input market clears, i.e.,* $Y_{2t} = (1 - n_t)f(k_{2t})$.

We now characterize the portfolio of investments in this economy.

The concavity of the instantaneous utility function drives banks dealing with type 1 entrepreneurs to provide them with risk-free contracts. This result holds for the rest of this section, so all economic variables are determined with certainty and we will omit z_t in front of variables.

Before providing the equilibrium values of the key endogenous variables, we first find the input demands. The demands for inputs are derived from the firms' problem and satisfy $p_{it} = \frac{\partial F(Y_{1t}, Y_{2t})}{\partial Y_{it}}$ for $i = 1, 2$. We can now characterize optimal contracts.

Lemma 1. *Optimal contracts offered by banks to entrepreneurs are*

$$\left(k_{1t} = f'^{-1}\left(\frac{r_t}{\overline{z}p_{1t}}\right); \tau_{1t} = \overline{z}p_{1t}\left[f\left(k_{1t}\right) - f'\left(k_{1t}\right)k_{1t}\right]\right) \tag{8}$$

to type 1 entrepreneurs, and

$$\left(k_{2t} = f'^{-1}\left(\frac{r_t}{p_{2t}}\right); \tau_{2t} = p_{2t}\left[f\left(k_{2t}\right) - f'\left(k_{2t}\right)k_{2t}\right]\right) \tag{9}$$

to type 2 entrepreneurs.

PROOF. This follows directly from the First Order Conditions (FOCs) of problems (3) and (6). For details, see appendix A. ■

As expected, the optimal contracts show that the demand for capital for the risky technology is a decreasing function of the interest rate, but an increasing function of average productivity and the price of the risky intermediate good. The same results hold for the demand for capital for the risk-free technology. The only difference is that the latter is not a function of productivity. The transfer is simply the remuneration of entrepreneurship. To obtain a closed-form solution, we assume until the end of this paper that inputs are produced with a Cobb-Douglas production function, i.e., $f(x) = x^\alpha$ with $\alpha < 1$.[4]

Lemma 2. *At equilibrium, in any period t,*

(i) each entrepreneur receives the same level of capital regardless of the type of technology implemented, i.e.

$$k_{1t} = k_{2t}; \tag{10}$$

(ii) the proportion of the type 1 entrepreneurs is a constant given by

$$n^* = \left[1 + \left(\frac{1-\gamma}{\gamma \bar{z}^\sigma}\right)^{\frac{1}{1-\sigma}}\right]^{-1}. \tag{11}$$

PROOF. These results are obtained using the values for optimal contracts provided by lemma 1, the indifference between technologies condition of entrepreneurs, and the market clearing conditions for intermediate goods. Details are provided in appendix A. ■

This lemma shows that the share of banks' portfolios used to produce the risky input in the entire economy is time invariant, so we omit t on n_t in the rest of this subsection. It also shows that this share increases with productivity, the distribution parameter γ, and with the substitution parameter σ.[5] When the substitution parameter increases, the share of bank portfolios allocated to the risky technology increases, and when this tends to 1, (i.e., the elasticity of substitution is equal to infinity), this share tends to 1. When $\sigma < 1$, i.e., the elasticity of substitution of inputs in the final good's production technology is different from infinity, n^* is strictly less than one. This is an interesting result, because empirically in economies without capital adequacy requirements or

[4]Assuming that $\alpha < 1$ allows us to fulfill the condition $f'' < 0$.

[5]When $\sigma = 0$, (case of the Cobb-Douglas technology, i.e., $F(Y_1, Y_2) = Y_1^\gamma Y_2^{1-\gamma}$) $n^* = \gamma$. In this case, n is just equal to the share of input 1 in the production process. It is then not a function of the inputs'productivity. When $\sigma = -\infty$, (case of the Leontief technology, i.e., $F(Y_1, Y_2) = \min(Y_1, Y_2)$) $n^* = \frac{1}{2}$.

asset holding restrictions, the amount of safe assets held by banks is strictly positive.[6] We assume for the rest of this paper that $\sigma \in (0,1)$.

Direct calculations show that prices (p_{1t} and p_{2t}) are time invariant. In fact, they are simply a function of n, which is constant. This result was expected, because input prices are a function of their relative scarcity and their complementarity in the production process. This result holds in the rest of this section.

Finally, by replacing n with its equilibrium value (n^*) in the final good production function, we obtain that the economy evolves exactly as a standard OLG economy of capital accumulation, with

$$\begin{aligned} Y_t &= \phi(\overline{z})\, k_t^{\alpha}, \qquad (12) \\ \text{where } \phi(\overline{z}) &= \left[(\gamma\overline{z}^{\sigma})^{\frac{1+\sigma}{1-\sigma}} + (1-\gamma)^{\frac{1+\sigma}{1-\sigma}}\right]\left[(\gamma\overline{z}^{\sigma})^{\frac{1}{1-\sigma}} + (1-\gamma)^{\frac{1}{1-\sigma}}\right]^{-\sigma}. \end{aligned}$$

It is obvious that the portfolio composition of banks in competitive equilibrium is efficient. In fact, this competitive equilibrium yields the same level of transfer, the same level of capital per entrepreneur, and also a deterministic interest rate for the old cohort. It is then like a competitive equilibrium with a representative agent in a deterministic environment. There is no way to have market failure, which could provide a rationale for a planner interventing to achieve a better portfolio of assets. Besides, we will focus on equilibrium where the Balasko-Shell (1980) criterion for optimality is met (i.e., the indifference curves have neither flat parts nor kinks, aggregate endowments are uniformly bounded from above, and the infinite sum of t-period gross interest rates diverges); and thus dynamic inefficiency of the OLG model is impossible here.

3.2 Regulated Banking

Since the competitive equilibrium portfolio of banks is efficient, regulation cannot be welfare improving. But what is its amplitude and its effect on the evolution of some major macroeconomic

[6] As pointed out by Alexander (2004), in the 1970s and early 1980s, most countries did not have minimum capital requirements for banks.

indicators?[7] To assess those effects, let us first define the new competitive equilibrium.

Definition 2. *Given k_0 units of capital in period $t = 0$, a sequential market equilibrium is defined by the consumption level of the initial old generation c_0^o, the consumption allocation for type 1 entrepreneurs $\{\widehat{c}_{1t}^y(z_t), \widehat{c}_{1t}^o(z_t)\}_{t=0}^{\infty}$, the consumption allocation for the type 2 entrepreneurs dealing with the risky bank $\{\widehat{c}_{2t}^y, \widehat{c}_{2t}^o\}_{t=0}^{\infty}$, the consumption allocation for the type 2 entrepreneurs dealing with the risk-free bank $\{c_{2t}^y, c_{2t}^o\}_{t=0}^{\infty}$, aggregate capital $\{k_{t+1}\}_{t=0}^{\infty}$, the proportion of the type 1 entrepreneurs in the risky bank $\{\widehat{n}_t\}_{t=0}^{\infty}$, the proportion of entrepreneurs who choose the risky bank $\{m_t\}_{t=0}^{\infty}$, the contracts $\left\{(\widehat{k}_{1t}, \widehat{\tau}_{1t}(z_t))\right\}_{t=0}^{\infty}$, for those operating the risky technology, $\left\{(\widehat{k}_{2t}, \widehat{\tau}_{2t})\right\}_{t=0}^{\infty}$ for entrepreneurs implementing the risk-free technology in the risky bank, $\{(k_{2t}, \tau_{2t})\}_{t=0}^{\infty}$ for those operating the risk-free technology in the risk-free bank, allocation $\{Y_t, Y_{1t}, Y_{2t}\}_{t=0}^{\infty}$ for firms, and sequences of prices $\{r_t, p_{1t}, p_{2t}\}_{t=0}^{\infty}$, such that for all $t \geq 0$:*

1. *consumers optimize, i.e., $c_0 = k_0(1 + r_0)$, for $t > 0$ $c_{2t}^y = \tau_{2t} - s(\tau_{2t}, r_{t+1})$* and *$c_{2t}^o = (1 + r_{t+1})s(\tau_{2t}, r_{t+1})$, and for $i = 1, 2$, $\widehat{c}_{it}^y(z_t) = \widehat{\tau}_{it}(z_t) - s(\widehat{\tau}_{it}(z_t), r_{t+1})$* and *$\widehat{c}_{it}^o(z_t) = (1 + r_{t+1})s(\widehat{\tau}_{it}(z_t), r_{t+1})$;*

2. *contracts are optimal, i.e., they solve the banks' problem;*

3. *ex ante, entrepreneurs operating the risk-free technology are indifferent between banks, i.e., $v(\widehat{\tau}_{2t}, r_{t+1}) = v(\tau_{2t}, r_{t+1})$;*

4. *ex ante, entrepreneurs in the risky bank are indifferent between technologies, i.e.,*

$$E\left[v(\widehat{\tau}_{1t}(z_t), r_{t+1})\right] = v(\widehat{\tau}_{2t}, r_{t+1});$$

5. *firms optimize, i.e., $\{Y_t, Y_{1t}, Y_{2t}\}_{t=0}^{\infty}$ solves their problem;*

[7] Bernanke and Gertler (1985) state that most of the original regulation was imposed on macroeconomic grounds. Therefore, to assess the welfare cost of regulation one needs to study its effect on macroeconomic variables.

6. *aggregate capital stock equals supply, i.e.,*

$$
\begin{aligned}
& m_{t+1}\widehat{n}_{t+1}\widehat{k}_{1t+1} + m_{t+1}(1-\widehat{n}_{t+1})\widehat{k}_{2t+1} + (1-m_{t+1})k_{2t+1} \\
= \;& m_t\widehat{n}_t\left[\pi\widehat{s}_{1t}(z_h) + (1-\pi)\widehat{s}_{1t}(z_l)\right] + m_t(1-\widehat{n}_t)\widehat{s}_{2t} + (1-m_t)s_{2t};
\end{aligned}
$$

7. *the risky input market clears, i.e.,* $Y_{1t} = m_t\widehat{n}_t\overline{z}f(\widehat{k}_{1t})$;

8. *the risk-free input market clears, i.e.,* $Y_{2t} = m_t(1-\widehat{n}_t)f(\widehat{k}_{2t}) + (1-m_t)f(k_{2t})$.

Before characterizing the portfolio of investments in this economy, let us define the new bank's problem. The regulated bank's problem is unchanged for those implementing the risk-free technology, but it is impossible for a bank to be specialized in the risky technology. Therefore, the formerly risky bank will now deal with both types of entrepreneurs. Since, as we stated in the previous subsection, banks provide risk-free contracts to entrepreneurs, we will not use the expected indirect utility function, will determine optimal contracts for entrepreneurs by solving the following problem,

$$\max_{(\widehat{k}_{1t},\widehat{\tau}_{1t},\widehat{k}_{2t},\widehat{\tau}_{2t})} v(\widehat{\tau}_{1t}, r_{t+1}) \tag{13}$$

subject to,

$$
\begin{aligned}
\widehat{n}_t\widehat{\tau}_{1t} + (1-\widehat{n}_t)\widehat{\tau}_{2t} + r_t\left(\widehat{n}_t\widehat{k}_{1t} + (1-\widehat{n}_t)\widehat{k}_{2t}\right) &= \widehat{n}_t\overline{z}p_{1t}\widehat{k}_{1t}^{\alpha} + (1-\widehat{n}_t)p_{2t}\widehat{k}_{2t}^{\alpha}, && (14)\\
v(\widehat{\tau}_{2t}, r_{t+1}) &\geq v(\tau_{2t}, r_{t+1}), && (15)\\
\frac{\widehat{n}_t\widehat{k}_{1t}}{\widehat{n}_t\widehat{k}_{1t} + (1-\widehat{n}_t)\widehat{k}_{2t}} &\leq \theta. && (16)
\end{aligned}
$$

Let us describe the objective function and then the constraints. The objective function is the indirect utility function of an entrepreneur implementing the risky technology. In fact, banks specialized in risky projects only value the welfare of type 1 entrepreneurs. Equation (14) is the zero-profit condition for intermediaries, while inequality (15) is the participation constraint for type 2 entrepreneurs. Inequality (16) is the regulatory constraint, which states that banks' portfolios cannot have more than a given proportion of capital allocated to the risky technology.[8] In fact,

[8]We do not omit t on $\widehat{n}_t$ in the above problem because it is a new one and we cannot say at this point if $\widehat{n}_t$ is an independent function of t.

in the presence of regulation, there is an additional constraint set for banks specialized in the risky technology. They are forced to provide at least a given share $(1-\theta)$ of their portfolio to entrepreneurs operating the risk-free technology.

We now characterize this new equilibrium. It depends on the value of θ. In fact, we have two different types of adjustment depending on the interval to which θ belongs.

Case of $\theta \in (n^*, 1)$

In this case, the equilibrium allocation of capital per entrepreneur satisfies the following property : $\widehat{k}_{1t} = \widehat{k}_{2t} = k_{2t}$. Let us consider the following solution: The proportion of type 1 entrepreneurs in the risky bank is $\widehat{n}_t = \theta$, while the proportion of people in the risky bank is $m_t = \frac{n^*}{\theta}$. This solution yields the same capital, transfer and interest rate to entrepreneurs as the unregulated economy solution. In fact, the introduction of regulation drives entrepreneurs to move only from the risk-free bank to the risky bank. They move until the transfer in the risky bank equals that in the risk-free bank. This will be achieved with no deterioration in welfare until this adjustment is no longer possible. Since, the maximum proportion of entrepreneurs in the risky bank cannot exceed 1, from $m_t = \frac{n^*}{\theta}$, we obtain that this way of adjustment is possible only if $\theta \geq n^*$.

Case of $\theta \in (0, n^*)$

In this case, banks and entrepreneurs cannot adjust to obtain the first-best solution. The following lemma provides the optimal contracts of the regulated risky banks.

Lemma 3. *Optimal contracts proposed by the regulated, risky banks are,*

$$\left(\widehat{k}_{1t} = \theta(1-\widehat{n}_t)\left[\frac{\alpha B_t}{r_t}\right]^{\frac{1}{1-\alpha}}; \widehat{\tau}_{1t} = (1-\alpha)\frac{(1-\widehat{n}_t)}{\widehat{n}_t}\left[\widehat{n}_t B_t^{\frac{1}{1-\alpha}} - p_{2t}^{\frac{1}{1-\alpha}}\right]\left[\frac{\alpha}{r_t}\right]^{\frac{\alpha}{1-\alpha}}\right)$$

for entrepreneurs using the risky technology, and

$$\left(\widehat{k}_{2t} = \widehat{n}_t(1-\theta)\left[\frac{\alpha B_t}{r_t}\right]^{\frac{1}{1-\alpha}}; \widehat{\tau}_{2t} = (1-\alpha)p_{2t}\left[\frac{\alpha p_{2t}}{r_t}\right]^{\frac{\alpha}{1-\alpha}}\right)$$

for entrepreneurs using the risk-free technology. Where

$$B_t = \overline{z}p_{1t}\theta^{\alpha}(1-\widehat{n}_t)^{\alpha-1} + p_{2t}(1-\theta)^{\alpha}\widehat{n}_t^{\alpha-1}. \tag{17}$$

PROOF. This follows from the FOCs of problems (13) and (6). The details are available in appendix B. ■

Lemma 4. *At equilibrium, in any period t,*

(i) the proportion of risky input producers (n_t) *is time invariant;*

(ii) the ratio of risky input to risk-free input, $\frac{Y_{1t}}{Y_{2t}}$ *denoted by* Φ_t, *is time invariant.*

PROOF. These results are obtained using the values of the optimal contracts, the indifference between technologies condition of entrepreneurs, and the market clearing conditions for intermediate goods. See appendix B for details. ■

Intuitively, the proportion of entrepreneurs implementing the risky technology and the ratio of risky to risk-free inputs depend on the final good technology and on the regulation coefficient. Since they are fixed, n_t is time invariant. This lemma also implies that input prices are time invariant, so we will omit t in the price notation.

Lemma 5. Y_{1t} *and* Φ_t *are increasing and continuous functions of* θ, *while* Y_{2t} *is a decreasing function of* θ.

PROOF. This result is obtained by using the values of the optimal contracts, the indifference between technologies condition of entrepreneurs, and the market clearing conditions for intermediate goods. The details are available in appendix B. ■

The amount of input produced by risk-free entrepreneurs increases with the amount of capital invested; we can refer to it as the volume effect, while the risk-free input price decreases since it is abundant. Since $\sigma > 0$, the volume effect dominates the price effect and therefore the anticipated transfer to type 2 entrepreneurs is an increasing function of θ. Thus, entrepreneurs produce more risk-free input. The demand for risk-free inputs by firms remains unchanged after regulation, because it is function of the final good's technology. However, as we have proven, its supply changes after regulation. In fact, with regulation, more capital is available for the risk-free technology. This shifts the supply curve of capital to the right, thus reducing the price of the risk-free input. The price reduction has a negative effect on supply (general-equilibrium effect), but this effect is not dominant when $\sigma > 0$. We assume for the remainder of this paper that we are under this condition.

3.3 The Effect of Regulation on Output

This subsection investigates the implications of banking regulation on output and growth .

Lemma 6 *Given the capital supply, the equilibrium aggregate output increases with θ.*

PROOF. To prove this, we differentiate the expression for aggregate production Y_t with respect to θ, using the results in lemma 4 and 5. Details are available in appendix C. ∎

Intuitively, when the supply of capital is given, regulation has a negative effect on production of the risky input and a positive effect on production of the risk-free input. Regulation thus has two opposite effects on aggregate output. This shifts the optimal composition of inputs to the left on the transformation frontier (TF). Since the isoquants of production curves are convex, the new equilibrium will be on an isoquant with a lower level of production. This is illustrated in Figure 8 output decreases from v_1 to v_2.

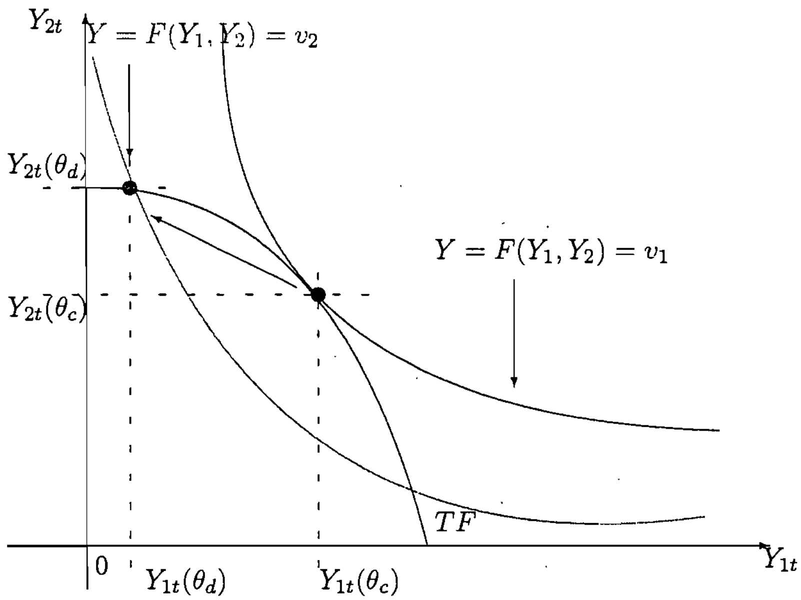
Proposition 1. *When the instantaneous utility function is logarithmic, growth is an increasing function of θ.*[9]

PROOF. The idea underlying this proof is to differentiate the expression for growth with respect to θ and verify that it is positive. We split this proof into two steps. The first step provides an expression for growth as a function of θ, the second finds its derivative with respect to θ and verifies under which conditions it is positive. Details are available in appendix C. ∎

This result also holds in any situation in which regulation has a negative impact on the level of savings. Let us show that intuitively, by comparing the dynamics of two economies differing only in terms of θ. Let θ_c and θ_d be the maximum shares of the portfolio a bank is allowed to invest in the risky technology in economy c, respectively economy d, and suppose $\theta_c > \theta_d$. Let us start at

[9] Growth refers here to the economic growth in the transition-state since it is well-known that in steady-state there is no growth in this model.

Figure 8: Effect of Regulation on Output.



time $t = 0$. Since the initial capital stock is given, the supply of capital by the old generation is completely inelastic at k_0. The impact of the regulation is reflected in different demand curves for aggregate capital. It results in a lower interest rate r_0 in the economy with θ_d, and the transfer received by entrepreneurs τ_0 is lower.

Intuitively, since the amount of capital invested in the production of the risky input is fixed and lower in economy d, and given that the demand for capital increases with productivity, demand is lower and supply is unchanged, so the interest rate will adjust, i.e., r_0 is lower. On the other hand, the production of the risky input will be lower while the production of the risk-free input will be higher. Lemma 6 shows that production is lower, i.e., $Y_0\left(\theta_d\right) < Y_0\left(\theta_c\right)$. It has the same effect on prices, that is $p_2\left(\theta_d\right) < p_2\left(\theta_c\right)$. Regulation has two opposite effects on τ_{20}, since τ_{20} is an increasing function of p_{20} and a decreasing function of r_0. The price effect is always dominated, because r_0 is proportional to p_{20} and its weight is less than p_{20}'s weight in the expression for τ_{20}.

Capital demand increases with θ. Therefore, economy d's demand curve is to the left of the economy c's demand curve. A lower value of τ_0 implies a shift in the capital supply curve to the left at $t = 1$ if the substitution effect deriving from the lower interest rate dominates the income effect. In this case, $k_1(\theta_d) < k_1(\theta_c)$. This is always the case when $\rho \leq 1$.

Finally, this means that for any pair of regulation parameters (θ_c, θ_d) with $\theta_c > \theta_d$, $\tau_0(\theta_c) > \tau_0(\theta_d)$. It will also be the case that $k_1(\theta_d) < k_1(\theta_c)$, $r_1(\theta_d) < r_1(\theta_c)$, and $\tau_1(\theta_c) > \tau_1(\theta_d)$. By repeating the same argument at any period t, we conclude that capital accumulation is higher in the economy with less regulation.

The result can be generalized when the income effect dominates the substitution effect, but in a way that causes the slope of the supply curve to be lower (in absolute value) than the slope of the demand curve. In this case, for all $t \geq 1$, $k_t(\theta_d) < k_t(\theta_c)$. Therefore, even when $\rho > 1$, we can still have the same result.

4. The Economy with Banking Crises

To introduce a possibility of banking failure, we use the competitive equilibrium results from section 3. Then we allow the occurrence of an unanticipated state ϖ, in which aggregate productivity in the risky sector is lower than the banking system's ability to meet its promise to lenders, and show that this can provide a rationale for regulation. We then compute the optimal level of regulation and study its welfare implications.

4.1 Characterization of Equilibrium

With $\rho \geq 1$, it is obvious that at any time t an individual must consume a positive amount of the final good. Thus, each bank must provide a positive transfer to each entrepreneur. This is not only a modeling assumption. In fact, Halac and Schmukler (2004) document many ways that borrowers are bailed out in the resolution of crises: (1) when bank loans are transferred to the central bank or an asset management company (making it relatively easy for borrowers to default on their debts), (2) when governments provide debt relief programs, (3) or when the central bank establishes a preferential exchange rate for foreign-currency denominated debt, i.e., the central bank sells dollars to debtors at a subsidized exchange rate.[10] To achieve this, let us assume in the rest of this section that banks must provide at least a minimum transfer to each entrepreneur and denote by $\underline{\tau}$ this minimum. We assume that the occurrence of the aggregate productivity shock is very unlikely. Therefore, it is unanticipated. Following Allen and Gale (2000), the state ϖ $(z_t = z_w)$ will occur with probability zero. We also assume that this occurs only at the steady state. Each bank is required to meet its promise to pay a given interest rate to lenders if it can at least pay the minimum transfer to each entrepreneur dealing with it.

We now describe the equilibrium at time t in state ϖ. At t, a bank can find itself in one of these two situations: It can be *solvent*, that is it provides the promised interest rate to lenders, or it can be *bankrupt*, that is it cannot pay the promised interest rate to lenders. These definitions are motivated by the assumption that lenders are very often the ones who are protected in case of banking crisis. In many countries, governments operate a deposit insurance fund that guarantees lenders' deposits.[11] Governments also stand ready to provide support to banks when they face difficulties, or banks can be taken over by the government, which then guarantees that depositors will receive all their deposits.

Lemma 7. *If the minimum transfer is strictly positive in any unregulated banking economy, there exists a positive number $\underline{z}$ such that if $z_w < \underline{z}$, any risky bank goes bankrupt when ϖ occurs.*

PROOF. We use the resource constraint of a bank specialized in the risky technology to show that it cannot fulfill its promise to lenders. The complete proof is available in appendix D. ∎

When the state of nature is $z_t = \bar{z}$, the economy continues to work as in section 3. But if the special state ϖ occurs, the risky bank in an unregulated economy cannot both pay the promised interest to its lenders and provide the minimum transfer to those implementing the risky technology. We assume in the rest of this section that $z_w < \underline{z}$. Therefore, when the unexpected state of nature occurs, any bank specialized in the risky technology goes bankrupt. In this case, the risky bank

[10] The transfer to debtors tends to be large because borrowers often take advantage of the bailout and stop paying their debts, regardless of their capacity to pay.

[11] In the United States of America, the Federal Deposit Insurance Corporation (FDIC) pays depositors the first $100,000 they deposited in the bank no matter what happens to the bank.

provides to entrepreneurs the minimum transfer and to lenders an equal share of the remaining resources. We will refer to this as the *bankruptcy rule.*

4.2 The Effect of Regulation on Banking Crises

As in the previous section, banking regulation forces risky banks to finance a positive proportion of the risk-free input's production. In the following proposition we show that there is an adequate value of θ (the coefficient set by the regulation) such that when the unanticipated state occurs, the regulated risky bank is able to pay the promised interest rate to lenders and still be able to provide more than the minimum transfer to entrepreneurs.

Proposition 2. *There is a non empty set $S \subset [0, n^*]$ containing an open interval of real numbers such that, if $\theta \in S$, the risky banks can always fulfill their promises toward lenders.*

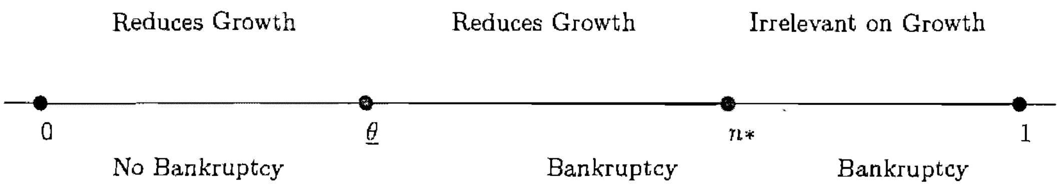
PROOF. This proof is based on the zero profit constraint. We show that under regulation, banks dealing with entrepreneurs implementing the risky technology have enough resources to provide at least the minimum transfer to entrepreneurs and pay the promised interest to lenders. The complete proof is available in appendix D. ■

It is hard to prove that S is an interval, but for all examples we computed numerically we obtained that it is an interval. We thus assume until the end of this section that S is an interval which has as upper bound $\underline{\theta}$. When $\theta < \underline{\theta}$, if $z_t = z_w$, the risky bank has enough resources to pay lenders and type 2 entrepreneurs and provide more than the minimum transfer to type 1 entrepreneurs. It is then possible to set a regulation coefficient such that a banking crisis cannot occur in this economy. But as we saw in the previous section, it can have a negative impact on economic development and growth. The next step is a welfare assessment of regulation.

4.3 Welfare Analysis of Regulation

We now turn to study the welfare implications of regulation. First, let us define the welfare notion we will use. Since the shock is unanticipated, the appropriate welfare notion is realized welfare. It was introduced by Starr (1973) and has been proven to have the best properties for

Figure 9: Effect of Regulation on Growth and Banking Stability



policy analysis. Let $W_t(c(z_t), c(z_{t+1}))$ be the Von Neumann-Morgenstern social welfare function per generation, which depends upon individuals' realized utility. It represents the realized welfare of generation t individuals and is defined by

$$\begin{aligned} W_t(c(z_t), c(z_{t+1})) &= n_t v^r(\tau_{1t}(z_t), r_{t+1}(z_{t+1})) + (1-n_t) v^r(\tau_{2t}(z_t), r_{t+1}(z_{t+1})), \textit{ with} \quad (18) \\ v^r(\tau(z_t), r_{t+1}(z_{t+1})) &= u\left[\tau(z_t) - s\left(\tau(z_t), r_{t+1}(\overline{z})\right)\right] + \beta\left(u\left[(1 + r_{t+1}(z_{t+1}))s\left(\tau(z_t), r_{t+1}(\overline{z})\right)\right]\right). \end{aligned}$$

In the case in which the productivity shock occurs, the welfare implications of regulation on generations living at that time is the result of a trade-off between the growth effect and the stabilization effect described by Figure 9.

With a regulation coefficient lower than $\underline{\theta}$, regulation helps to protect banks from bankruptcy, but it reduces the expected output, which translates into lower growth. We assume in the remainder of this section that $\theta \leq \underline{\theta}$, i.e., regulation helps the banking system gain stability—it cannot go bankrupt even when the unexpected state of nature occurs. Regulation affects social welfare through four channels:

(1) the weight channel, which is its effect through the proportion of type 1 entrepreneurs (n_t): Regulation can reduce n_t, diminishing the number of individuals exposed to crises in the economy. It is then welfare improving in case of a crisis, but welfare reducing in its absence.

(2) the type 1 *revenue channel,* which is its effect through the transfer received by type 1 entrepreneurs (τ_{1t}): Regulation increases τ_{1t} in case of a crisis, since it exceeds the minimum. The type 1 revenue channel is then welfare improving in the case of a crisis and welfare reducing

otherwise.

(3) the type 2 revenue channel, which is its effect through the transfer received by type 2 entrepreneurs (τ_{2t}): Regulation reduces τ_{2t} in any case, so it is welfare reducing. In fact, the steady state transfer to type 2 entrepreneurs is low in a regulated economy, even in crisis periods, compared to in the unregulated economy.

(4) the interest channel, which is its effect through the interest rate, r_t: Regulation reduces the productivity of capital, resulting in a lower interest rate. This can reduce the savings rate, or the amount saved, thus diminishing the amount of consumption when individuals are old. Therefore, in the absence of a crisis, this channel is welfare reducing. However, in the case of a crisis, regulation helps banks to provide the promised interest rate. It is then welfare improving.

The type 2 revenue channel is related to the growth effect, while the interest rate channel is related to the stabilization effect. Two others channels, the type 1 revenue channel and the weight channel, account for both effects.

Let us assume that, at $t = t_1$, the economy is at the steady state and the shock occurs. Even for generation t, the overall social effect of regulation is ambiguous. Regulation is welfare improving only if the stabilization effect dominates the growth effect. There are two generations living in a crisis period. In fact, if the productivity shock occurs at t_1, the old (generation $t_1 - 1$) will be affected through the interest channel. When there is a crisis at t_1, the old who are dealing with the risky bank cannot obtain the promised interest rate. Thus, the crisis affects the ex post interest rate negatively.

For the rest of this section we will focus on situations in which regulation is welfare improving for generations living in a crisis period. In this case, it is obvious that for generations living in a crisis period, the optimal regulation is less than $\underline{\theta}$, i.e., there is an appropriate level of capital adequacy requirements that is welfare improving.[12]

But there are many generations in the economy, and the above analysis has shown that the portfolio composition of banks at time t affects future generations through its effects on the dynam-

[12]This result helps to provide a rationale for the Barth, Caprio and Levine (2003) empirical result. If the regulation coefficient is inappropriate i.e., $\theta \in (\underline{\theta}, n^*)$ it will end up with a negative effect on financial and economic development.

ics of the capital stock. If t is an ex ante crisis period, regulation is welfare reducing as we saw in section 3. In fact, in an ex ante crisis period, regulation affects welfare through two channels—the revenue channels and the interest channel. In fact, the type 1 revenue channel is exactly the type 2 revenue channel and the weight channel is irrelevant since type 1 entrepreneurs have exactly the same welfare as type 2. It follows from section 3 that the revenue channel and the interest channel are welfare reducing. Therefore, the regulation is welfare reducing for the generation living before a crisis.

What about generations living after the crisis? At $t_1 + i;\ i \geq 1$, individuals obtain the same transfer and the same interest rate regardless of the type of technology they implement. Therefore, the weight channel is irrelevant. After the crisis, in many cases there is more aggregate capital in the regulated than in the unregulated economy. But the implications for welfare are complex and depend on the technology's parameters. After some periods, the economy returns to the steady state and then regulation has a negative impact on the welfare of generations living in those periods.

To take into account the welfare of future generations, we define a social welfare measure. Unfortunately, as pointed out by Ennis and Keister (2003), there is no clear criterion for aggregating utilities across generations. Following them, we take a simple approach and define the realized social welfare function by

$$
\begin{aligned}
W(c(z^t)) &= \sum_{t=0}^{\infty} \delta^t W_t(c(z_t), c(z_{t+1})), \\
with\ 0 &< \delta < 1.
\end{aligned}
\tag{19}
$$

To assess the welfare cost of banking regulation, we follow Lucas (1988) to define it as the additional proportion Ω of consumption that a representative agent should pay the planner to ensure implementation of the regulation. If this proportion is positive, then regulation is welfare improving; if it is negative, then it is welfare reducing. We refer to Ω as the relative welfare gain from regulation. Ω is then the solution of the following equation:

$$
W((1+\Omega)c(z^t)) = W(\widehat{c}(z^t)). \tag{20}
$$

Due to the complexity of the problem and the number of channels, it is not possible to provide an analytical assessment of the effect of regulation on aggregate social welfare. Thus, we will conduct a numerical assessment.

5. Numerical Analysis

We conduct a quantitative assessment of our model by simulating it with calibrated parameters from the US economy. Let us first calibrate the model to fit the observed data.

5.1 Calibration

The aim of calibration is to match the proportion of investment in the risky sector and also the relative productivity of that sector. Some parameters are taken in the literature as a priori information, others are estimated.

A priori information. We take, as is usual in the literature, the power utility parameter $\rho = 1.5$, and the share of capital in the production of the inputs, $\alpha = 0.34$.

Estimated and calibrated parameters. Table 13 provides the estimated average life expectancy, the annual interest rate, and the proportion of high-tech production in total exports from these economies over the period 1960–2000.[13]

Table 13: Data, Average (1960–2004).

Country	Life expectancy (years)	Interest rate (%)	High-Tech (%) of Exp. (%)
USA	74	4.1	33

Source: WDI 2006

Given the fact that people typically start to work at age 16, while in our model individuals begin working at birth, we remove 16 years from the life expectancy to obtain the life span of an individual. We obtain 58 years, so we assume that a period represents 29 years. It follows from the

[13]This seems the best proxy for the importance of the higher productivity sector in an economy.

annual interest rate of 4.1 per cent that a period interest rate is $r = 2.2$.

To calibrate productivity in the higher productivity sector, we use a proxy for its return. We assume that high-tech is usually financed through the stock market. From stock market data, the long run annual rate is estimated as 6.8 per cent. This yields a return of $R = 5.7$ over a period. A proxy for the return in other sectors is the average real interest rate. Since we normalized the productivity of other sectors to one, we have $\overline{z} = \frac{R}{r} = 2.5$. We calibrate the lower productivity to a major crisis period, such as the episode in 2001 when the NASDAQ index lost more than 1/3 of its value. This also means that, over a period, the return in the high-tech sector is approximately the same as the return in the other sector. This allows us to set $z_w = 0.8$.

The intergenerational discount rate is $\beta = 0.3$. It is equivalent to an annual discount factor of 0.96 which is set to match the steady state interest rate of 2.2. We calibrate σ so that the effect of a shock on prices is less than the productivity effect, precisely $\sigma = 0.9$. We calibrate γ to obtain the proportion $n^* = 0.33$, i.e., we solve $n^* = \left[1 + \left(\frac{1-\gamma}{\gamma \overline{z}^{\sigma}}\right)^{\frac{1}{1-\sigma}}\right]^{-1}$, and we obtain $\gamma = 0.3$.

We now need to provide a value for the minimum transfer to type 1 entrepreneurs in case of a crisis. We use as a proxy the revenue that the creditor retains in case of bankruptcy. It follows from Richardson and Troost (2006) that, during the great depression, more that 50 per cent of loans were not recovered. During the 1980s and 1990s, Mason (2005) documents that the maximum rate of loan recoveries was close to 75 per cent. We thus take $\underline{\tau} = 0.25\tau$ as a proxy for the minimum transfer received by entrepreneurs. Finally, we assume that social and individual discount factors are the same. Table 14 summarizes the calibrated parameters.

5.2 Results

Using the above parameters, we obtain that the optimal level of regulation, which can prevent the banking crisis and be welfare improving for generations living in a crisis period, is $\theta^* = 0.3$, corresponding to a reduction of 10 per cent in the level of investment devoted to the risky technology. Figure 9 in appendix E provides several charts on the dynamics of an economy with and without regulation using the above parameters.

Table 14: Benchmark Parameter Values

Symbol	Value	Description
Preferences		
β	0.30	individual discount factor
δ	0.30	social discount factor
ρ	1.50	coefficient of relative risk aversion
Technology		
α	0.34	capital's share of income
γ	0.30	distribution parameter
σ	0.70	substitution parameter
$\overline{z}$	2.50	anticipated productivity
z_w	0.80	unanticipated productivity shock
Bankruptcy rules		
$\underline{\tau}$	0.25	minimum transfer to entrepreneurs
Period		
t	29	number of years in a period

Table 15 provides a social welfare assessment as a function of the arrival time of the productivity shock and the relative risk-aversion coefficient of individuals.

Table 15: Relative Welfare Gain (%)

$T/*$ ρ	1	2	3	4	5
1.5	0.2	−8.4	−10.8	−11.6	−11.8
2.5	13.4	−3.7	−9.4	−11.1	−11.7
3.5	37.0	7.2	−5.5	−9.9	−11.3
4.5	65.3	27.0	4.2	−6.3	−10.1
5.5	90.4	51.4	21.5	2.6	−6.7
6.5	101.0	74.0	42.5	18.0	1.7

/ * is the number of periods before the shock occurs

The benchmark simulation shows that the relative welfare gain from regulation is a decreasing function of the time of the crisis. More specifically, if the crisis occurs at the beginning of the steady state, the relative gain from regulation is close to 0.2 per cent. This relative gain declines to a negative value if the shock occurs later. It also increases with the power utility function parameter, ρ. In fact, an increase in ρ improves the stabilization effect of regulation.

We conduct another assessment assuming that the arrival time of the productivity shock is unknown. The results are presented in Figure 10 in appendix E. The benchmark simulation shows that the relative welfare gain of regulation is a decreasing function of ρ. More specifically, when the relative risk aversion coefficient is lower than 4.7, the stabilization effect of regulation is dominated by the growth effect and therefore the regulation is not needed. But when the coefficient is greater than 4.7, the stabilization effect is dominant. Specifically, when $\rho = 5.5$, the relative welfare gain from regulation is evaluated at 15 per cent. However, when $\rho < 4.7$, the regulation is welfare reducing: e.g., when $\rho = 1.5$, the relative welfare gain is evaluated at −13 per cent—it is then a cost. The result that the welfare gain of regulation increases with the risk-aversion coefficient is robust to changes to some parameters of the model.

The first parameter which may be relevant, but which has not been calibrated, is the discount factor of the regulator. Let us assume now that the regulator discounts the future more than individuals (this has sometimes been viewed as a rationale for regulating by the regulator). Suppose that the time preference for the planner is 0.98 per year, which corresponds to 0.55 for a period. The qualitative results do not change, but quantitatively the risk-aversion coefficient is now lower than before. When $\rho = 4$, the welfare improvement is up to 7.5 per cent. As before, when $\rho = 1.5$, the welfare gain is evaluated at -11 per cent.

Another parameter of interest is the minimum transfer received by entrepreneurs ($\underline{\tau}$). Let us assume that entrepreneurs receive less; for example, suppose $\underline{\tau} = 0.23\tau$. The result of the simulation is that a decrease in the minimum transfer to entrepreneurs induces a greater welfare improvement from regulation. In fact, when entrepreneurs receive less, they save less, so the stock of capital in an unregulated economy is lower when $\underline{\tau} = 0.23\tau$ than when $\underline{\tau} = 0.25\tau$. This raises the importance of bankruptcy rules or liquidation rules in the welfare-gain analysis of regulation.

6. Discussion

In the above development we have not taken into account the fact that banking crises often have associated costs. Four main costs are highlighted by Hoeslcher and Quintyn (2003). Three of these costs are fiscal, so are irrelevant when we are studying the economy without modeling government, but the macroeconomic cost attributable to the fact that bankruptcy can impair the intermediation function of banks is relevant to our analysis.[14] Taking this into account increases the welfare gain of regulation on generations living after the crisis. In fact, after the crisis, banks specialized in the risky technology can suffer under-financing, so risky investments will be lower than usual. This can lead to a transitional or permanent structural change in the magnitude of inputs into the final good production process. In any case, it will reduce the growth effect of

[14]According to Bernanke and Gertler (1989), and Mishkin (2000), a banking crisis reduces the amount of financial intermediation undertaken by banks and therefore leads to a decline in investment and aggregate economic activity.

unregulated banking in the post-crisis period—thereby enhancing the welfare effect of regulation. This does not change the qualitative result obtain previously. It extends the maximum period of time during which the shock can occur and regulation continues to be welfare improving, and increases the relative welfare improvement in all periods.

Also, in the previous developments, two key assumptions explain why the economy is subject to banking crises: the productivity shock and the fact that entrepreneurs must receive a minimum transfer in any case. A third assumption presented above is the fact that the shock is unanticipated. Although we have not provided an assessment of the case in which the shock occurs with a positive probability, we believe we can obtain the same results without this assumption. In fact, under the second assumption, type 1 entrepreneurs have a kind of insurance in the case of a banking crisis, therefore their expected utility is higher than the effective expected utility. Since banks maximize only the expected utility of entrepreneurs, they will end up with more risky portfolios, and thus be subject to banking crises.

7. Conclusion and Policy Implications

In the first part of this paper we introduced banking regulation in the familiar two-period OLG model of capital accumulation, in which technological shocks are idiosyncratic. The level of regulation is measured by capital adequacy requirements—the main quantitative component of Basel Accords. In this environment, our model produces several interesting implications. First, the portfolio of banks in competitive equilibrium is efficient. Second, banking regulation is detrimental to economic growth. In fact, it constrains banks to adjust their portfolio of investments towards safer, less productive assets. This structural change reduces output and also individuals' incomes. It then results in decreased savings and, therefore, investment.

In the second part we introduced an unanticipated sectorial shock, equivalent to overall lower productivity in the risky sector. We found that the economy will be subject to banking crises. In this event, there is an optimal capital adequacy requirement coefficient that can prevent crises. Although it is generally welfare improving for generations living in the crisis period, it is generally welfare reducing for populations living outside of this period.

We calibrated the model to reflect an economy such as the United States. We found that it is socially optimal to regulate when the regulator thinks that a shock will occur soon. This shows that, even when banking crises are due to real productivity shocks and impose no extra cost, there still exists a rationale for regulation when the magnitude of the productivity shock is sufficiently large and the likelihood of the shock is high. When there is no information available on the likelihood of shocks, regulation is welfare improving only with a greater level of risk aversion—levels that are higher than the usual acceptable level of risk aversion for the US economy. We also found that parameters on the bankruptcy rule, preferences, and technologies have a significant effect on the welfare improvements attributable to regulation.

Some policy implications can be drawn from this paper. First, since the welfare gain is a function of when the shock occurs, it is important for regulators to predict this time with a great degree of accuracy and raise capital requirements only when they believe that a crisis is imminent. Therefore, we advocate for a time variant regulation scheme. Second, since bankruptcy rules matter and are country variant, we advocate for country-variant regulation.

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8. Appendix

8.1 Appendix A

Proof of Lemma 1

PROOF. τ_{1t} is obtained from the risky bank's problem, and since banks provide a risk-free transfer to entrepreneurs, this problem is now set as:

$$\max_{(k_{1t},\tau_{1t})} v(\tau_{1t}, r_{t+1})$$

subject to the zero-profit constraint $\tau_{1t} + r_t k_{1t} = p_{1t}\overline{z} f(k_{1t})$.

Also, τ_{2t} is obtained from the risk-free bank's problem:

$$\max_{(k_{2t},\tau_{2t})} v(\tau_{2t}, r_{t+1})$$

subject to the zero-profit constraint $\tau_{2t} + r_t k_{2t} = p_{2t} f(k_{2t})$.

From the zero-profit conditions, transfers are given by $\tau_{1t} = p_{1t}\overline{z} f(k_{1t}) - r_t k_{1t}$ and $\tau_{2t} = p_{2t} f(k_{2t}) - r_t k_{2t}$. Then, by strict monotonicity, banks will simply choose capital to maximize transfers. The optimal capital levels derived from the bank's problem are

$$(k_{1t}) \quad : \quad \overline{z} p_{1t} f'(k_{1t}) = r_t \tag{21}$$

$$(k_{2t}) \quad : \quad p_{2t} f'(k_{2t}) = r_t \tag{22}$$

From (21), we have $k_{1t} = f'^{-1}\left(\frac{r_t}{\overline{z} p_{1t}}\right)$, and from (22), $k_{2t} = f'^{-1}\left(\frac{r_t}{p_{2t}}\right)$ Finally, substituting r_t by its value yields

$$\begin{aligned} \tau_{1t} &= \overline{z} p_{1t} \left[f(k_{1t}) - f'(k_{1t}) k_{1t} \right] \\ \tau_{2t} &= p_{2t} \left[f(k_{2t}) - f'(k_{2t}) k_{2t} \right]. \end{aligned}$$

■

Proof of Lemma 2

PROOF. (i) With Assumption 2, at equilibrium each entrepreneur receives the same level of capital at any time t regardless the technology implemented. In fact, from lemma 1, $r_t = \overline{z} p_{1t} f'(k_{1t}) = p_{2t} f'(k_{2t})$, which implies the following relationship between input prices:

$$\frac{\overline{z} p_{1t}}{p_{2t}} = \frac{f'(k_{2t})}{f'(k_{1t})}. \tag{23}$$

On the other hand, the monotonicity of $v(\tau_t, r_{t+1})$ in its first argument yields that the indifference condition between technologies is given by $\tau_{1t} = \tau_{2t}$. Substituting (23) in this indifferent condition yields $\frac{f'(k_{2t})}{f'(k_{1t})} = \frac{f(k_{2t})-f'(k_{2t})k_{2t}}{f(k_{1t})-f'(k_{1t})k_{1t}}$. Given assumption 2, the above equation is equivalent to $\left[\frac{k_{1t}}{k_{2t}}\right]^{\alpha-1} = \left[\frac{k_{1t}}{k_{2t}}\right]^{\alpha}$. This implies that

$$k_{1t} = k_{2t}.$$

(ii) From $k_{1t} = k_{2t}$, equation (23) yields $\frac{\bar{z}p_{1t}}{p_{2t}} = 1$. But this is just a relation between prices. To obtain n_t, we must go further and provide an expression for prices as a function of n_t. For that purpose, we use the market clearing conditions for intermediate goods; i.e., $Y_{1t} = n_t \bar{z} k_{1t}^{\alpha}$, and $Y_{2t} = (1-n_t)k_{2t}^{\alpha}$. We recall that $p_{1t} = F_{1t}$, $p_{2t} = F_{2t}$, and $F(Y_{1t}, Y_{2t}) = [\gamma Y_{1t}^{\sigma} + (1-\gamma)Y_{2t}^{\sigma}]^{\frac{1}{\sigma}}$. Therefore,

$$\frac{\bar{z}p_{1t}}{p_{2t}} = \frac{\bar{z}F_{1t}}{F_{2t}} = \frac{\bar{z}^{\sigma}\gamma}{1-\gamma}\left(\frac{n_t}{1-n_t}\right)^{\sigma-1}. \tag{24}$$

Substituting the above equality in $\frac{\bar{z}p_{1t}}{p_{2t}} = 1$ yields $n_t = \left[1 + \left(\frac{1-\gamma}{\gamma\bar{z}^{\sigma}}\right)^{\frac{1}{1-\sigma}}\right]^{-1}$. ∎

8.2 Appendix B

Proof of Lemma 3

PROOF. The bank provides capital for both types of technology. The optimal capital supply must satisfy the regulatory constraint with equality. The regulatory constraint can then be reset as

$$\widehat{k}_{2t} = \frac{n_t(1-\theta)}{\theta(1-n_t)}\widehat{k}_{1t}. \tag{25}$$

Therefore, to obtain the optimal capital offered by the bank for each type of contract, we simply need to maximize the objective function according to $\widehat{k}_{1t}$. Furthermore, we have seen that the indirect utility function is a strictly increasing function of its first argument, given the zero-profit constraint and the free entry assumption for any type of bank in the economy, the bank will provide $\tau_{2t} = \widehat{\tau}_{2t}$ to type 1 entrepreneurs. Given that there is no uncertainty and that the indirect utility of individuals is an increasing function of the transfer, the optimal choice of capital for the risky technology will be one that maximizes the amount of transfer provided to entrepreneurs. i.e., $\widehat{k}_{1t} \equiv \arg\max_k \{\tau_{1t}(k)\}$. Where $\tau_{1t}(k)$ is obtained by substituting $\widehat{k}_{2t}$ and $\widehat{\tau}_{2t}$ with their expressions in the zero-profit condition. Then,

$$\widehat{\tau}_{1t} = \frac{B_t}{\theta^{\alpha}(1-n_t)^{\alpha-1}}\widehat{k}_{1t}^{\alpha} - \frac{r_t}{\theta}\widehat{k}_{1t} - \frac{(1-n_t)}{n_t}\widehat{\tau}_{2t}. \tag{26}$$

From the FOC, capital demand for the risky technology is given by,

$$\widehat{k}_{1t} = \theta(1-n_t)\left[\frac{\alpha B_t}{r_t}\right]^{\frac{1}{1-\alpha}}. \tag{27}$$

Given (25), and replacing $\widehat{k}_{1t}$ by its value in (27), we obtain $\widehat{k}_{2t} = (1-\theta)n_t\left[\frac{\alpha B_t}{r_t}\right]^{\frac{1}{1-\alpha}}$. Substituting for $\widehat{k}_{1t}$ and $\widehat{\tau}_{2t}$ in the zero-profit condition yields,

$$\widehat{\tau}_{1t} = (1-\alpha)\frac{(1-n_t)}{n_t}\left[n_t B_t^{\frac{1}{1-\alpha}} - p_{2t}^{\frac{1}{1-\alpha}}\right]\left(\frac{\alpha}{r_t}\right)^{\frac{\alpha}{1-\alpha}}. \tag{28}$$

$\widehat{\tau}_{2t}$ is obtained from the participation constraint $\tau_{2t} = \widehat{\tau}_{2t}$ and from Lemma 1 (in case of Assumption 2). ■

Proof of Lemma 4

PROOF. (i) The proof when $\theta \in (n^*, 1)$ is straightforward. We now investigate when $\theta \in (0, n^*)$. equilibrium proportion of entrepreneurs using the risky technology in the bank is obtained from the indifference between technologies condition, $\widehat{\tau}_{1t} = \widehat{\tau}_{2t}$. Using the optimal transfers given by Lemma 3, this condition is equivalent to

$$[(1-\widehat{n}_t)\widehat{n}_t]^{1-\alpha} B_t = p_{2t}. \tag{29}$$

To complete the determination of $\widehat{n}_t$, we must determine p_{2t} and B_t.

1. Computation of p_{2t} :

From the market clearing conditions, we have $Y_{1t} = m_t \widehat{n}_t \overline{z} \widehat{k}_{1t}^{\alpha}$; and $Y_{2t} = m_t(1-\widehat{n}_t)\widehat{k}_{2t}^{\alpha} + (1-m_t)k_{2t}^{\alpha}$. In this case we know that $m_t = 1$, so $\widehat{n}_t = n_t$. Substituting for $\widehat{k}_{1t}$ and $\widehat{k}_{2t}$ in the above equations yields

$$Y_{1t} = n_t \overline{z}\theta^{\alpha}(1-n_t)^{\alpha}\left[\frac{\alpha B_t}{r_t}\right]^{\frac{\alpha}{1-\alpha}}, \text{ and} \tag{30}$$

$$Y_{2t} = (1-n_t)n_t^{\alpha}(1-\theta)^{\alpha}\left[\frac{\alpha B_t}{r_t}\right]^{\frac{\alpha}{1-\alpha}}. \tag{31}$$

Let us recall that, in the proof of Lemma 2, we found that $\frac{\overline{z}p_{1t}}{p_{2t}} = \frac{\overline{z}\gamma}{1-\gamma}\left(\frac{Y_{1t}}{Y_{2t}}\right)^{\sigma-1}$. Substituting Y_1 and Y_2 in the above expression yields,

$$p_{2t} = p_{1t}\frac{(1-\gamma)}{\gamma}\left[\frac{n_t \overline{z}\theta^{\alpha}(1-n_t)^{\alpha}}{(1-n_t)n_t^{\alpha}(1-\theta)^{\alpha}}\right]^{1-\sigma} \tag{32}$$

2. Computation of B_t.

We know from (17) that

$$B_t = \overline{z} p_{1t} \theta^{\alpha} (1-n_t)^{\alpha-1} + p_{2t}(1-\theta)^{\alpha} n_t^{\alpha-1}.$$

We will express this as function of p_{2t}. From (32) we have $p_{1t} = \frac{\gamma p_{2t}}{1-\gamma}\left[\frac{n_t^{1-\alpha}\theta^{\alpha}\overline{z}}{(1-n_t)^{1-\alpha}(1-\theta)^{\alpha}}\right]^{\sigma-1}$. Substituting p_{1t} in the expression of B_t yields

$$B_t = \left[\frac{\gamma}{1-\gamma}\frac{\overline{z}\theta^{\alpha}}{(1-n_t)^{1-\alpha}}\left(\frac{n_t^{1-\alpha}\theta^{\alpha}\overline{z}}{(1-n_t)^{1-\alpha}(1-\theta)^{\alpha}}\right)^{\sigma-1} + (1-\theta)^{\alpha} n_t^{\alpha-1}\right] p_{2t}. \tag{33}$$

We now substitute the above expression of B_t into (29) and obtain

$$\frac{\gamma \overline{z}^{\sigma}\theta^{\alpha\sigma}}{1-\gamma} n_t^{(1-\alpha)\sigma}(1-n_t)^{(1-\alpha)(1-\sigma)}(1-\theta)^{\alpha(1-\sigma)} = 1-(1-\theta)^{\alpha}(1-n_t)^{1-\alpha}. \tag{34}$$

This is also equivalent to $G(n_t)=0$ where

$$G(x) = \frac{\gamma \overline{z}^{\sigma}\theta^{\alpha\sigma}}{1-\gamma} x^{(1-\alpha)\sigma}(1-x)^{(1-\alpha)(1-\sigma)}(1-\theta)^{\alpha(1-\sigma)} - 1 + (1-\theta)^{\alpha}(1-x)^{1-\alpha}.$$

Since no term in $G(.)$ depends on t , $\widetilde{n_t}$ (which is the solution to $G(n_t)=0$) is independent of t , therefore it will be denoted $\widetilde{n}$.

(ii) The ratio of the aggregate risky input to the aggregate risk-free input is

$$\Phi_t = \frac{Y_{1t}}{Y_{2t}}. \tag{35}$$

Substituting Y_{1t} and Y_{2t} by their respective values from (30, resp. 31) yields $\Phi_t = \overline{z}\left(\frac{n_t}{1-n_t}\right)^{1-\alpha}\left(\frac{\theta}{1-\theta}\right)^{\alpha}$. Since n_t is time invariant, it follows that Φ_t is time invariant. ∎

Proof of Lemma 5

PROOF. (1) We use the logarithmic transformation to study the monotonicity of Y_{1t} with respect to θ. We obtain

$$\frac{\partial \log(Y_{1t})}{\partial\theta} = \frac{1-\alpha}{n}\frac{\partial n}{\partial\theta} + \frac{\alpha}{\theta}.$$

It follows that

$$\frac{\partial \log(Y_{1t})}{\partial\theta} > 0 \Leftrightarrow \frac{\partial n}{\partial\theta} > -\frac{\alpha n}{\theta(1-\alpha)}. \tag{36}$$

(2) We use the logarithmic transformation to study the monotonicity of Φ with respect to θ. The transformation is equivalent to

$$\log(\Phi) = \log(\overline{z}) + (1-\alpha)\log(n) - (1-\alpha)\log(1-n) + \alpha\log(\theta) - \alpha\log(1-\theta).$$

■

Lemma 8.1 PROOF. This implies that

$$\frac{\partial \log(\Phi)}{\partial \theta} = \frac{(1-\alpha)}{n(1-n)}\frac{\partial n}{\partial \theta} + \frac{\alpha}{\theta(1-\theta)},$$

and it follows that

$$\frac{\partial \log(\Phi)}{\partial \theta} \geq 0 \Longleftrightarrow \frac{\partial n}{\partial \theta} \geq -\frac{\alpha n(1-n)}{\theta(1-\theta)(1-\alpha)}.$$

(3) Following the same method we obtain that

$$\frac{\partial \log(Y_{2t})}{\partial \theta} = -\frac{(1-\alpha)}{1-n}\frac{\partial n}{\partial \theta} - \frac{\alpha}{1-\theta}.$$

which implies

$$\frac{\partial \log(Y_{2t})}{\partial \theta} < 0 \Leftrightarrow \frac{\partial n}{\partial \theta} > -\frac{\alpha(1-n)}{(1-\theta)(1-\alpha)}. \tag{37}$$

(1), (2), and (3) are verified if

$$\frac{\partial n}{\partial \theta} > -\frac{\alpha}{(1-\alpha)}\left[\min\left\{\frac{(1-n)}{(1-\theta)}, \frac{n(1-n)}{\theta(1-\theta)}, \frac{n}{\theta}\right\}\right].$$

It follows that

$$\frac{\partial n}{\partial \theta} > \begin{cases} -\frac{\alpha}{(1-\alpha)}\frac{n}{\theta} & if \quad n < \theta \\ -\frac{\alpha}{(1-\alpha)}\frac{(1-n)}{(1-\theta)} & if \quad not \end{cases}.$$

So, we now need to compute $\frac{\partial n}{\partial \theta}$ to complete this proof.

We differentiate the logarithm of (34) with respect to θ and obtain

$$\begin{aligned} \frac{\partial n}{\partial \theta} &= \frac{\alpha n(1-n)}{(1-\alpha)\theta(1-\theta)}\frac{\left[-\theta + \sigma\left(1-(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right)\right]}{\left[n - \sigma\left(1-(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right)\right]} \\ &= -\frac{\alpha n(1-n)}{(1-\alpha)\theta(1-\theta)}\frac{[\theta - \sigma C]}{[n - \sigma C]}, \\ with\ C &= 1-(1-\theta)^{\alpha}(1-n)^{1-\alpha}. \end{aligned} \tag{38}$$

It follows from direct calculations that the lemma holds under this condition

$$\begin{cases} \frac{[\theta-\sigma C]}{[n-\sigma C]} > \frac{(1-\theta)}{(1-n)} & if \quad n < \theta \\ \frac{[\theta-\sigma C]}{[n-\sigma C]} < \frac{\theta}{n} & if \quad not \end{cases}.$$

When $n < \theta$, $\frac{[\theta-\sigma C]}{[n-\sigma C]} > \frac{(1-\theta)}{(1-n)}$ implies $\sigma < \frac{1}{C}$ which is obvious since $C < 1$; $n < \theta$, it is obvious that $\frac{[\theta-\sigma C]}{[n-\sigma C]} < \frac{\theta}{n}$.

It follows that, in any case, this lemma holds unconditionally. ■

8.3 Appendix C

Proof of Lemma 6

PROOF. The idea of this proof is to differentiate the expression for aggregate production (Y_t) with respect to θ and verify that it is a positive quantity. We can split this proof into three steps. The first step provides an expression for aggregate production as a function of θ, the second provides the derivative of Y_t with respect to θ, and the third verifies under which conditions this is a positive quantity. We assume in this proof that k_t is given .

Step 1. the accurate expression of Y_t.

Let us start with the aggregate production expression

$$Y_t = [\gamma Y_{1t}^{\sigma} + (1-\gamma) Y_{2t}^{\sigma}]^{\frac{1}{\sigma}}.$$

In the case of regulation, we have found that $Y_{1t} = n^{1-\alpha}\theta^{\alpha}\overline{z}k_t^{\alpha}$ and $Y_{2t} = (1-n)^{1-\alpha}(1-\theta)^{\alpha}k_t^{\alpha}$. Substituting Y_{1t} and Y_{2t} into $Y_t = [\gamma Y_{1t}^{\sigma} + (1-\gamma) Y_{2t}^{\sigma}]^{\frac{1}{\sigma}}$ yields

$$Y_t = \left[\gamma \left(n^{1-\alpha}\theta^{\alpha}\overline{z}\right)^{\sigma} + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^{\alpha}\right)^{\sigma}\right]^{\frac{1}{\sigma}} k_t^{\alpha}. \tag{39a}$$

But n is a function of θ. We now use this fact to simplify the above expression for Y_t. From (34), we have that

$$\gamma \left(n^{1-\alpha}\theta^{\alpha}\overline{z}\right)^{\sigma} = \frac{(1-\gamma)\left[1-(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right]}{[(1-\theta)^{\alpha}(1-n)^{1-\alpha}]^{(1-\sigma)}}.$$

Substituting the above expression into (39a) yields,

$$Y_t = (1-\gamma)^{\frac{1}{\sigma}}\left[(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right]^{\frac{(\sigma-1)}{\sigma}} k_t^{\alpha}. \tag{40}$$

Step 2. Derivative of Y_t.

It is appropriate, given the above expression for Y_t, to use logarithmic differentiation:

$$\frac{\partial log(Y_t)}{\partial \theta} = \frac{(1-\sigma)}{\sigma}\left[\frac{\alpha}{(1-\theta)} + \frac{(1-\alpha)\frac{\partial n}{\partial \theta}}{(1-n)}\right]. \tag{41}$$

Step 3. Discussion.

The sign of the above derivative is positive if $\frac{\partial n}{\partial \theta} \geq -\frac{\alpha}{(1-\alpha)}\frac{(1-n)}{(1-\theta)}$; which is exactly condition (37). It follows then from the proof of Lemma 5 that this is always the case. Therefore, $\frac{\partial log(Y_t)}{\partial \theta} \geq 0$. ∎

Proof of Proposition 1

PROOF. The idea of this proof is to differentiate the expression for growth with respect to θ and verify that it is positive. We will split this proof into two steps. The first step provides an expression for growth as a function of θ, the second provides the derivative of economic growth with respect to θ, and verifies under which conditions this is positive. We assume in this proof that k_t is given.

Step 1. Expression for growth as a function of θ

We start with $Y_t = [\gamma Y_{1t}^{\sigma} + (1-\gamma)Y_{2t}^{\sigma}]^{\frac{1}{\sigma}}$, and obtain, as in the proof of Lemma 5, that $Y_t = (1-\gamma)^{\frac{1}{\sigma}}\left[(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right]^{\frac{(\sigma-1)}{\sigma}} k_t^{\alpha}$. Therefore, $\frac{Y_{t+1}}{Y_t} = \left(\frac{k_{t+1}}{k_t}\right)^{\alpha}$. From the definition of equilibrium we have $k_{t+1} = s_t$, but

$$s_t(\tau_t, r_{t+1}) = b(r_{t+1}))\tau_t \tag{42}$$

$$\text{with } b(r_{t+1}) = \frac{1}{1+\left[\beta\,(1+r_{t+1})^{1-\rho}\right]^{\frac{-1}{\rho}}}. \tag{43}$$

Since, at equilibrium, $\tau_t = \tau_{2t}$, from Lemma 3, $\tau_t = (1-\alpha)p_{2t}\left[\frac{\alpha p_{2t}}{r_t}\right]^{\frac{\alpha}{1-\alpha}}$. Besides, $k_t = n\widehat{k}_{1t} + (1-n)\widehat{k}_{2t}$. Using the expressions for $\widehat{k}_{1t}$ and $\widehat{k}_{2t}$ provided by Lemma 3, we obtain

$$k_t = n(1-n)\left[\frac{\alpha B}{r_t}\right]^{\frac{1}{1-\alpha}}. \tag{44}$$

Furthermore, the indifference between technologies condition of entrepreneurs yields

$$n(1-n)B^{\frac{1}{1-\alpha}} = p_2^{\frac{1}{1-\alpha}}. \tag{45}$$

Substituting (45) into (44) yields $k_t = \left[\frac{\alpha p_2}{r_t}\right]^{\frac{1}{1-\alpha}}$. We observe that $\tau_t = (1-\alpha)p_2 k_t^{\alpha}$. Then $k_{t+1} = b(r_{t+1})(1-\alpha)p_2 k_t^{\alpha}$, which implies that the growth rate of capital is given by

$$\frac{k_{t+1}}{k_t} = (1-\alpha)b(r_{t+1})p_2 k_t^{\alpha-1}. \tag{46}$$

With the logarithmic utility function $b(r_{t+1}) = \frac{\beta}{1+\beta}$, so (46) is equivalent to

$$\frac{k_{t+1}}{k_t} = \frac{(1-\alpha)\beta}{1+\beta} p_2 k_t^{\alpha-1}.$$

Step 2. Differentiating growth with respect with θ.

Since, at t, k_t is given, $\frac{\partial\left[\frac{k_{t+1}}{k_t}\right]}{\partial\theta}$ has the sign of $\frac{\partial p_2}{\partial\theta}$. We will now focus on p_2.

We obtain from direct calculation that

$$p_2 = (1-\gamma)\left[\frac{Y_t}{Y_{2t}}\right]^{1-\sigma}.$$

Substituting Y_t and Y_{2t} by their values in the above expression yields

$$p_2 = (1-\gamma)^{\frac{1}{\sigma}}\left[(1-\theta)^{\alpha}(1-n)^{1-\alpha}\right]^{\frac{\sigma-1}{\sigma}} = \frac{Y_t}{k_t^{\alpha}}.$$

Therefore, $\frac{\partial p_2}{\partial\theta}$ has the sign of $\frac{\partial Y_t}{\partial\theta}$. Under the conditions of Lemma 6, $\frac{\partial Y_t}{\partial\theta}$ is always positive. ∎

8.4 Appendix D

Proof of Lemma 7

PROOF. The idea underlying this proof is to use the resource constraint of a bank specialized in the risky technology to show that it cannot fulfill its promise to lenders. At the steady state, the promised interest rate is given by $r = \alpha p_2 k^{\alpha-1}$, it has a constant value, the minimum transfer to entrepreneurs is a positive number $\underline{\tau}$, and τ_{1t} has a constant positive value. Banks cannot meet their promises toward lenders when the unexpected state of nature occurs if resources are less than the promised interest (rk) plus the minimum transfer. i.e.,

$$p_1(z_w) z_w k^{\alpha} < \underline{\tau} + rk. \tag{47}$$

Since $\underline{\tau} > 0$, there exists a positive number κ such that $\underline{\tau} = \kappa\tau_1$, where $\tau_1 = (1-\alpha)p_1(\overline{z})\overline{z}k^{\alpha}$ and $rk = \alpha p_2(\overline{z})k^{\alpha} = \alpha p_1(\overline{z})\overline{z}k^{\alpha}$. Substituting r and $\underline{\tau}$ by their values in (47) yields the following price-ratio inequality,

$$\frac{p_1(z_w)z_w}{p_1(\overline{z})\overline{z}} < \kappa(1-\alpha) + \alpha.$$

Furthermore, the price of the risky intermediate good is given by $p_1 = \gamma Y_1^{\sigma-1}\left[\gamma Y_1^{\sigma} + (1-\gamma)Y_2^{\sigma}\right]^{\frac{1-\sigma}{\sigma}}$; with $Y_1 = nz_w k^{\alpha}$ and $Y_2 = (1-n)k^{\alpha}$. Substituting Y_1 and Y_2 in the above expression for $p_1(z_t)$ yields,

$$p_1(z_t) = \gamma\,(nz_t)^{\sigma-1}\left[\gamma\,(nz_t)^{\sigma} + (1-\gamma)(1-n)^{\sigma}\right]^{\frac{1-\sigma}{\sigma}}.$$

So the price ratio can be rewritten as,

$$\frac{p_1(z_w)z_w}{p_1(\overline{z})\overline{z}} = \left(\frac{z_w}{\overline{z}}\right)^\sigma \left(\frac{\gamma\,(nz_w)^\sigma + (1-\gamma)(1-n)^\sigma}{\gamma\,(n\overline{z})^\sigma + (1-\gamma)(1-n)^\sigma}\right)^{\frac{1-\sigma}{\sigma}}.$$

It follows that (47) is now equivalent to

$$\left(\frac{z_w}{\overline{z}}\right)^\sigma \left(\frac{\gamma\,(nz_w)^\sigma + (1-\gamma)(1-n)^\sigma}{\gamma\,(n\overline{z})^\sigma + (1-\gamma)(1-n)^\sigma}\right)^{\frac{1-\sigma}{\sigma}} < \kappa(1-\alpha)+\alpha. \tag{48}$$

We obtain from $n = \left[1 + \left(\frac{1-\gamma}{\gamma\overline{z}^\sigma}\right)^{\frac{1}{1-\sigma}}\right]^{-1}$ that $\gamma n^{\sigma-1}\overline{z}^\sigma = (1-\gamma)(1-n)^{\sigma-1}$. It then follows by direct calculations that (48) is equivalent to

$$z_w^\sigma((nz_w^\sigma + \overline{z}^\sigma(1-n)))^{\frac{1-\sigma}{\sigma}} < (\kappa(1-\alpha)+\alpha)\overline{z}.$$

Since $z_w < \overline{z}$, when $\sigma > 0$, we have $z_w^\sigma < nz_w^\sigma + \overline{z}^\sigma(1-n) < \overline{z}^\sigma$. Therefore,

$$z_w^\sigma((nz_w^\sigma + \overline{z}^\sigma(1-n)))^{\frac{1-\sigma}{\sigma}} < z_w^\sigma\overline{z}^{1-\sigma}.$$

If $z_w^\sigma\overline{z}^{1-\sigma} < (\kappa(1-\alpha)+\alpha)\overline{z}$, a bank specialized in the risky technology will fail to fulfill its promise. This condition is equivalent to $z_w < (\kappa(1-\alpha)+\alpha)^{\frac{1}{\sigma}}\overline{z}$. We can then take $\underline{z} = \frac{(\kappa(1-\alpha)+\alpha)^{\frac{1}{\sigma}}\overline{z}}{1+\epsilon}$ where ϵ is any small positive number. ■

Proof of Proposition 2

PROOF. This proof is based on the zero profit constraint. We show that under regulation, banks dealing with the type 1 entrepreneurs have enough resources to provide at least the minimum transfer to entrepreneurs and pay the promised interest to lenders.

When the aggregate shock occurs, the total resources of the regulated risky bank is given by $p_1(z_w)nz_w\widehat{k}_1^\alpha + p_2(z_w)(1-n)\widehat{k}_1^\alpha \equiv Y^r(z_w)$. From the expressions for $\widehat{k}_1$ and $\widehat{k}_2$ given by Lemma 3 and direct calculations, we obtain $\widehat{k}_1 = \frac{\theta}{n}k_2$ and $\widehat{k}_2 = \frac{(1-\theta)}{(1-n)}k_2$. Therefore, $n\widehat{k}_1 + (1-n)\widehat{k}_2 = k_2$. The overall interest promised to lenders, $r(n\widehat{k}_1 + (1-n)\widehat{k}_2)$ is then equal to $\alpha p_2(\overline{z})k_2^\alpha$, while the promised transfers are $\tau_2(\overline{z}) = \tau_1(\overline{z}) = (1-\alpha)p_2(\overline{z})k_2^\alpha$.

We need to make explicit the expressions for $p_2(\overline{z})$ and $p_1(z_w)nz_w\widehat{k}_1^\alpha + p_2(z_w)(1-n)\widehat{k}_1^\alpha$ in order to use them in the zero profit constraint analysis. Direct calculations yield

$$\begin{aligned} p_2(\overline{z}) &= (1-\gamma)\left[(1-n)^{1-\alpha}(1-\theta)^\alpha k_2^\alpha\right]^{\sigma-1} Y(\overline{z})^{1-\sigma}, \text{ and} \\ Y^r(z_w) &= \left[\gamma\left(n^{1-\alpha}\theta^\alpha z_w\right)^\sigma + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^\alpha\right)^\sigma\right]^{\frac{1}{\sigma}} k_2^\alpha. \end{aligned}$$

Therefore, saying that when the state ϖ occurs the promised transfers and interests will be less than the available resources (i.e., $rk_2 < Y^{\tau}(z_w) - (1-n)\tau_2 - n\kappa\tau_1$), is equivalent to the following inequality,

$$\alpha + (1-\alpha)\left[(1-n) + n\kappa\right] < \frac{Y^{\tau}(z_w)}{p_2(\overline{z})k_2^{\alpha}}. \tag{49}$$

The explicit form of the right-hand side of the above inequality is,

$$\frac{Y^{\tau}(z_w)}{p_2(\overline{z})k_2^{\alpha}} = \frac{\left[(1-n)^{1-\alpha}(1-\theta)^{\alpha}\right]^{1-\sigma}\left[\gamma\left(n^{1-\alpha}\theta^{\alpha}z_w\right)^{\sigma} + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^{\alpha}\right)^{\sigma}\right]^{\frac{1}{\sigma}}}{(1-\gamma)\left[\left[\gamma\left(n^{1-\alpha}\theta^{\alpha}\overline{z}\right)^{\sigma} + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^{\alpha}\right)^{\sigma}\right]^{\frac{1}{\sigma}}\right]^{1-\sigma}}.$$

We now use functional analysis to obtain a set of regulation coefficients under which no banking crisis can occur. For that purpose, we use inequality (49) to define G, a continuous function of θ, as follows:

$$G(\theta) = \frac{(1-\gamma)\left[\alpha + (1-\alpha)\left[(1-n) + n\kappa\right]\right]}{\left[(1-n)^{1-\alpha}(1-\theta)^{\alpha}\right]^{1-\sigma}} - \left[\frac{\gamma\left(n^{1-\alpha}\theta^{\alpha}z_w\right)^{\sigma} + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^{\alpha}\right)^{\sigma}}{\left[\gamma\left(n^{1-\alpha}\theta^{\alpha}\overline{z}\right)^{\sigma} + (1-\gamma)\left((1-n)^{1-\alpha}(1-\theta)^{\alpha}\right)^{\sigma}\right]^{1-\sigma}}\right]^{\frac{1}{\sigma}}. \tag{50}$$

We also recall that in the proof of lemma 4 (in appendix B), n solves

$$\frac{\gamma\overline{z}^{\sigma}\theta^{\alpha\sigma}}{1-\gamma}n^{(1-\alpha)\sigma}(1-n)^{(1-\alpha)(1-\sigma)}(1-\theta)^{\alpha(1-\sigma)} = 1 - (1-\theta)^{\alpha}(1-n)^{1-\alpha}. \tag{51}$$

Using equations (50) and (51) we obtain that $G(0) = -\gamma$ and $G(n^*) > 0$. Since G is a continuous function of θ, there exists at least one θ_0 such that $G(\theta_0) = 0$. Let us denote by $S \equiv \{\theta \in [0, n^*]/G(\theta) \leq 0\}$ and by $\underline{\theta}$the minimum of θ such that $G(\theta) = 0$, then $(0, \underline{\theta})$ is an open interval included in S.

■

8.5 Appendix E

Figure 10: Comparative Dynamic of a Regulated and an Unregulated Banking Economies

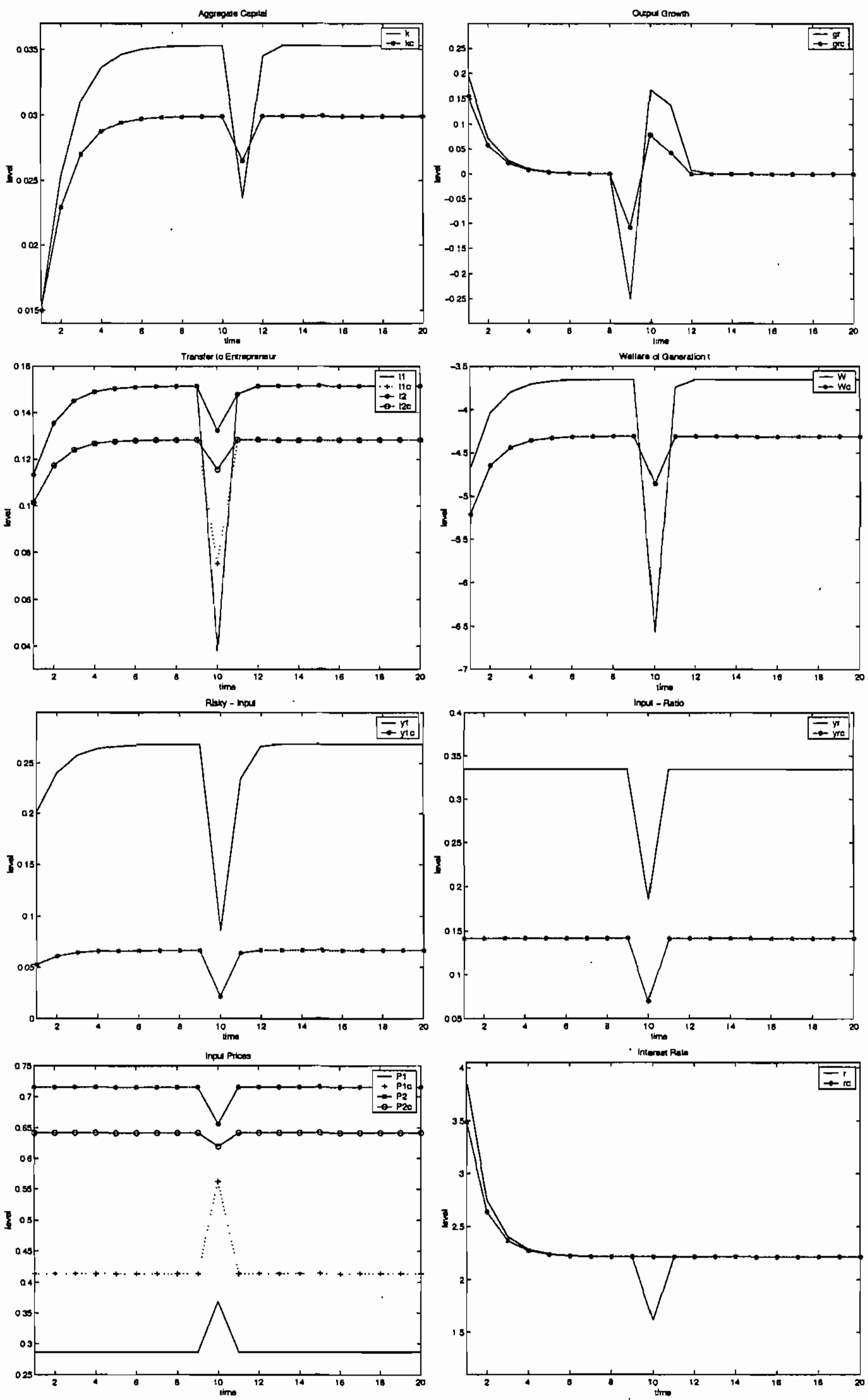
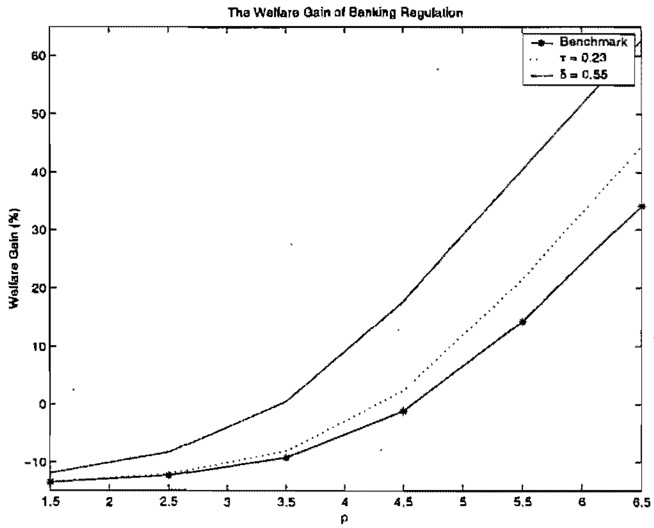


Figure 11: Relative Welfare-Gain



Conclusion générale

Dans le premier chapitre de cette thèse, nous avons passé en revue les études empiriques déjà réalisées sur le lien entre la réglementation bancaire et la stabilité du système bancaire et avons trouvé que ces études présentent le plus souvent des résultats contradictoires. En effet, il existe plusieurs méthodes pour évaluer l'efficacité d'une réglementation donnée. Nous en avons distinguées deux grandes méthodes, la méthode de risque implicite et la méthode de risque explicite. Ces deux méthodes utilisent des techniques économétriques différentes pour effectuer leurs estimations: la méthode de risque implicite repose très souvent sur les modèles à équations simultanées et les modèles de survie; alors que la méthode de risque explicite repose très souvent sur les modèles de régression logit ou probit.

De nombreux travaux se sont consacrés à un nombre restreint de réglementations à savoir l'exigence minimale de fonds propres, l'assurance dépôts, les restrictions à l'entrée, et la surveillance des pratiques dans le secteur bancaire. Jusqu'à présent, ces études n'ont pas réussi à fournir un résultat convaincant quant à l'impact de nombreux types de réglementations sur la stabilité bancaire. Par conséquent, au lieu de fournir une solution aux résultats théoriques conflictuels, ces études empiriques en ajoutent à la confusion. D'autre part, les études utilisant une mesure implicite d'instabilité ne font pas l'unanimité dans le sens que l'exposition au risque couplée à une bonne technique de gestion de risque n'est en aucun cas un signe d'instabilité. Pour les études utilisant la méthode explicite, les résultats sont généralement peu robustes. Ces études souffrent principalement du problème de biais de sélection qui provient de la méthode utilisée pour construire la variable mesurant l'instabilité bancaire.

Dans le second chapitre, nous avons développé une méthode d'estimation moins sujette au problème de biais de sélection et l'avons utilisée pour évaluer empiriquement l'effet de la réglementation bancaire sur la stabilité du système bancaire. Le deuxième objectif a été l'évaluation de l'effet de chaque type de réglementation sur la durée des crises. À cette fin, nous avons développé un modèle à changement de régime Markovien à trois états. Plus précisément, nous avons introduit quatre grandes règlementations (les barrières à l'entrée, l'assurance dépôts, les réserves obligatoires, et les exigences minimales de fonds propres) comme variables explicatives de la probabilité de transition d'un état à un autre afin d'évaluer l'effet de ces règlements sur la fréquence et la durée des crises bancaires systémiques. Nous avons ensuite dérivé analytiquement l'effet marginal de chaque variable exogène sur la probabilité que le système soit dans un état donné. Puis nous avons appliqué notre stratégie au système bancaire Indonésien qui a souffert d'une crise bancaire systémique au cours des deux dernières décennies et où il y a eu une certaine dynamique sur les mesures réglementaires au cours de la même période.

Nous avons trouvé que: (i) les restrictions à l'entrée réduisent la durée des crises et la probabilité d'être dans l'état de crise. Ce résultat est conforme à d'autres résultats disponibles dans la littérature reliant les crises bancaires et l'absence des barrières à l'entrée; (ii) les réserves obligatoires accroissent la fragilité bancaire, mais ce résultat est obtenu uniquement lorsque nous prenons en compte l'existence de l'assurance-dépôts. Dans le même temps, les réserves obligatoires tendent à réduire la durée des crises bancaires; (iii) l'assurance-dépôts augmente la stabilité du système bancaire Indonésien et réduit la durée des crises bancaires; (iv) les exigences minimales de fonds propres améliorent la stabilité et réduisent la durée des crises bancaires.

Nous avons également fourni une idée du biais de sélection existant dans les travaux précédents. Nous avons constaté que les études précédentes présentaient un biais de sélection positif pour l'assurance-dépôts et sur les réserves obligatoires, un bais de sélection négatif pour l'exigence minimale de fonds propres mais pas de biais de sélection concernant les restrictions à l'entrée.

Dans le troisième chapitre de cette thèse nous avons étudié l'impact de la présence de la réglementation bancaire sur la croissance et le bien-être. Dans la première partie nous avons présenté la réglementation bancaire dans le cadre du modèle à générations imbriquées d'accumulation de capital, dans lequel les chocs technologiques sont idiosyncratiques. Le niveau de la réglementation est mesuré par le niveau d'exigence d'adéquation de fonds propres. Dans ce contexte, notre modèle produit plusieurs implications intéressantes. Tout d'abord, l'équilibre concurrentiel est efficace. Deuxièmement, la réglementation bancaire est préjudiciable à l'économie. En fait, il contraint les banques à adapter leur portefeuille de placements aux actifs plus sûrs mais moins productifs.

Ce changement structurel entraîne la réduction de la production et ainsi le revenu des agents économiques. Il s'ensuit une diminution de l'épargne et, par conséquent, de l'investissement.

Dans la deuxième partie, nous avons introduit la possibilité d'un choc technologique non anticipé dans le secteur le plus productif et qui équivaut à une baisse de la productivité globale dans le secteur à risque. Nous avons constaté que dans ce cas, l'économie sera soumise à des crises bancaires et nous avons montré qu'il existe un niveau optimal de fonds propres réglementaires qui est en mesure de prévenir les crises. Bien que ce niveau optimal améliore le bien-être des générations vivant dans la période de crise, il induit généralement une détérioration du bien-être pour les populations vivant en dehors de cette période.

Nous avons calibré le modèle afin de refléter une économie comme celle des États-Unis. Nous avons trouvé qu'il est socialement optimal de réglementer lorsque le régulateur estime qu'un choc se produira bientôt. Cela montre que, même lorsque les crises bancaires sont dues à des chocs de productivité, la réglementation reste utile lorsque l'ampleur et la probabilité du choc de productivité sont suffisamment grandes.

Quand on ne dispose d'aucune information sur la probabilité du choc, la réglementation ne permet d'améliorer le bien-être que lorsque le niveau de l'aversion pour le risque est élevé, plus élevé que les niveaux d'aversion acceptables pour l'économie américaine.

Quelques implications de politiques économiques peuvent être tirées de cette partie. Tout d'abord, puisque l'effet de la réglementation sur le bien-être est fonction du moment où le choc se produit (plus précisément le gain en bien-être est plus grand si le choc se produit juste après l'introduction de la réglementation), il est important pour les régulateurs de prévoir avec un grand degré de précision le moment d'apparition de la crise et d'exiger un plus grand taux de fonds propres lorsque qu'ils estiment qu'une crise est imminente. Par conséquent, nous plaidons pour un régime réglementaire variable dans le temps. Deuxièmement, puisque les lois sur les faillites sont importantes pour savoir si la réglementation bancaire améliore le bien être ou pas et que ces lois varient suivant les pays, nous préconisons un niveau de fonds propres réglementaires variable par pays.