



Three Essays on the Prudential Supervision of the Banking System

Alexandru Monahov

► To cite this version:

Alexandru Monahov. Three Essays on the Prudential Supervision of the Banking System. Economics and Finance. Université Côte d'Azur, 2016. English. NNT : 2016AZUR0025 . tel-01472815

HAL Id: tel-01472815

<https://theses.hal.science/tel-01472815>

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Ecole doctorale DESPEG (ED 513)
Unité de recherche : GROUPE DE RECHERCHE EN
DROIT, ECONOMIE ET GESTION (GREDEG-CNRS/UMR 7321)

Thèse de doctorat

Présentée en vue de l'obtention du
grade de docteur en Sciences Economiques
de
UNIVERSITÉ CÔTE D'AZUR

par
ALEXANDRU MONAHOV

TROIS ESSAIS SUR LA SUPERVISION PRUDENTIELLE DU SYSTEME BANCAIRE

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Soutenue le : 02.12.2016

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Trois essais sur la supervision prudentielle du système bancaire

Résumé

Cette thèse propose une analyse détaillée des effets de la supervision prudentielle (une composante de la réglementation bancaire) sur la stabilité du secteur bancaire, la solvabilité des institutions financières et, au niveau macro-économique, étudie son impact sur le crédit domestique. La méthodologie de recherche adoptée permet l'intégration de l'hétérogénéité dans l'analyse, tant au niveau systémique qu'à celui de l'agent individuel. Des méthodes d'estimation bayésiennes sont à la base de la partie empirique, alors que les sections théoriques utilisent la modélisation multi-agent. Le premier chapitre étudie les effets de la supervision prudentielle sur le crédit domestique dans 27 pays de l'UE. Les résultats montrent qu'une aggravation de la dureté de la supervision produit des effets positifs sur le crédit dans les pays ayant un système de supervision unifié. Le deuxième chapitre étudie les effets de la supervision couplée avec des outils réglementaires « traditionnels » sur la résilience et les profits bancaires dans des conditions de crise de long-terme. Dans ce contexte, les normes prudentielles servent seulement à repousser la faillite de la banque. Les instruments de marché sont efficaces uniquement si une autorité centrale supervise. La taxe est l'instrument le plus puissant car il permet d'assurer la rentabilité bancaire à long terme en favorisant l'adaptation de la banque aux conditions de crise. Le troisième chapitre étudie une fraude financière grave et complexe qui a eu lieu en Moldavie en 2011-2015. Une analyse détaillée des schémas de fraude est présentée. Ensuite, un modèle qui réplique les schémas de fraude est construit pour étudier l'optimalité de la décision de non-intervention de la Banque Centrale. Les résultats montrent qu'une intervention précoce n'aurait pas minimisé les pertes du système bancaire, mais que la Banque Centrale aurait pu améliorer la situation en intervenant quand l'exposition du secteur aux fraudeurs était minimale.

Mots clé : Supervision prudentielle ; Supervision dans l'UE ; Supervision du système bancaire ; Réglementation des institutions financières ; Estimateurs de régression bayésiens ; Modélisation Multi-Agent ; Simulation Multi-Agent ; Intervention de la Banque Centrale.

Three Essays on the Prudential Supervision of the Banking System

Abstract

This thesis aims to provide an in-depth analysis of the effects of prudential supervision (a component of banking system regulation) on the stability of the banking sector, the soundness of financial institutions and, at a macro-economic level, its impact on domestic credit. The adopted research methods facilitate the integration of heterogeneity at the systemic and individual-agent levels into the analysis. Bayesian estimation techniques are used in the empirical part, whereas the theoretical sections utilize agent-based modeling. The first chapter studies the effects of prudential supervision on domestic credit in 27 EU countries. The results show an increase in supervisory stringency to produce a positive effect on credit in countries with unified supervisory frameworks. The second chapter investigates the effects of prudential supervision coupled with “traditional” regulatory tools on bank resiliency and profits under long-lasting crisis conditions. In this context, prudential norms only postpone the failure of the bank. Market-based instruments are only effective in the presence of supervision by a central authority. Taxes are found to be the most efficient tool as they potentiate profitable bank operations on the long-run by allowing the bank to adapt to the crisis conditions. Finally, the third chapter provides a case-study of a severe and complex financial fraud that took place in Moldova in 2011-2015. A detailed analysis of the perpetrated fraud schemes is presented. Furthermore, an agent-based model that replicates the schemes is constructed to study the optimality of the Central Bank's decision to not intervene. The results show that early intervention wouldn't necessarily have minimized the financial losses of the banking sector, but that the Central Bank could have improved the outcome of the crisis by intervening when the exposure of the banking sector to the fraudsters was minimal.

Keywords: Prudential supervision; Supervision in the EU; Banking system supervision; Financial institution regulation; Bayesian shrinkage estimator; Agent Based Modeling; Multi-Agent Simulation; Financial fraud; Central Bank intervention.

L'université n'entend donner aucune approbation ni improbation aux opinions émises dans les thèses : ces opinions doivent être considérées comme propres à leurs auteurs.

Remerciements :

J'aimerais commencer en dédiant quelques lignes pour remercier les personnes qui m'ont encouragé et aidé à parcourir le chemin, parfois tumultueux, dont la finalité est la réalisation de cette thèse.

Avant tout, j'aimerais exprimer ma plus profonde, sincère et inépuisable gratitude au Pr Thomas Jobert qui a été non seulement un excellent directeur de thèse, mais aussi un mentor et un guide qui m'a introduit au monde de la recherche. Par sa perspicacité, rapidité et éthique de travail infailible, il m'a aidé à organiser et structurer le travail que j'ai effectué. Un éternel optimiste, humaniste et un très bon psychologue – il a su comment gérer les circonstances et aborder les défis qui se sont présentés. Chaque rencontre avec lui était une opportunité d'apprendre quelque chose de nouveau car le Pr Jobert est un spécialiste du plus haut niveau avec une intuition économique impeccable issue de sa vaste expérience. Enfin, rencontrer une personne tellement intelligente, dévouée et bienveillante comme le Pr Jobert est un événement rare, qui peut-être n'a lieu qu'une fois dans la vie. Je suis honoré et infiniment remercient d'avoir eu cette chance.

J'aimerais aussi prendre un moment pour remercier mes parents qui ont soutenu mes aspirations professionnelles, qui m'ont offert leur assistance à chaque fois que la situation l'a nécessité et qui m'ont toujours encouragé à aller plus loin, à franchir des frontières et à devenir le meilleur dans tout ce que je fais. C'est grâce à leurs efforts et sacrifices que j'ai eu les opportunités qui m'ont amenés jusqu'ici.

J'aimerais aussi remercier l'Université de Nice « Sophia Antipolis » pour l'ouverture d'esprit et la curiosité académique qui ont donné la possibilité à un étudiant étranger de réaliser sa thèse en France, au même titre qu'un français, et en réjouissant des mêmes opportunités.

En même temps, je souhaite exprimer ma plus sincère gratitude au Professeur Patrick Musso, le directeur du GREDEG, laboratoire qui m'a accueilli, ainsi qu'à l'ensemble de l'équipe administrative qui a assuré le bon fonctionnement du laboratoire. J'aimerais aussi remercier Pr Olivier Bruno, ainsi que Patrice Bougette et Frédéric Marty, responsable du projet structurant « Stratégies et Régulation des Marchés » auquel j'ai été rattaché, mais aussi l'ensemble de la communauté des chercheurs du GREDEG pour l'animation des séminaires et conférences qui m'ont permis de mettre en pratique les connaissances théoriques acquises.

Finalement, je souhaiterais remercier les membres du jury, à savoir les Professeurs Dominique Torre, Etienne Farvaque, Murat Yildizoglu et Mauro Napoletano pour leur acceptation de participer à cette soutenance de thèse.

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INTRODUCTION GENERALE

Le développement intensif de la finance durant ces dernières décennies s'est accompagné d'une prise de risque de plus en plus importante dans la sphère financière, et notamment de la part des banques. Celle-ci a été rendue possible par la hausse graduelle du levier financier des institutions bancaires, l'implication de plus en plus active des banques sur les marchés financiers, et la multiplication des innovations financières (titrisation des créances, création de produits dérivés, etc.). Pourtant, ces mutations, qui auraient dû donner lieu à une mise à jour et réorganisation des règles gouvernant la prise de risque (la réglementation prudentielle), ont été très souvent ignorées dans la période de la Grande Modération¹. Ainsi, l'accumulation de défaillances réglementaires permettant aux institutions financières d'assumer de plus en plus de risques a amené au déclenchement d'une crise financière grave en 2007 – 2009 qui avait commencé aux Etats-Unis par la crise des subprimes² et qui s'est ensuite propagé au reste du monde à travers les fortes interconnexions transcontinentales existantes entre les institutions du secteur financier. Afin d'éviter l'apparition d'une crise similaire dans l'avenir, le Comité de Bale, une institution réglementaire internationale, a proposé un remaniement de la réglementation prudentielle, avec de nouveaux instruments et indicateurs capables de mieux quantifier le risque et de prévenir son accumulation.

La réglementation prudentielle représente un ensemble de politiques et de dispositions juridiques qui ont pour but la réduction du risque encouru par les institutions financières, ainsi que par le système financier dans sa totalité. Cette réglementation a connu depuis la crise de 1929 différentes phases résumées dans la Figure 1.1.

La phase de constitution d'une réglementation prudentielle structurée a débuté en 1933 avec l'introduction de l'Acte Glass-Steagall séparant l'activité de détail de celle d'investissement des établissements bancaires. Ensuite, pendant toute la période des trente glorieuses, la

¹ Période de très faible volatilité des principales variables macro-économiques comprise entre le milieu des années 1980 et le début du nouveau millénaire.

² aux Etats-Unis, la crise des subprimes est associée à la tendance des institutions bancaires à accorder des crédits non-performants aux ménages dont le revenu ne permettait pas de rembourser le prêt et qui, pour cette raison étaient nommées « subprimes » (ce qui, en traduction, signifie « de niveau bas », ou « de qualité moindre »). Afin d'éviter la dégradation de leurs indicateurs prudentiels, les banques se débarrassaient souvent de ces crédits subprimes par le biais de la titrisation des créances ou de la cession d'actifs. Ces pratiques qui ont servi seulement à cacher le risque et non à l'éliminer, sont à l'origine de la crise financière profonde qu'a connu le monde en 2007 – 2009.

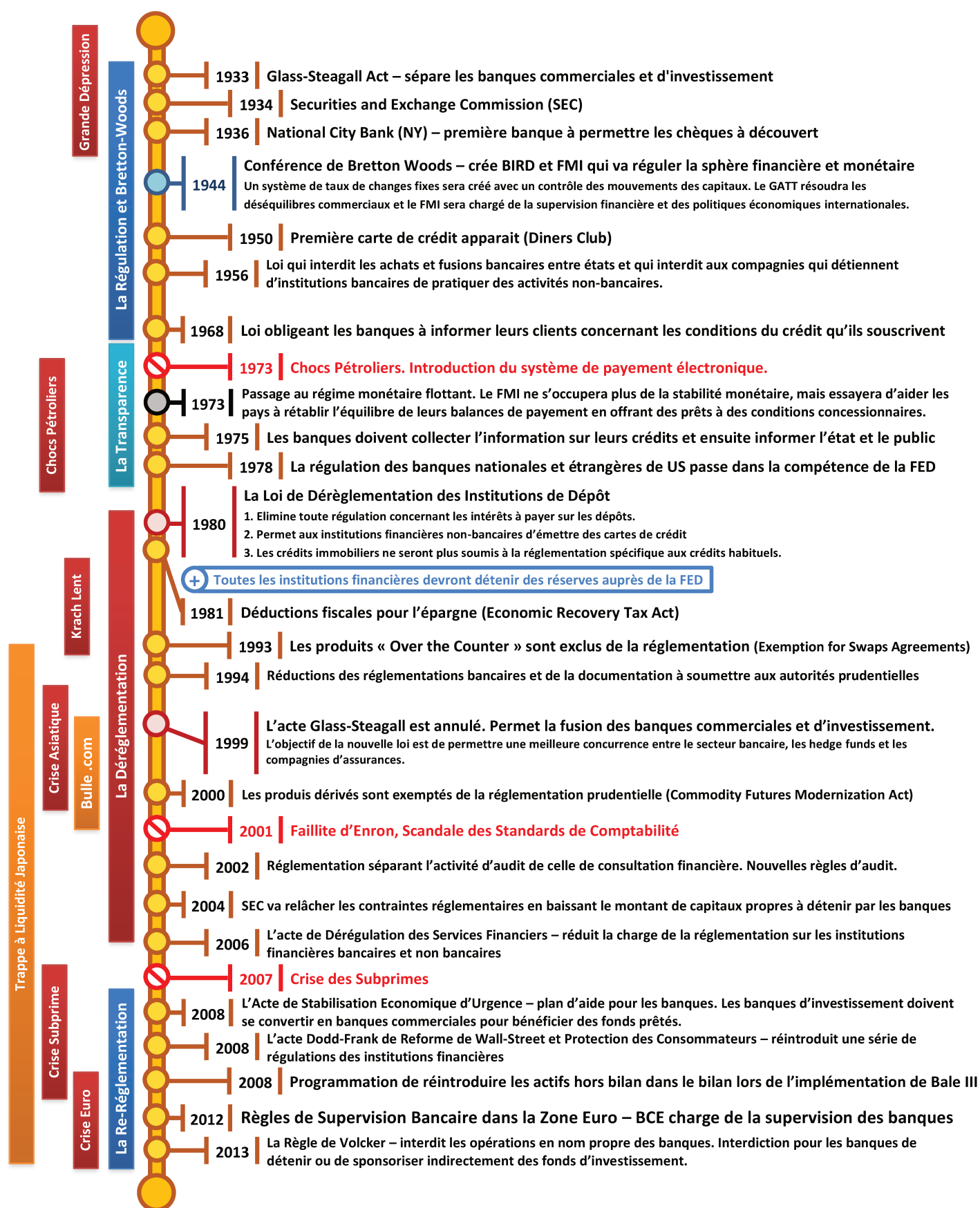
régulation de la sphère financière a connu un développement graduel mais stable, de nouvelles institutions et règles étant créées. L'effondrement du système de Bretton Woods a conduit au démantèlement très rapide du cadre réglementaire entrepris au nom de l'efficience des marchés financiers. Ce processus a culminé au tournant du nouveau millénaire avec l'abrogation de l'Acte de Glass-Steagall et l'exclusion des produits dérivés de toute réglementation prudentielle. Ceci a pavé la voie pour un développement précipité et incontrôlable des innovations financières conduisant à la crise de 2008.

Suite à cette crise, la nécessité d'une réglementation prudentielle a refait surface au sein de la communauté scientifique, de la sphère publique, mais aussi dans la société civile. Pour répondre au besoin de contrôler les risques encourus par les institutions financières, une clarification des objectifs et des fonctions de la réglementation prudentielle est apparue. De même, une spécification du cadre institutionnel et des prérogatives des établissements chargés de la politique prudentielle est devenu impérative.

De plus, la crise de 2008 a souligné l'importance d'un déterminant-clé de la stabilité du secteur financier auparavant ignoré : la prise de risque systémique. En effet, à travers l'enchaînement des événements qui se sont produits après l'apparition de la crise, les communautés scientifiques et réglementaires se sont rendues compte des effets néfastes d'une potentielle faillite généralisée des institutions financières.

Pour mieux gérer la composante systémique du risque il est apparu nécessaire d'ajouter à la réglementation micro-prudentielle traditionnelle, une réglementation macro-prudentielle. En effet, la réglementation micro-prudentielle s'occupe de la réduction du risque spécifique, individuel encouru par chaque institution financière. L'établissement bancaire constitue le centre de l'analyse et le risque (exogène) agit sur l'institution. L'objectif de cette réglementation est d'aider la banque à se préparer à un choc défavorable. De son côté, la réglementation macro-prudentielle doit étendre le champ d'action de la régulation au-delà de l'institution individuelle. Ainsi, le centre de l'étude se déplace de chaque établissement bancaire vers le système financier dans sa totalité. La réglementation macro-prudentielle comprend que les actions collectives des institutions financières ont un impact sur le risque systémique et la stabilité du système financier dans sa globalité. Ainsi, l'objectif de la réglementation devient, au-delà de ses tâches traditionnelles de la préparation de l'institution au risque spécifique, d'agir sur le comportement des institutions de façon à réduire le risque systémique et à éviter les récessions.

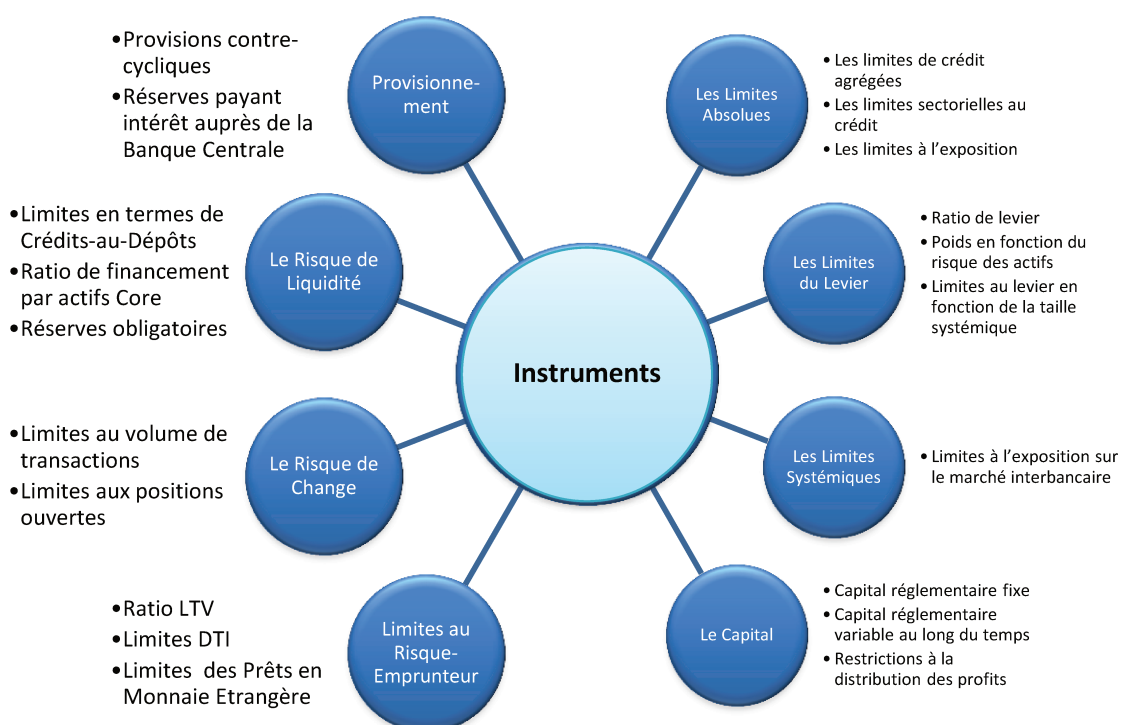
Figure 1.1. Chronologie de la réglementation et déréglementation financière



Sources : sur la base de: US Commodity Futures Trading Commission (2012), CEPR (2009), Tufts Archive (2009), FMI (2012), Thomson Reuters (2012), Library of Congress THOMAS (2010), Federal Deposit Insurance Corporation (2010)

La réglementation prudentielle est, en règle générale, confiée à une autorité prudentielle qui est chargée de la stabilité du secteur financier. Cependant, il existe plusieurs configurations réglementaires possibles. Dans les pays de l'Europe occidentale qui ont historiquement manifesté une tendance à centraliser le pouvoir dans des institutions nationales, les prérogatives de la réglementation prudentielle ont souvent été assumées par les Banques Centrales. D'autres parts, aux Etats-Unis, Royaume Uni et en Europe de l'Est, les fonctions prudentielles sont exercées par une ou plusieurs autorités, indépendantes des objectifs et politiques de la Banque Centrale. Cependant, la littérature n'arrive pas à mettre en avant un système clairement supérieur à l'autre, les deux comportant des avantages et inconvénients, qui sont discutés dans Schoenmaker (2011), Cihak et Podpiera (2008) ou Pellegrina et al. (2013). Alors qu'un système dominé par la Banque Centrale permet une meilleure coordination entre les politiques monétaires et prudentielles, il est sujet à l'aléa moral (car, en absence d'institutions qui pourraient s'entre contrôler, les dirigeants de la Banque Centrale sont libre à poursuivre toute politique souhaitée sans pouvoir être contestés) et aux objectifs conflictuels (lorsque la banque Centrale doit poursuivre une politique monétaire allant à l'encontre de la politique prudentielle nécessaire pour assurer la stabilité du secteur financier – ceci étant notamment le cas lorsque la Banque Centrale souhaite implémenter des politiques macro-prudentielles contre-cycliques).

Figure 1.2. Instruments de la Réglementation Prudentielle



La Figure 1.2 résume les principaux instruments de la réglementation prudentielle, par groupe.

Le système comportant des autorités prudentielles indépendantes a l'avantage d'être plus ciblé, chacune des autorités étant responsable du domaine financier lui étant confié : la réglementation des marchés financiers, la stabilité du secteur bancaire, la concurrence des entreprises ou le marché de l'assurance. Dans un tel système, le temps de réaction face à des distorsions ou crises peut être plus rapide, mais l'étendue de l'intervention est plus faible à cause des compétences limitées de chacune des autorités. Un autre inconvénient de ce système provient des défauts de coordination qui peuvent apparaître entre les institutions prudentielles et la Banque Centrale.

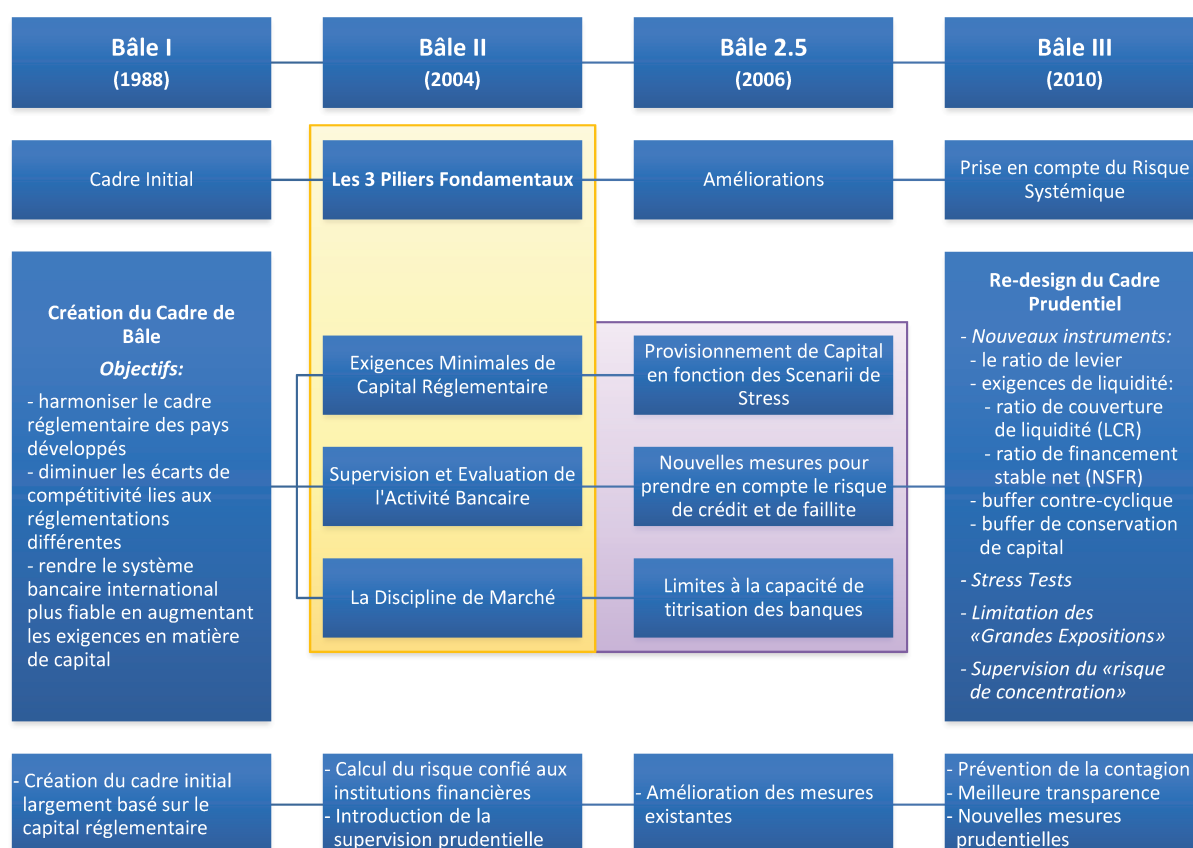
En termes d'instrumentaire, indicateurs prudentiels et méthodes de supervision et d'intervention, à ce jour, dans le monde, il existe de multiples cadres prudentiels qui manifestent, cependant, certains traits communs. Ainsi, dans la plupart des pays, on retrouve le capital réglementaire, le ratio de levier et les réserves obligatoires comme paquet minimal d'instruments prudentiels. A travers le temps, la recherche dans le domaine de la réglementation ainsi que la pratique des autorités prudentielles ont relevé l'existence d'autres indicateurs et outils, mais aussi des nouvelles méthodes de calcul et de mise en œuvre des instruments existants. Un résumé visuel de ces avancées est présenté dans la Figure 1.2. Un grand rôle dans le développement et la systématisation des outils prudentiels a été joué par le Comité de Bâle qui est un forum réunissant les principales autorités prudentielles des pays développés. Les principales décisions en matière de réglementation et de supervision du secteur financier sont prises dans le cadre de ce format qui s'est de plus en plus institutionnalisé. Ainsi, le Comité de Bâle a proposé, à travers le temps, plusieurs cadres réglementaires de niveau international visant à :

- adapter les mesures prudentielles existantes aux nouveaux défis de la sphère financière dont le développement a rapidement accéléré pendant ces dernières décennies avec la création de produits financiers de plus en plus complexes et « innovants » qui ont rendu plus difficile l'évaluation et le suivi des risques assumés par les institutions financières.
- proposer des nouveaux outils et indicateurs permettant de mieux suivre les risques encourus par le système bancaire

- harmoniser le cadre réglementaire des pays développés pour assurer une meilleure mobilité des capitaux, transparence et confiance dans le système, et prise en compte des risques à l'échelle globale.

La Figure 1.3 présente les principales phases de développement de l'instrumentaire prudentiel utilisé par les Banques Centrales. Ces phases correspondent aux Accords de Bâle, qui représentent des conventions signées par les responsables des finances en provenance des pays développés et par les principaux acteurs du système financier mondial – réunis pour trouver des outils et indicateurs compréhensifs capables d'élucider³, de quantifier, et de limiter le risque encouru par les institutions financières.

Figure 1.3. *L'évolution du cadre réglementaire international*



³ le développement mondial de la finance a vu apparaître des produits financiers de plus en plus complexes, comportant des titres et/ou obligations de différents niveaux de risque, maturités, en provenance d'acteurs issus de différents marchés – fusionnés dans des produits unitaires dont le risque (et la nature-même du produit) étaient difficilement appréhendables.

La Figure 1.3 *montre l'évolution* du cadre réglementaire international dans le temps. *A travers plusieurs accords successifs, le comité de Bâle essaye d'adapter la réglementation* prudentielle aux nouveaux défis avec lesquelles se confronte la finance. Des nouvelles mesures du risque, instruments prudentiels et méthodes de calcul sont proposés à chaque reprise.

Initialement, le Cadre Bâle visait à limiter le risque encouru par les institutions financières principalement à travers le capital réglementaire. Le cadre visait à unifier les mesures et les exigences en matière de capital à détenir par les banques des pays signataires. Malgré un succès initial qui s'était traduit par une meilleure résistance aux chocs des banques suite aux buffers de capital⁴ accrus, les institutions financières avaient trouvé des moyens d'échapper à la nouvelle réglementation qui était perçue comme étant une restriction à l'activité bancaire. Afin de combattre ce phénomène de contournement de la réglementation, le nouveau cadre Bale II avait redéfini les objectifs et l'esprit de la réglementation prudentielle en mettant en avant les trois piliers fondamentaux destinés à assurer la stabilité du secteur financier. Une concession est accordée aux banques sous la forme d'une provision de l'accord permettant aux institutions financières d'évaluer le risque à travers des modèles internes non-sujets à la divulgation. Ainsi, les tampons de capital à détenir pour des raisons prudentiels commencent à être calculés sur la base des modèles internes et, donc, sortent partiellement du contrôle des régulateurs. En même temps, c'est à ce point de l'évolution du cadre réglementaire international que la supervision prudentielle est introduite. Cependant, le développement rapide des innovations financières et l'avènement d'une nouvelle tendance bancaire de cession des actifs risqués à des institutions financières de gestion d'actifs contrôlés par la banque – ont à nouveau poussé les limites de la réglementation qui s'est montrée insuffisante pour contenir les risques associés à ces activités. La crise de 2007 – 2009 fut une conséquence directe de la défaillance du cadre réglementaire. En particulier, les constats des autorités prudentielles internationales ont souligné l'insuffisance de liquidités⁵ et la contagion systémique⁶ comme causes principales de la crise. Ainsi, le nouveau cadre Bale III fut conçu

⁴ le terme « buffer de capital » fait référence à un montant-tampon de capital prudentiel réservé par la banque au-delà des exigences normatives établies par l'autorité réglementaire.

⁵ voir Borio (2009) qui présente une revue des défaillances qui ont été trouvées et qui propose certaines solutions.

⁶ voir Bekaert et al. (2011) qui présentent un rapport de la BCE sur la contagion systémique qui a eu lieu dans la période de la crise ou Ozkan et Unsal (2012) qui traitent dans une étude du FMI de l'effet de la contagion et des crises financières sur les pays en cours de développement.

comme une ré-imagination du cadre prudentiel avec un retour en puissance des modèles standardisés de calcul du risque, un focus accru sur la transparence et l'introduction de multiples instruments et mesures prudentielles visant à mieux gérer les différents aspects du risque encouru par les banques. Des ratios de liquidité et de levier ont été introduits pour la première fois et des nouveaux ratios de capital (y inclus des buffers contre-cycliques) ont été proposés. Finalement, la nouvelle réglementation a aussi mis l'accent sur les institutions systémiquement importantes, les stress tests, et la limitation des « grandes expositions » des institutions bancaires.

Cependant, malgré l'arrivée d'un nombre significatif de nouveaux instruments prudentiels, le problème de l'effet restrictif de la réglementation sur le crédit est resté pratiquement inchangé. Effectivement, la plupart des nouveaux outils proposés dans la littérature⁷ continuent à aboutir à l'objectif de réduction du risque par le même canal que celui des instruments « traditionnels » - celui du crédit. Ces outils reposent fondamentalement sur le même principe visant à limiter la capacité des banques d'émettre des crédits afin de limiter le risque auquel elles sont exposées. Un nombre très restreint de nouveaux outils vise à éliminer cet effet secondaire indésirable en cherchant d'autres canaux par lequel le risque pourrait être réduit. Dans le cadre de cette thèse, je me focaliserai sur l'un de ces outils – la supervision réglementaire utilisée comme instrument prudentiel.

La supervision, dans le système financier, représente un processus par lequel une autorité habilitée par le gouvernement assure un suivi et une évaluation des institutions financières dans le but d'assurer leur sûreté, solvabilité et conformité avec les normes prudentielles en vigueur (qui peuvent être élaborés par l'autorité réglementaire ou qui peuvent constituer des normes internationales auxquelles le pays a souscrit à l'issue d'une convention). Les objectifs de la supervision financière sont de :

- assurer la stabilité du système financier
- assurer le bon fonctionnement des institutions bancaires et des marchés financiers
- protéger les consommateurs contre la conduite inadéquate des gestionnaires des institutions financières qui pourrait conduire, à travers une prise de risque excessive, à la faillite bancaire ou aux fluctuations déstabilisatrices des valeurs sur les marchés.

⁷ on peut faire référence aux travaux comme Agénor et da Silva (2014), Martinez-Miera et Suarez (2011) ou Angelini et al. (2011).

Tableau 1.1. Avantages et inconvénients des formes de supervision, en fonction de l'appartenance systémique

Système de supervision		Autorité responsable de la supervision	Avantages et inconvénients	
Sectorielle		Multiples autorités prudentielles	+	Suivi minutieux de son propre domaine
			+	Temps rapide de réaction
			–	Défauts de coordination par manque d'accès aux données (issues d'autres secteurs)
Multi-Secteur	Intégrée sans rôle pour Banque Centrale	Une autorité prudentielle	o	Meilleure coordination et accès au données que dans le cas su système sectoriel et un temps de réponse plus rapide que dans le cas du système fonctionnel.
	Intégrée avec rôle pour Banque Centrale		+	Accès aux données de tous les secteurs financiers (niveau supérieur de coordination)
	Fonctionnelle		+	Possibilité de détecter les liens ou interconnexions systémiques
			–	Le volume important de données alourdit le suivi

source : basée sur Schoenmaker (2011), Caprio (forthcoming).

Le Tableau 1.1 montre les avantages et inconvénients des différentes formes de supervision, en fonction des institutions chargées de la supervision du secteur financier et du système adopté.

La supervision dans le secteur financier peut être accomplie par des différentes institutions, en fonction du cadre réglementaire adopté par le pays. Ainsi, la supervision peut être accomplie par : la Banque Centrale ; une autorité prudentielle chargée de la réglementation de tous les secteurs financiers ; un ensemble d'autorités prudentielles qui supervisent chacune le secteur financier qui leur est confié ; ou bien un couple Banque Centrale – Autorité(s) Prudentielle(s). Le Tableau 1.1 présente les avantages et désavantages des différentes formes de supervision.

La « supervision prudentielle comme outil » vise à adopter un certain niveau de dureté dans la suivie et intervention des autorités réglementaires afin d'induire l'institution ciblée à adopter un comportement moins risqué. L'effet ne passe pas forcément par une baisse du volume de crédits octroyé, mais repose plutôt sur une hausse de la qualité du crédit accordée à travers : une meilleure sélection des bénéficiaires, un contrôle plus rigoureux de la part des institutions émettrices, une diversification du portefeuille des crédits, etc. Une mesure de cet outil est déjà utilisée dans les études de la Banque Mondiale et représente une innovation qui pourrait potentialiser une révision des instruments prudentiels existants à cause de l'effet positif que peut produire l'instrument sur le crédit - effet que j'étudie dans l'un de chapitres de la thèse. Les résultats encourageants de cette thèse confirment que pour les prochaines révisions des cadres réglementaires de la Commission de Bale, un objectif-clé sera de trouver un instrumentaire prudentiels capable à réduire la prise de risque, mais sans pour autant diminuer la capacité des banques à créditer les agents de l'économie.

Ainsi, l'objectif de ma thèse est d'analyser l'utilisation de la supervision comme outil de la réglementation prudentielle au niveau européen et de construire des modèles capable à quantifier les effets de la réglementation sur : la prise de risque, le crédit et les indicateurs de rentabilité des banques. Un apport majeur de cette thèse par rapport à la littérature existante est la prise en compte de l'hétérogénéité des systèmes et des agents dans la construction des modèles. Du côté théorique, l'analyse de la réglementation prudentielle dans le cadre des modèles DSGE traditionnels se fait à l'aide des « agents représentatifs » qui sont des constructions rigides consistant à incorporer tous les acteurs économiques d'une certaine branche en une seule entité, qui à travers des opérations d'optimisation déterminent les

valeurs des variables recherchées. En revanche, la modélisation multi-agent que j'adopte pour les chapitres théoriques de ma thèse me permet d'intégrer l'hétérogénéité des agents au niveau micro-économique, la variété de leurs processus décisionnels, ainsi que leurs interactions sans devoir passer obligatoirement par des processus d'optimisation, mais plutôt en faisant appel aux algorithmes d'adaptation, d'apprentissage et de réaction face aux défis – comportements qui semblent plus proches de la réalité que l'optimisation. Au niveau empirique, les modèles économétriques traditionnels ont aussi du mal à intégrer l'hétérogénéité dans l'analyse des variables. Ainsi, lorsqu'on étudie des données ou les effets des variables exogènes sur la variable expliquée diffèrent par pays, région ou secteur économique – on risque, en utilisant les modèles traditionnels de ne pas repérer des liens significatifs entre les variables. On peut, donc, être induit à penser qu'il n'y a pas de lien de causalité entre des variables qui sont en effet interconnectées. Pour éviter de commettre cette erreur, dans le premier chapitre empirique, on utilise des modèles économétriques bayésiens qui nous permettent spécifiquement d'intégrer l'hétérogénéité dans l'analyse des données, et en ce faisant, de trouver des groupes de pays qui manifestent des similarités en termes des effets des variables de la supervision prudentielle sur le crédit domestique.

En tant qu'outil méthodologique principal utilisé dans l'élaboration des modèles théoriques que je présente dans le deuxième et troisième chapitre de la thèse, j'ai sélectionné la Modélisation Multi-Agent. Lorsqu'on parle de Modèle Multi-Agent, encore connu sous le nom de Modèle Basé sur les Agents et ayant dans le monde anglo-saxon l'abréviation ABM, on sous-entend la construction d'un système économique ou social complexe, peuplé d'agents divers avec des comportements prédéfinis ou adaptatifs, situé dans un environnement particulier et comportant un nombre de règles définissant le changement de l'état du système – dans lequel on effectue des simulations afin de tester des hypothèses, comportements ou politiques. Cette définition n'offre qu'un aperçu très général des possibilités qu'ouvre la modélisation multi-agent à l'analyse économique et financière de la réglementation prudentielle du système bancaire dans un cadre théorique.

L'écriture d'un modèle multi-agent repose en règle générale sur la programmation informatisée, accompagnée d'un certain nombre de formules mathématiques qui sont à la base des comportements des agents ou qui représentent des lois économiques, financières et comptables. La structure d'un modèle multi-agent comporte trois aspects principaux :

- L'environnement global

- Les agents et leurs comportements
- L'aspect simulé (variables, politiques, hypothèses etc. à tester)

La modélisation multi-agent reste un domaine relativement récent, mais qui prend de plus en plus d'ampleur dans la recherche issue des Banques Centrales comme la Bundesbank et la Banque de Japon. Ces institutions utilisent cette forme de modélisation pour étudier les politiques monétaires et prudentielles des Banques Centrales, ainsi que, plus globalement, pour effectuer des expériences sur les politiques économiques et financières.

Une alternative méthodologique plus « traditionnelle » permettant de mener une analyse des politiques monétaires et prudentielles est celle des modèles Dynamiques Stochastiques d'Equilibre General (dont l'abréviation anglo-saxonne est : DSGE) ou encore les modèles Computables d'Equilibre General (CGE). Ces formes de modélisation ont largement été accusées d'avoir menés à la crise financière de 2007 – 2009 par leur : incapacité de produire des estimations fiables dans la proximité des points de retournement, l'inadaptation de leur usage en temps de crise, leur inhabilité de prendre en considération les caractéristiques environnementales des économies étudiées, leur rigidité structurelle responsable d'une récurrence accrue de certaines constructions et formalisations dans les modèles proposés, leur usage des agents représentatifs, et ainsi pour l'impossibilité de prendre en compte la diversité des agents et de leurs comportements.

La Modélisation Multi-Agent permet de créer des économies virtuelles comportant un grand nombre d'agents individuels (ou agrégés) remplissant toute fonction économique ou financière concevable : clients, entreprises, banques, compagnies d'assurance, gouvernements, régulateurs, etc. Dans le cadre de ces modèles, chaque agent peut avoir un comportement individuel et une réaction personnalisée aux événements. Les agents peuvent interagir de manière complexe. Ils peuvent créer, maintenir et rompre des relations en fonction de leurs intérêts et objectifs. Ces comportements et interactions donnent lieu à des modifications de variables individuelles qui peuvent ensuite être agrégées pour déterminer l'état du système. On parle dans ce cas, de modèles macro-économiques micro-fondés. Dans ce type de modèles il est possible de mener une analyse des politiques économiques et financières, et dans le cas de Banques Centrales – des décisions monétaires et prudentielles. Un rôle important dans les modèles multi-agent est joué par l'irrationalité dont les agents peuvent faire preuve dans leur processus de prise de décision. C'est un atout important de ce type de modèles, car la littérature théorique a depuis longtemps stipulé que le comportement des

agents n'est pas complètement rationnel, en particulier pendant les épisodes de crise. Ainsi, il est bénéfique de pouvoir mener une analyse macro-économique dans un cadre où il est possible d'intégrer les « tâches solaires » et les « comportements grégaires ». En même temps, la modélisation multi-agent permet aux agents de changer leurs comportements à travers des algorithmes d'apprentissage et des formes d'intelligence artificielle. Ainsi, les agents peuvent agir de manière inattendue, et des conclusions peuvent être faites sur les différentes manières de résoudre un problème ou de prendre une décision.

En général, pour l'analyse du secteur financier et bancaire, les principaux atouts des modèles multi-agent par rapport aux autres formes de modélisation sont :

- la possibilité d'incorporer des traits individuels aux agents issus d'une typologie prédéfinie
- la facilité de créer des réseaux d'agents par lequel les individus peuvent échanger ou communiquer
- la possibilité d'étudier les interactions entre agents dans un environnement compétitif
- la facilité d'intégrer des modèles d'autres typologies dans les outils numériques d'analyse (i.e. possibilité d'incorporer des modèles comptables, économétriques, etc.)
- la possibilité d'effectuer des tests de robustesse en présence d'aléas, ce qui renforce la crédibilité des modèles proposés.

A nouveau, le grand atout de l'usage des modèles multi-agent par rapport aux modèles traditionnels est la possibilité d'incorporer l'hétérogénéité dans la structure des agents et dans leurs comportements. La prise en compte de l'hétérogénéité nous permet de faire des simulations dans des conditions plus proches de la réalité et d'effectuer une analyse macro-économique après avoir étudié les comportements et interactions au niveau micro. Ainsi, en prenant en considération les avantages des modèles multi-agent, ainsi que les limites des autres instruments alternatifs, on peut affirmer que le choix de la Modélisation Multi-Agent comme outil méthodologique, permet d'entreprendre une analyse plus riche et profonde de la réglementation prudentielle du secteur bancaire que ce qui aurait été possible avec tout autre instrumentaire.

La thèse se structure en trois chapitres. Le premier chapitre s'interroge sur les effets de la supervision prudentielle sur le crédit domestique dans 27 pays de l'Europe, l'objectif étant de déterminer si la supervision réussit à éviter les effets restrictifs que produisent les autres outils pruden- tiels sur le crédit. Dans ce premier chapitre, l'avantage de l'utilisation des

modèles économétriques bayésiens est de nous permettre de repérer trois groupes de pays qui sont différemment affectés par la supervision prudentielle – certains manifestant un accroissement du crédit domestique lors d'un durcissement de la supervision alors que d'autres ne manifestaient pas d'effet ou voyaient une baisse du crédit. Le second chapitre analyse l'impact de la supervision prudentielle introduite à côté de trois instruments réglementaires « traditionnelles » sur la résilience et la rentabilité des banques dans le contexte d'une crise financière de longue durée. La modélisation multi-agent nous permet de simuler, dans des conditions plus réalistes, le fonctionnement et la réaction des banques face aux chocs. Le cadre multi-agent nous permet aussi d'étudier l'effet d'un choc persistant (ou de longue durée) – ce qui est plus difficile à faire dans un cadre traditionnel. Finalement, le troisième chapitre présente une étude de cas d'un épisode de fraude financière qui s'est produit dans le secteur bancaire de la Moldavie. L'étude se focalise sur le rôle joué par les mesures prudentielles de la santé des banques dans le choix d'intervention (ou non) de l'institution superviseuse. Le choix de la modélisation multi-agent comme outil méthodologique se montre particulièrement efficace car il permet de créer le marché interbancaire et de simuler les opérations qui ont lieu entre institutions financières. Il permet aussi d'intégrer des comportements concurrentiels dans les choix et décisions prises par les institutions bancaires, mais il enrichit aussi le modèle à travers l'hétérogénéité des agents qui suivent des objectifs différents. Ensuite, je propose plusieurs indices composés qui permettent aux superviseurs de mieux appréhender, quantifier et comparer le risque financier des institutions bancaires. Ces nouvelles mesures proposées offrent un plus d'information par rapport aux outils existants car ils combinent l'information fournie par plusieurs indicateurs prudentiels dans un seul indice qui permet plus facilement, et avec plus de fiabilité de repérer le moment quand une institution bancaire risque de faire faillite. De plus, ces indices sont configurables, afin de permettre aux régulateurs de les adapter en fonction de l'importance relative de chaque indicateur prudentiel dans le secteur financier analysé.

CHAPITRE 1 :

DOMESTIC CREDIT IN TIMES OF SUPERVISION: AN EMPIRICAL INVESTIGATION OF EUROPEAN COUNTRIES

Co-authored with Thomas Jobert and Anna Tykhonenko

Abstract

We study the impact of prudential supervision on domestic credit in 27 European countries throughout 1999-2012. We use the Empirical Iterative Bayes' estimator to account for country heterogeneity. We find: (i) the interest rate not to be a fundamental variable in explaining domestic credit, (ii) negative relations between credit sensitivity to past investment and to financial dependence, (iii) that the effects of supervision on credit differ by country, but (iv) that it is possible to achieve an increase in supervisory stringency with positive effects on credit in the context of unified financial supervision.

1. Introduction

The 2008 financial crisis constituted a wake-up call for researchers and practitioners alike, as the soundness of theoretical models and empirical results was put into question. The crisis was largely unforeseen and, furthermore, had a magnitude that defied expectations. Initially a relatively insignificant disturbance in the housing sector, it quickly turned into a full-scale banking sector crisis as the linkages between financial institutions through opaque and inefficient risk-diversification instruments started to take shape. In an effort to reduce risk and maximize profitability in order to obtain better safety ratings, many Western European and American banks had opted to use highly complex instruments that served to pool assets of different quality into a single instrument, deemed more secure and easily tradable. The faults of this logic were proven when mortgage-backed securities started to lose value as a result of the defaulting households, which, given the conjectural macroeconomic situation were unable to return their loans.

The crisis shed light on the dangers of a banking system functioning in a largely deregulated environment. In the US and the other European countries that were affected, a lot of focus was placed on improving and increasing the regulatory stance of the prudential agencies. New research, models and tools started to be considered by authorities increasingly worried of the recession and, later on, lack of growth that had left the developed world at a standstill.

Whereas many began to focus on traditional prudential regulation research branches, such as the ones on the effects of capital ratios on risk and growth, others took bolder moves in proposing new tools and transmission mechanisms⁸, such as the liquidity ratio proposed by the Basel committee, prudential reserve requirements or LTV-ratios⁹.

The European Union, in particular, is an interesting case in this affair. Within the EU, Eurozone countries have taken up the challenge of creating a unified supervision mechanism aiming to ensure the safety and stability of the European banking system and provide mechanisms for an efficient response to disturbances encountered in the banking sector¹⁰. The particularity of the envisaged set-up is that the supervisory mechanism will consist of a supra-national body (the European Central Bank), as well as the habilitated national authorities tasked with the prudential regulation of the banking system. Amidst this consolidation effort, the prudential supervision landscape remains largely disparate amongst western euro-zone member countries with significant supervisory unification and their eastern counterparts, aspiring to join the monetary union, but currently endowed with multi-supervisor set-ups. Amongst the presence of multiple possible supervisory configurations, this raises the question of whether one supervisory model should be favored over another. In terms of determining which model that might be, we would have to carefully strike a balance between the benefits of attaining the prudential objective and the possible side-effects of the regulation on production and growth.

Given both the recent theoretical foundations of the interactions between prudential supervision and credit, as well as the practical interest in studying the interactions between these two variables as a result of the recent changes to the supervisory structure of the EU our paper investigates the impact of prudential supervision on credit. We find that as a result of the heterogeneity of European economies, the impact of supervision on credit is not the same for all the countries that we study. Indeed, increased supervision has a positive effect on credit for most countries, while some remain unaffected and two experience a decline in

⁸ see Agenor and da Silva (2014), Gertler and Kiyotaki (2010), Benigno et al. (2012) for examples

⁹ Loan-to-Value ratios (LTV ratios, in short) have been used in some countries as a prudential instrument specifically geared towards controlling housing-market credit.

¹⁰ For more information see: ECB (2014), The Single Supervisory Mechanism (<http://www.ecb.europa.eu/ssm/html/index.en.html>) and ECB (2014), List of Supervised Entities Notified of the ECB's Intention to Consider them Significant (<http://www.ecb.europa.eu/ssm/pdf/SSM-listofdirectlysupervisedinstitutions.en.pdf>)

credit. We delve deeper into why this is the case and what implications this may have in the following sections.

The rest of this paper is structured as follows: Section 1 has presented an introduction into our work, its scope and objectives. Section 2 investigates the model specification and provides a literature review explaining the choice of exogenous variables, as well as the need for research into prudential regulation. It also takes a closer look at the data used and presents our expectations with respect to the exogenous variables chosen for the model. Section 3 explains the advantages of extending the credit empirical analysis to the Bayesian framework given the non-uniformity of countries in the EU. In this section, we propose to apply the Empirical Iterative Bayes' estimator suggested by Maddala et al. (1997) since it provides a heterogeneous (country by country) estimation of the credit-supervision relationship and allows us to establish a classification of countries according to their credit sensitivity. Section 4 provides an in-depth discussion of our findings. Finally, we formulate conclusions regarding the effects of supervision on credit.

2. Data and model specification

Our choice of an endogenous variable is subjected to both data availability constraints, as well as pertinence with regard to our objective. Most theoretical studies focus on the effects of regulation on credit supply. As such, we will also choose an indicator for credit: domestic credit provided by the financial sector, as a percentage of GDP. This is the variable with the largest scope that covers most of the sources of domestic credit in the economy. The data is taken from the World Development Indicators database.

2.1. The impact of traditional macro-economic variables on credit

The impact of macro-economic indicators on credit has been studied in a number of prominent papers. Some of the most commonly examined relationships are that between interest rates and credit, as well as that between credit and investment. Furthermore, recent studies also focus on the relationship between the financial dependence of a country and its private credit to determine the efficiency of the banking sector in ensuring productivity and output growth. We refer in particular to Inklaar and Koetter (2008).

When looking at the impact of interest rates on credit, early literature focusing on the credit supply suggests that there should be a positive impact of interest rates on credit. The McKinnon-Shaw Hypothesis (1973) presents an empirical study based on the proposed

theoretical hypothesis of credit rationing as a result of financial repression. The study concludes that artificial ceilings on interest rates prevent banks from attaining a sufficient interest margin and thereby can lead to lower credit (via credit rationing) concurrently potentiating lower investment levels. Fry (1988) finds that credit supply receives a positive boost from an increase in interest rates.

More recent literature on asymmetric information indicates the presence of a negative relationship between interest rates and credit. The basis for this is explained in studies such as Walsh (1998) which focus on the credit rationing effects that may occur as a result of an increase in interest rates. Higher interest rates are accompanied by an increase in moral hazard and adverse selection. This means higher expected default rates for banks, and consequently higher monitoring costs to avoid bankruptcy situations. Banks can therefore resort to credit rationing because of higher perceived risk levels. Bernanke et al. (1999) in their study of the financial accelerator mechanism confirm the negative relationship between interest rates and credit.

It would seem that this second strand of literature is more in line with the Keynesian school of thought that viewed the increase of interest rates as having a negative effect on credit, passing through the demand channel. The literature regarding the interactions between credit and investment does not attempt to decipher the potential effect of investment on credit, focusing largely on the inverse relation. We do, however, believe that there exists a causality effect of past investments on credit. Prabodhachandran (2004) argues that past investment serves to build momentum for present investment. A result confirmed by Hsieh and Hong (2004), who similarly, in an analysis of Asian economies, find that present investment is an increasing function of past investment. Finally, Hernandez et al. (2001), in their study on private capital flows during the 1990s find that increasing investment influences debt flows positively. They find a similar effect for past investment. We therefore have reason to believe that past investment is an indicator of anticipations of the private sector regarding present and future investments to be made and consequently influences credit. We do expect however, that the effect may vary amongst countries of different development levels. For instance, countries with experienced firms focused on high-tech production or on export will most likely take previous investment levels into consideration, as these will be crucial for their current credit decisions. Developing and transition countries may have a weaker link between past investment and credit, as their fledgling private sector struggles with issues such as

excessive demand for collateral by the banking sector¹¹, under-developed financial markets¹² and a preponderance of very small to small firms with little power to negotiate credit requests¹³. As such, credit to enterprises in these countries is likely to be restricted by factors unrelated to previous investment levels. Our empirical analysis confirms that there are strong linkages between past investment and current credit levels. We, therefore, opt to keep past investment as an exogenous variable for our model.

Finally, the interactions between credit and the financial dependence ratio are explained in more recent articles such as Inklaar and Koetter (2008) or Rajan and Zingales (1998). Rajan and Zingales (1998) find that the financial dependence ratio is linked to credit. The channel through which this effect passes involves financial development which reduces the costs of external finance to firms, thereby facilitating access to credit. Inklaar and Koetter (2008) find similar results, however, using a different indicator formulation.

2.2. Why study prudential supervision and what are its expected effects?

In our selection of prudential instrument to analyze we are encouraged by recent papers such as Delis and Staikouras (2011) that start to question the effectiveness of traditional tools such as capital requirements in reducing risk. They instead focus on supervisory efficiency in terms of bank audits and sanctions to find that such “alternative” tools produce significant results where capital requirements falter. Acharya and Merrouche (2012) study the precautionary liquidity behavior of financial institutions during crises leading us to believe that, unless properly timed, the insertion of liquidity ratios may also have limited efficiency. Furthermore, Ratnovski (2013) finds that “alternative” regulatory measures aiming to increase the transparency of the banking sector improve both the resiliency of the banking sector to shocks, and the efficiency of prudential tools such as the liquidity ratio.

In terms of supervisory efficiency, we would ideally want a supervisory structure that would allow for reduced risk, without having a negative impact on growth or credit supply. This, however, may be difficult to attain according to some of the recent theoretical literature. DeWalque et al. (2010) in their paper on financial (in)stability, supervision and liquidity injections provides a dynamic stochastic general equilibrium model that explains that

¹¹ see Agenor and da Silva (2014)

¹² see Levine R.(2004)

¹³ see the ECB 2014 survey on the access to finance of small and medium-sized enterprises in the Euro Area

prudential tools such as capital ratios serve to improve the resilience of the economy, but may also lead to output contraction via the credit-investment channel. Martinez and Suarez (2011) conclude that capital requirements reduce the systemic risk taking of the bank, and, hence the losses caused by systemic shocks, but such prudential tools concurrently reduce credit and, subsequently, output in normal times. The results of these papers confirm the negative impact of “classic” prudential tools such as capital requirements and leverage ratios on domestic credit.

However, a number of new papers start to investigate the role of banking sector supervision as a prudential tool, and specifically the impact of supervisory stringency on credit. Maddaloni and Peydro (2013) find that softening supervisory stringency serves to reduce the risk of a credit crunch when lending conditions are tightened as a result of higher bank capital requirements and/or liquidity ratio constraints. They conclude that because of this effect, supervisory measures and traditional macro-prudential tools should coexist. Bassett et al. (2012) find that increased supervisory stringency increases the quality of loans by incentivizing banks to lend to relatively risk-free clients. However, if stringency levels become elevated, then the lending activity of financial institutions may become perturbed. The Federal Reserve System (2014) of the United States dictates that there must be a correlation between supervisory stringency and the degree of risk that the financial institution assumes, its size and scope. Implicitly this is indicative of the existence of linkages between supervisory stringency and the amount of credit emitted by a financial organization. Finally, Hardy and Nieto (2008) confirm that increased supervisory stringency has positive effects on risk reduction and therefore contributes to the stability of the financial system as a whole, the reduction of the risk of default for individual institutions and that of a credit crunch. Therefore, according to these recent papers, increased supervisory stringency seems to avoid producing a negative effect on credit, or has a positive impact by means of enhanced project selection oriented towards lower-risk projects.

2.3. The data

The "traditional" macro-economic variables that we will take as exogenous variables will consist of: the interest rate, investment and the financial dependence ratio. The data for these variables comes from several databases: the World Bank's World Development Indicators, the World Bank DataBank and Eurostat. Our indicator of the interest rate is the bank's net interest margin (annual, in %). Although not an interest rate indicator per se, the bank's

interest margin represents the accounting value of the bank's net interest revenue as a share of its average interest-bearing assets. Since we are studying a net interest indicator and given the stability of the interest rate for deposits in most European countries, the variations of this indicator are expected to be proportional with those of the interest rate for credit. The indicator is taken with a minus one-year lag to account for the systemic rigidities that may exist. We assume that there is a relationship between past investment and credit. It is expected that higher previous investment levels should contribute positively to present credit levels, although that may not be the case for all countries, as explained above. Finally, the financial dependence ratio is an advanced indicator that can be constructed in multiple ways. Rajan and Zingales (1998) use Compustat data on U.S. firms to construct a measure of dependence on external finance, which constitutes the benchmark for other countries. Their financial dependence indicator is constructed as follows:

$$\text{Financial Dependence Ratio} = \frac{\text{Capital expenditures} - \text{Cash flow}}{\text{Capital expenditures}} \quad (1)$$

Inklaar and Koetter (2008), in their study of the financial dependence of European firms, refer to Furstenberg and Kalckreuth (2006) who argue that external dependence is not a 'structural' parameter, as implicitly assumed by Rajan and Zingales (1998). They find that another way of expressing the financial dependence ratio, as suggested by Guevara and Maudos (2006):

$$\text{Financial Dependence Ratio} = \frac{\text{Debt}}{\text{Total assets}} \quad (2)$$

Given the macro-level orientation of our research, we maintain Inklaar and Koetter's (2008) formulation of the financial dependence ratio. In the debt category, we take into consideration both internal and external private sector debt. The total assets position is filled by total fixed assets, which is the only indicator that is concurrently available for all of the countries we select.

In our selection of the variable to include in our study of the impact of supervision on credit, we find the World Bank's survey on bank regulation by Barth et al. (2013) to be highly adequate. It provides macro-level data on prudential regulation and supervision for 180 countries from 1999 to 2011. In the given timeframe four surveys have been conducted.

Answers have been collected from regulatory authorities and consist of both quantitative and qualitative data, with qualitative data having been converted into indices by the authors. All in all, the database comprises 52 indicators categorized into one of 10 sections: I. Bank Activity Regulatory Variables ; II. Financial Conglomerate Variables ; III. Competition Regulatory Variables ; IV. Capital Regulatory Variables ; V. Official Supervisory Action Variables ; VI. Official Supervisory Structural Variables ; VII. Private Monitoring Variables ; VIII. Deposit Insurance Scheme Variables ; IX. Market Structure Indicators ; X. External Governance Variables.

Given our interest in the impact of supervisory measures on credit, we will focus on section V, Official Supervisory Action Variables. The index is constructed by combining the answers to 14 questions regarding the ability of supervisors to change the internal organization of banks by means of restructuring or reorganization, their ability to order the bank to constitute provisions to cover for existent or potential losses, off-balance sheet item disclosure, as well as the supervisor's powers to examine bank auditors. Higher index values indicate a greater power for the supervisory agency, and therefore a more stringent regulatory system.

The database provided by Barth, Caprio and Levine is used in a number of empirical papers focused on banking sector efficiency. Gaganis et al. (2013) use the data to study bank efficiency in different financial supervision regimes. They find that banks in advanced countries are the most efficient. Furthermore, they also find evidence that suggests that banks in transition economies are less efficient than banks in developing countries. Finally, they indicate that banks located in countries with a greater degree of supervisory unification are less profit efficient. Barth et al. (2013) also study the impact of prudential regulation on bank efficiency. They find that tougher restrictions on bank activities decrease bank efficiency, that increasing the official supervisory power is positively associated with bank efficiency in countries with independent prudential authorities, and that market-based monitoring of banks increases bank efficiency. Finally, Chortareas et al. (2012) use an earlier version of the database and find results similar to the ones detailed in the aforementioned papers. Fonseca and Gonzales (2010) study the influence of regulation on bank capital buffers and find that restrictions on bank activities and supervision leads to lower capital buffers being held by banks as a result of the lack of market discipline, but, at the same time, the restrictions lead to higher capital buffers because of increased market power. Finally, Serres et al. (2006) use the database to study competitiveness and economic growth in an OECD research paper. They find that regulation aiming to reduce banking sector barriers to competition does have a

statistically significant influence on output, productivity growth and firm entry levels, with most of the effect stemming from industrial sectors dependent on external financing. The authors also find evidence that, given the negative impact of barriers to competition in the banking sector on firm entry rates, greater market power does not lead to increased entry levels via a mechanism of easier access to credit for new firms.

For our study, we select 26 of the now 28 countries of the European Union, plus Switzerland. That gives us a total of 27 countries¹⁴. Two EU countries have had to be excluded for lack of data – Croatia and Slovakia. Croatia has entered the European Union in 2013 and access to its data is still unavailable. Both, however, represent some of the smallest countries in terms of both GDP and population in the EU. As such, their exclusion is not expected to affect the reliability of the results presented in this paper. The selected period for our study will span from 1999 to 2012. The year 1999, coinciding with the introduction of the euro in the EU, is the first year in which the survey on prudential regulation was conducted, and 2012 is the last year for which we have data for all of our indicators.

2.4. Model formulation and methodological considerations

We specify our two models. For each model, we use three independent variables. The introduction of another explanatory variable would require more coefficients (specifically 27 coefficients in the case of the Empirical Iterative Bayes' estimator) to estimate, thus reducing the efficiency of the estimation procedure (in terms of degrees of freedom).

For our first (baseline) model we select three traditional macro-economic variables that are known to produce an effect on credit: the interest rate, investment, and the financial dependence ratio.

$$\text{Credit}_{it} = \alpha_i + \beta_i \text{Fin_Dep}_{it} + \delta_i \text{Inv}_{it-1} + \gamma_i \text{Bank_Margin}_{it-1} + \varepsilon_{it} \quad (3)$$

where Credit is the domestic credit provided by financial sector, as a % of GDP, Fin_Dep - the Financial Dependence Ratio, Inv - the lagged total investment to GDP ratio, Bank_Marg -

¹⁴ Austria (AUT), Belgium (BEL), Bulgaria (BLG), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITL), Latvia (LTV), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Poland (PLD), Portugal (PRT), Romania (ROM), Slovenia (SVN), Spain (SPA), Sweden (SWE), Switzerland (SWZ), United Kingdom (UK).

the lagged bank's net interest margin, t - the time index indicating periods spanning from 1999-2012, and i - the index indicating the country.

The second model introduces the prudential supervision indicator (Supervis) and excludes the interest rate (Bk_marg). As such, our three explanatory variables are: the interest rate (Bk_Marg), investment (Inv) and prudential supervision (Supervis).

$$\text{Credit}_{it} = \alpha_i + \beta_i \text{Fin_Dep}_{it} + \delta_i \text{Inv}_{it-1} + \gamma_i \text{Supervis}_{it} + \varepsilon_{it} \quad (4)$$

Please make note, however, that the parameter estimates should not be interpreted as elasticities, because we do not provide our results in logarithmic form.

In order to include the country heterogeneity that characterizes European economies (both in terms of size, but also development levels) into our analysis we must find a method of estimation adequate for the task.

Recent empirical panel studies point to the problem of inconsistent estimators due to the insufficient consideration of cross-country heterogeneity (Baltagi and Kao, 2000; Baltagi et al., 2008; Hsiao, 2003). Indeed, the hypothesis of homogeneity in the slope parameters across the countries (implicit in the use of a pooled estimator) is often rejected in favor of heterogeneous regressions (Hsiao et al., 1999; Baltagi et al., 2003). An alternative estimation method for heterogeneous panel data comes from a Bayesian approach which considers the parameters as random, drawn from a joint distribution with a finite number of parameters (Maddala et al., 1997; Hsiao et al., 1999). The random coefficients formulation reduces the number of parameters to be estimated, while still allowing the coefficients to differ across countries. As such, given the Bayesian framework that we will utilize, we will have 108 coefficients to estimate (4 for each of the 27 European countries that we analyze) per model.

At this stage, we also provide interpretations for the exogenous variables that we have chosen and explain what our expectations are with respect to the sign taken by the parameters.

Inv is an "instrumental variable" that measures anticipated investment. As such, the coefficient associated with this variable indicates the sensitivity of credit to firms' investment needs. We expect to have a positive sign, since a firm with higher past investment levels would, all things equal, expect to have higher credit needs in the present or future periods.

Dep_fin is presented as a debt-to-assets ratio and its coefficient may be interpreted as the sensitivity of credit to the dependence of firms on external financing. We also expect it to have a positive sign.

Bk_Marg can be regarded as an indicator of the cost of credit. The parameter associated with it may have either a positive or a negative sign. A negative sign reflects a traditional Keynesian credit demand effect, whereas a positive sign underscores the dominance of the credit supply channel.

With respect to our supervisory variable, the “prudential supervision index”, the theoretical literature provides arguments that suggest that increased supervisory stringency has positive effects on credit.

3. The empirical iterative Bayes estimator

In order to better take into consideration the cross-country heterogeneity, we will use the empirical iterative Bayes estimator, which is a shrinkage-type estimator. Indeed, in the panel data analysis, it is customary to pool the observations with or without individual-specific dummies. These dummy variables are assumed to be fixed (fixed-effects models) or random (random-effects or variance-components models). This procedure, however, assumes a complete homogeneity of the slope coefficients. On the other hand, when the time series estimation is used to obtain the separate estimates of cross-section coefficients, the parameters are assumed to be all different. This implies that the equations should be estimated separately for each country rather than obtaining an overall pooled estimate. For Maddala et al. (1997), the reality is situated between complete homogeneity and complete heterogeneity. “The truth probably lies somewhere in between. The parameters are not exactly the same, but there is some similarity between them. One way of allowing for the similarity is to assume that the parameters all come from a joint distribution with a common mean and a nonzero covariance matrix” (Maddala et al., 1997, p. 91). The authors show that the resulting parameter estimates are a weighted average of the overall pooled estimate and the separate time-series estimates based on each cross-section. In this framework, the empirical Bayes method allows us to calculate the shrinkage-type estimators: each individual estimator is shrunk toward the overall pooled estimate. Maddala et al. (1997), Hsiao et al. (1999) show that, in the case of panel data models with coefficient heterogeneity, this method provides more stable estimates and better predictions, since the two other estimation methods, of either pooling the data or obtaining separate estimates for each cross-section, are based on

extreme assumptions (namely, cross-sectional homogeneity and heterogeneity of slope coefficients). Similarly, Maddala and Hu (1996) have presented some Monte Carlo evidence to suggest that the iterative procedure gives better estimates for panel data models. For instance, Hsiao (2003), Trapani and Urga (2009) also confirmed that in the case of panel data models with coefficient heterogeneity, the shrinkage estimators should be preferred, even when the time dimension is small.

3.1. The Bayes' iterative procedure

In the framework of the random-coefficients model, the Bayesian approach for the Domestic Credit Model can be rewritten with the following specification:

$$y_i = X_i \gamma_i + u_i \quad (5)$$

where y_i contains the domestic credit time series, X_i is the matrix with explanatory variables and γ_i slope coefficients. In the Bayesian framework, the prior distribution of γ_i is given by: $\gamma_i \sim N(\mu, \Sigma)$ where the parameters μ (mean of γ_i), Σ (variance of γ_i) and σ_i^2 (residual variance) are unknown. That is why some assumptions have to be made on prior specification of these parameters. Then we can derive the posterior distribution for the parameters γ_i . On the other hand, if μ , Σ and σ_i^2 are all known, the posterior distribution of γ_i is normal and calculated by:

$$\gamma_i^* = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1} \right]^{-1} \left[\frac{1}{\sigma_i^{*2}} X_i' X_i \hat{\gamma}_i + \Sigma^{*-1} \mu^* \right] \quad (6)$$

where $\hat{\gamma}_i$ is the OLS estimator of γ_i . The posterior distribution mean of γ_i and its variance are shown in Equations (3) and (4) respectively.

$$\mu^* = \frac{1}{N} \sum_{i=1}^N \gamma_i^* \quad (7)$$

$$V[\gamma_i^*] = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1} \right]^{-1} \quad (8)$$

Since in general, Σ and σ_i^2 are unknown parameters, one needs to specify priors for them. For this purpose, Smith (1973) suggested using the mode of the joint posterior distribution given by the following equations:

$$\sigma_i^{*2} = \frac{1}{T + \varsigma_i + 2} \left[\varsigma_i \lambda_i + (y_i - X_i \gamma_i^*)' (y_i - X_i \gamma_i^*) \right] \quad (9)$$

and

$$\Sigma^* = \frac{1}{T - k - 2 + \delta} \left[R + \sum_{i=1}^N (\gamma_i^* - \mu^*)(\gamma_i^* - \mu^*)' \right] \quad (10)$$

where the parameters ς_i , λ_i , δ and R arise from the specification of the prior distributions. Moreover, Smith (1973) proposed the approximation of these parameters by setting $\varsigma_i = 0$, $\delta = 1$ and R as a diagonal matrix with small positive entries (e.g., 0.001). By doing so, the estimators take the following forms:

$$\sigma_i^{*2} = \frac{1}{T + 2} \left[(y_i - X_i \gamma_i^*)' (y_i - X_i \gamma_i^*) \right] \quad (11)$$

$$\Sigma^* = \frac{1}{T - k - 1} \left[R + \sum_{i=1}^N (\gamma_i^* - \mu^*)(\gamma_i^* - \mu^*)' \right] \quad (12)$$

$$\gamma_i^* = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1} \right]^{-1} \left[\frac{1}{\sigma_i^{*2}} X_i' X_i \hat{\gamma}_i + \Sigma^{*-1} \mu^* \right] \quad (13)$$

and

$$\mu^* = \frac{1}{N} \sum_{i=1}^N \gamma_i^* \quad (14)$$

$$V[\gamma_i^*] = \left[\frac{1}{\sigma_i^{*2}} X_i' X_i + \Sigma^{*-1} \right]^{-1} \quad (15)$$

Then Equations (7-11) should be solved iteratively, with the initial iteration using the OLS estimator $\hat{\gamma}_i$ to compute μ^* , Σ^* and σ_i^{*2} . The second iteration is based on the empirical iterative Bayes' estimator γ_i^* . The third and the following iterations are identical to the second one. The empirical Bayes' estimator was proposed by Maddala et al. (1997). The only

difference with the Smith's estimator lies in the computation of the parameters σ_i^{*2} and Σ^* , that is, we have:

$$\sigma_i^{*2} = \frac{1}{T-k} (y_i - X_i \gamma_i^*)' (y_i - X_i \gamma_i^*) \quad (16)$$

$$\Sigma^* = \frac{1}{N-1} \left[R + \sum_{i=1}^N (\gamma_i^* - \mu^*)(\gamma_i^* - \mu^*)' \right] \quad (17)$$

In what follows, we present our results from applying this procedure to the Domestic Credit model.

3.2. Empirical results

In order to better grasp the analysis method to be used for the survey data, we look at the way in which other papers using the bank regulation survey integrate the prudential indicators into the regression. Serres et al. (2006) resort to multiplication in order to alleviate the lack of variability resulting from the presence of limited observations. We remind the reader that the survey comprises 4 observations for each country within the 1999 – 2012 timespan. As such, they multiply the chosen prudential indicators by an external finance dependence indicator à la Rajan and Zingales (1998). Fonseca and Gonzales (2010) also multiply the prudential indicators with one of two variables: the Lerner Index or the cost of deposits. The cost of deposits is chosen as a multiplication variable since, according to the authors, it represents a measure of the discipline that the market imposes on the bank. In other words it represents an amplifier for prudential regulation. Finally, Gaganis et al. (2013) work on an unbalanced dataset. They perform a cross-sectional analysis and provide no temporal dimension. It is also noteworthy that they study bank-level data and assign the value taken by the prudential indicator in the respective year and country to each of the banks included in the study.

In our analysis, we will refrain from using the multiplication method, as this renders data interpretation cumbersome and diminishes its meaningfulness. Consequently, for the years in which no survey was performed, we will assume that the value of the prudential indicator has not changed from its last known value. This will allow us to study the effect solely of the prudential indicator, without introducing any unnecessary distortions.

The complete regression results for both models can be found in Appendix: Empirical Bayes' estimator, by country, 1999–2012 timeframe in the Annex.

We notice, as depicted in Table 2.1, that the financial dependence ratio is significant for all the countries that we study in both models. Past investment significantly explains domestic credit for 85% of the European countries we analyze in the first model. When we select prudential supervision instead of the interest rate as an explanatory variable, past investment becomes significant for all of the countries. Bk_Marg, which we include in the first model, is explicative for only 37% of the countries, whereas Supervis, which replaces Bk_Marg in the second model, is significant for 63% of the countries we study.

Table 2.1. Countries for which regression coefficients are individually insignificant at a 5% significance level

	Model 1	Model 2
Fin_Dep	None	None
Inv	CZE, ITL, LUX and ROM	None
Bk_Marg	AUT, BEL, CYP, DNK, FIN, FRA, GRC, HUN, ITL, MLT, NLD, PLD, PRT, ROM, SWE, SWZ, UK	-
Supervis	-	BLG, CYP, FIN, ITL, LTU, LUX, ROM, SVN, SPA, SWZ

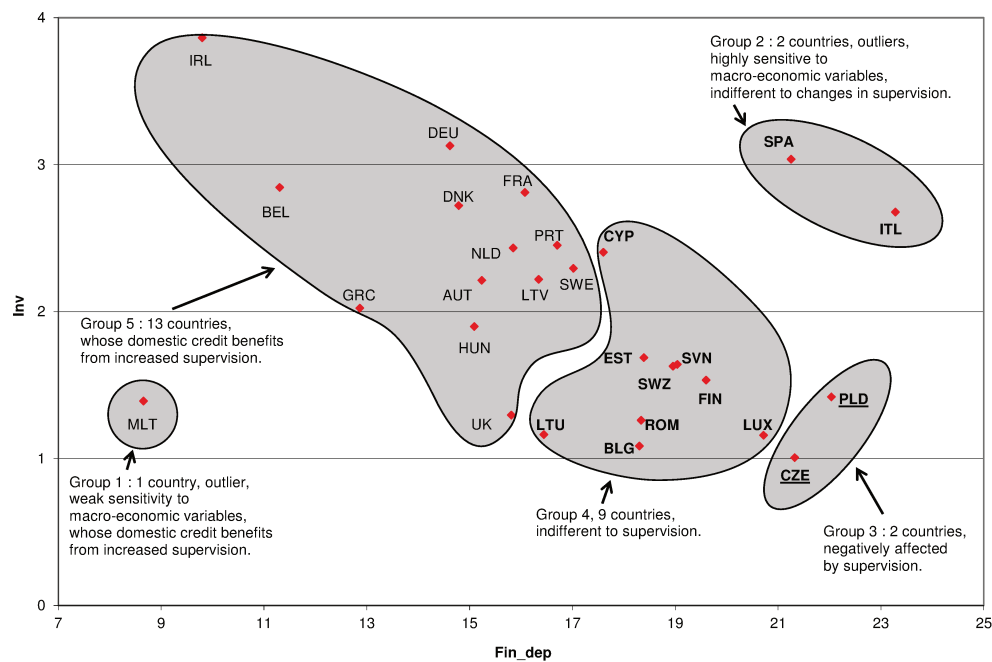
Notes: “None” means that the coefficient associated with the given variable is significant for all countries included in our research.

This table shows the countries for which the regression coefficients (Fin_Dep, Inv, Bk_Marg and Supervis) are individually insignificant at a 5% significance level. Model 1 considers Fin_Dep, Inv and Bk_Marg as exogenous variables, whereas Model 2 considers Fin_Dep, Inv and Supervis. The aim is to find a model manifesting a lower number of countries with insignificant parameters.

The Empirical Iterative Bayes estimator allowing for heterogeneity in the results shows that Fin_Dep and Inv always have a positive coefficient sign, which is in line with our expectations.

Within Model 1 which, we remind, has no prudential supervision indicator, Bk_marg has a significant positive coefficient sign for Germany, Ireland and Spain. We can, therefore, conclude that credit supply effects are dominant in these countries. The sign is negative and significant for Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Slovenia (all Eastern European countries), and Luxembourg. We can interpret the negative sign as an indicator of credit rationing à la Walsh (1998) in the countries manifesting this effect. We anticipate slightly the results of our next section by mentioning that we find such negative correlation between interest rates and credit only in the countries in which supervision has no effect on credit, and specifically, the ones in the low-right region of Figure 2.1.

Figure 2.1. Overview of the estimation results for Model 2



Note: On the horizontal and vertical axes we have the coefficients associated with Fin_dep and Inv , respectively.

This figure groups countries according to the effect that supervisory stringency produces on domestic credit. In bold we have countries for which prudential supervision does not manifest a significant effect on credit. In bold and underlined, we have countries in which increased prudential supervision stringency produces a negative effect on credit. For all other countries, increased prudential supervision stringency produces a positive effect on credit.

In our second model which incorporates prudential supervision we notice that the financial dependence ratio coefficient is always positive and is significant for all countries. The past investment coefficient is similarly positive and significant. As for the supervision variable coefficient, it is:

negative – only for two countries: the Czech Republic and Poland;

insignificant – for 11 countries: Bulgaria, Cyprus, Estonia, Finland, Italy, Lithuania, Luxembourg, Romania, Slovenia, Spain, Switzerland;

positive – for 14 countries: Austria, Belgium, Germany, Denmark, France, Greece, Hungary, Ireland, Latvia, Malta, Netherlands, Portugal, Sweden, and the United Kingdom.

As such, we can conclude that taking country heterogeneity into consideration brings to light the effect of prudential supervision – an effect which is otherwise hidden (when using standard OLS regression techniques).

We therefore keep the second model which includes prudential supervision, both on account of the number of countries for which individual variables are significant, and as a result of that, on the basis of the lower residual sum of squares (RSS). In what follows, we focus our attention exclusively on the second model.

3.3. All different?

The Empirical Iterative Bayes estimator has made it possible to introduce country heterogeneity into our analysis. Now, our objective turns to finding out if there are countries with similar profiles that could be grouped together.

When plotting our regression results with lagged investment and the financial dependence ratio on the vertical and horizontal axis, respectively (see Figure 2.1), we notice a grouping of countries. We see that in the lower-right-hand corner we mostly have transition economies characterized by a low level of past investment dependence and a higher level of financial dependence ratio. Conversely, in the upper-left area of the graph, we notice highly developed countries with lower financial dependence ratios, but higher dependence on past investment. When we factor in the significance level of the variable Supervis on domestic credit, we notice that for countries with a higher level of the financial dependence ratio, supervision has no significant effect on domestic credit. Also, many of the countries in this region also have low levels of credit sensitivity to past investment.

Upon first inspection, the most likely groups that we can divide the analyzed countries into are the following:

Group 1: Malta constitutes a first exception. Situated in the lower-left region of the graph, it concurrently manifests weak sensitivity both to financial dependence and past investment. Malta is positively affected by supervision.

Group 2: Italy and Spain are both situated in the upper-right part of the graphic and manifest high credit sensitivity to financial dependence and past investment, but remain unaffected by prudential supervision. We must note that Italy and Spain are the fourth and fifth largest economies of the EU (after Germany, the UK and France).

Group 3: the Czech Republic and Poland are highly sensitive to financial dependence, but manifest weak sensitivity to past investment. Supervision has a negative effect on the quantity of allocated credit in these two countries.

Group 4: Bulgaria, Cyprus, Estonia, Finland, Lithuania, Luxembourg, Romania, Slovenia and Switzerland are sensitive to financial dependence, but manifest low sensitivity to past investment. Supervision has an insignificant effect on these countries.

Group 5: Austria, Belgium, Germany, Denmark, France, Greece, Hungary, Ireland, Latvia, Netherlands, Portugal, Sweden and the United Kingdom are highly sensitive to past investment and have lower sensitivity to financial dependence. Increased supervision has a positive effect on credit in these countries. It is noteworthy that these are the largest European economies in terms of GDP.

This division imposes a study of the countries that we have observed in order to determine what characteristics have brought them together, and how we should explain the results that we have obtained.

4. Discussion of the findings and concluding remarks

After careful consideration of the literature on the matter, we find that our results correspond with the theoretical framework of supervisory systems adopted by various countries proposed by Schoenmaker (2011) and depicted in Table 2.2. Countries experiencing a positive effect of supervision on credit can be seen as “winners” in the sense that increased supervisory stringency has a positive effect on the development of their credit markets, whereas states in the process of supervisory system transition, such as some of the Central European countries

struggling with the task, tend to experience a negative impact of increased supervision on credit.

Table 2.2. Types of supervisory systems

Countries		Basic models		
	(1) Sectoral	(2) Cross-sector: Functional	(3a) Cross-sector: Integrated without central bank role in banking supervision	(3b) Cross-sector: Integrated with central bank role in banking supervision
European Union	Bulgaria	Belgium (2011)	Denmark (1988)	Austria (2002)
	Cyprus	France (2003/10)	Estonia (2002)	Czech Republic (2006)
	Greece	Italy (1999)	Hungary (2000)	Finland (2009)
	Lithuania	Netherlands	Latvia (2001)	Germany (2002)
	Luxembourg	(2002)	Malta (2002)	Ireland (2003)
	Romania	Portugal (2000)	Poland (2008)	Slovakia (2006)
	Slovenia	United Kingdom	Sweden (1991)	
	Spain	(2011)		
Outside EU		Australia (1998)	Japan (2000)	
		Canada (1987)		
		United States (2010)		

Source: Schoenmaker (2011), Caprio (forthcoming). “Encyclopedia of Financial Globalization”, in parentheses is the year when the country transitioned to the current model.

This table lists the supervisory systems adopted by various countries from both within and outside the EU, as presented by Schoenmaker (2011). Most of the countries from the Eastern-European block have retained a sectoral supervisory system characterized by multiple prudential institutions, each having separate objectives and functions. Most of the countries from Western Europe have transitioned towards newer, enhanced supervisory systems in which either the Central Bank plays an increasing role in banking sector supervision and regulation (as is the case of the Cross-Sector Functional model and the Cross-sector: Integrated with central bank role in banking supervision model) or there is a tendency towards unification of supervisory tasks into one unique national prudential regulator (the Cross-sector: Integrated without central bank role in banking supervision system).

4.1. Regulatory system effect

After investigating, in Goodhart et al. (2002), the micro and macro-approaches of regulators in environments with varying central bank involvement in prudential regulation, Schoenmaker (2011) studies European and some non-European nations from the perspective of their adherence to one of several supervisory systems: sectoral, cross-sector functional, cross sector integrated without central bank role in supervision (CSI-NOCB) and cross sector integrated with central bank role in supervision (CSI-WITHCB).

The sectoral model implies that countries have separate supervisory agencies for various financial activities (banking, securities, insurance). The Central Bank is not actively involved in prudential regulation, but focuses on its own independent objective (implicitly, utilizing monetary policy to ensure price stability).

The cross-sector functional archetype involves two prudential regulators. One of them ensures prudential supervision while the other focuses on business conduct. In the Eurozone, where countries have assigned their monetary policy prerogatives to the European Central Bank, central banks also play a role in prudential supervision.

The CSI-NOCB model implies that there is only one prudential regulator responsible for all supervisory matters, ensuring both prudential supervision and business conduct functions. The regulator does so without active involvement from the Central Bank. Both institutions pursue largely separate objectives.

Finally, the CSI-WITHCB model, similarly to the previous one, has a single prudential institution. However, here, the central bank plays an important role in regulation and

supervision as it actively directs and dominates the prudential authority. As with the cross-sector functional archetype, this model involves less independence between the central bank's and the prudential regulator's objectives.

In order to reinforce the results that we obtained in Model 2 and to provide insight into the formation of country groups, we focus our attention to the impact that supervisory systems have on domestic credit. To ascertain the extent to which credit is impacted by the supervisory systems themselves, we must perform an additional regression with indicators that reflect the characteristics of the supervisory frameworks. The Financial Authorities' Concentration Index (FAC) and the Central Bank as Financial Authority Index (CBFA) developed by Masciandaro (2004, 2006) are indicators that allow us to pursue this objective. The FAC is indicative of the degree of unification that exists in financial sector supervision. It contrasts the multi-regulatory supervisory structure characteristic of the sectoral method with the more unified supervisory set-ups of the functional and cross-sector integrated approaches. Higher indicator values are assigned to single authorities supervising all three aforementioned financial sectors (banking, securities, insurance), whereas lower values are indicative of multi-regulator setups where each regulatory agency supervises its own field of activity. The CBFA index presents the degree to which the Central Bank is involved in financial supervision. The CBFA indicates the number of sectors that the Central Bank is responsible for. Higher values are associated with the Central Bank being responsible for the supervision of more sectors, and, conversely, the minimal value is obtained when the Central Bank is not involved in any of the sectors. This indicator expands our understanding of the degree of unification by providing information regarding the dominance of the Central Bank on the regulatory landscape.

We regress domestic credit provided by the financial sector on the FAC and CBFA indicators. Since data for the two indicators is available in the form of cross-section observations for only one year, we must remove the control variables due to the degrees of freedom constraint that we will be facing given the smaller sample size. Both the FAC and CBFA indicators have positive coefficient signs which are significant at a 95% confidence interval¹⁵.

¹⁵ Detailed estimation results are available upon request.

Higher levels of the FAC indicator, which represents the degree of supervisory unification, contribute positively towards domestic credit. This means that countries with single supervisory institutions for all three sectors of financial supervision are expected to have the largest boost on credit. Similarly, the CBFA indicator, which is indicative of the degree of Central Bank involvement in supervision, also has a positive impact on credit. This indicates that supervisory systems where the Central Bank plays a more dominant role in supervision (i.e. CSI-WITHCB and some functional system affiliated countries) benefit from higher conductivity of supervision on credit. Conversely, the lower the degree of supervisory unification or Central Bank participation in supervision, the lower the domestic credit variable is expected to be. We notice, therefore, that functional and cross-sector integrated systems characterized by higher unification and Central Bank involvement determine higher credit levels. At the same time, the more we move towards a multi-regulator system with no central bank involvement, the more the domestic credit variable diminishes in value. This reinforces the results that we obtained from our estimation of the model containing the Supervis variable since it constitutes additional proof that supervision produces an effect on credit. Furthermore, it confirms that the effect of supervision on credit is dissimilar amongst countries having different supervisory system adherence, thereby confirming the existence of the different country groups that we have found and represented in Figure 2.1. Overview of the estimation results for Model 2.

With respect to the sign of the effect, our model with the supervisory stringency variable indicates that countries belonging to the cross-sector functional, cross-sector integrated without central bank role in banking supervision and cross-sector integrated with central bank role in banking supervision models all manifest a positive and significant relationship between supervision and domestic credit.

As for the other countries, we notice that with the exception of Greece, all the countries from the sectoral group are located in the lower-right quadrant where supervision has no effect on credit. These countries all retained their initial sectoral regulatory structure. Greece is an exception, in the sense that in its case, supervision does tend to affect domestic credit significantly. Although Greece traditionally manifested high fragmentation in its regulatory structure, it began a slow transition towards unification in 2007. Bank of Greece (2014) describes the beginning of unification with the transition towards the Basel II regulatory framework in 2007, which was further enhanced by the transfer of all insurance supervision responsibilities to the Central Bank in 2010. Still, the transition is, as of yet, incomplete as the

securities market remains regulated by a separate institution. Presumably, the slow transition is the reason why Greece initially manifested positive results of supervision on credit, which given the data range, is what our results have captured. Subsequently, however, as we have seen, Greece's economic and financial situation has worsened. As such, when new data becomes available it will be interesting to see how Greece's credit sensitivity to increased supervision will have changed.

In the unaffected group, we also notice Switzerland which has recently undergone changes to its regulatory stances, but whose regulatory system remains similar to the initial sectoral model, despite aiming to transition towards a cross-sector, integrated, with central bank role in banking supervision archetype¹⁶. Furthermore, we have Italy which would seem to be an exception, given its adherence to the cross-sector functional category. Still, supervision does not manifest any effects on credit. Indeed, Italy's financial supervision system could be described as a "mixed" model, not belonging to any of the traditional categorizations of supervision¹⁷. This indetermination, coupled with two anomalies¹⁸ raising questions about the proper functioning of the supervisory branch of Italy's Central Bank are responsible for the desensibilization of Italy's credit with respect to supervision. Finland is an example of a country that very recently changed its supervisory structure, passing in 2009 from the sectoral model to the cross-sector, integrated, with central bank role in banking supervision archetype. The effects of this transition have yet to be felt, as Finland continues to stay anchored to its sectoral model counterparts. Similarly, we have two countries, Poland and the Czech Republic who recently underwent similar transitions from the sectoral model to the cross-sector, integrated, without central bank role in banking supervision model (for Poland, in

¹⁶ see the FDF 2012 report on macro-prudential oversight in Switzerland addressing the issue of financial institutions too big to fail

¹⁷ See Di Giorgio et al. (2000)

¹⁸ The two anomalies referenced in Di Giorgio et al. (2000) raise the issue of the Italian Central Bank being assigned mutually conflicting objectives in two areas. The first contradiction occurs as a result of the Central Bank being assigned the objective of both ensuring the stability, as well as preserving competition, in the banking sector. This is a practice that is unique to the Italian Central Bank in the Euro-zone and may constitute a weakness since, as the authors mention, there is contradiction between the objective of stability and competition, which, by nature, involves fluctuations in the form of entries and exits from the market. The second conflict of interests emerges as a consequence of the Central Bank owning shares and equities of banks and financial institutions controlling banks. Indeed, the Central Bank invests both ordinary reserves and part of the contributions of employee's pension funds in such equities. This translates into potential moral hazard with respect to supervisory and regulatory decisions.

2008) and to the cross-sector, integrated, with central bank role in banking supervision model (for the Czech Republic, in 2006).

These post-socialist transition economies may well have taken the changes in regulatory structure more difficultly, as evidenced by the significant negative correlation between the stringency of their supervisory stance and the domestic credit variable. Indeed, these are the only two countries that have a negative correlation between supervision and credit. This conjecture could be due to a signaling effect ignited by the regulatory structure reform. In effect, for these post-socialist countries, the transition to a new system could have been associated with a lack of trust (stemming from both local private agents and public authorities) in the financial sector. As such, increases in supervisory stringency may have been misinterpreted as attempts to bring increasing banking insecurity under control, rather than efforts to improve an already sound system, thus influencing credit in a negative manner.

There also exists an alternative explanation where countries with no effect of supervision on credit are, in fact, winners, in the sense that it is their economies that would seem to be better adapted to face financial shocks. This alternative explanation based on the findings of Ueda and Valencia (2012) indicates that when central banks are assigned the additional objective of regulating the financial system by ensuring the supervision of the banking sector as well as the prerogative of intervention in the event of disturbances, the Central Bank is, in fact, incapable of satisfying both objectives at the same time. Given its statutory role of ensuring price stability, it will first and foremost focus on this primary objective. As for prudential regulation, it will tend to get sidelined and, therefore become less efficient. This is the main reason for which we observe a positive and significant effect of regulation on credit. In other words, due to the overlapping objectives, regulation does not fulfill its role of tightening credit to reduce risk. On the contrary, it seems that the higher the regulation the more credit is issued. This way of viewing things would indicate that transitioning towards prudential systems based on a single regulator reduces the efficiency of prudential regulation and, specifically, supervision. It would also indicate that the recent crisis experienced first and foremost by western nations may have come as a result of a transition towards such systems. If that were indeed the case, then it would be recommendable for countries to reconsider their stance on the unification of regulatory systems. Consider that since entrusting supervisory roles to the central bank of one's own country leads to efficiency losses, delegating these responsibilities to a supra-national body would only serve to exacerbate the situation.

All in all it seems to be that increased supervision has a signaling effect with higher supervisory stringency indicating increased safety of the banking sector and thus resulting in an increase in overall credit.

We must, however, note that in order to further enhance the accuracy of our results, ideally we would isolate the singular impact of supervision on credit, when other prudential regulation indicators remain unchanged. However, since in the vast majority of recent cases prudential regulation measures and changes have come as “package deals”, including alterations to multiple areas of regulatory control, we must also consider the effects of other prudential tools on the economy and in particular on the supply of credit, when making any conclusions or previsions regarding the effects of supervision on domestic credit.

4.2. Conclusion

To conclude, we find, as suggested in the recent theoretical literature, that prudential supervision can have a positive effect in terms of credit growth. This positive effect, however, is conditional on a signaling mechanism. Enhanced prudential regulation in the form of increased supervisory stringency signals to creditors and depositors alike a safer business environment suitable for increased credit and growth. As stressed in the literature however, this effect is only applicable to advanced economies with competitive markets and developed financial institutions. Indeed, in countries with weaker market foundations, potentially also undergoing a transition from multi-regulator setups to more unified supervisory models, one finds only weak or (even) restrictive effects of increased supervisory stringency on credit. However, the transition to newer forms of prudential regulation with either central bank involvement in prudential affairs or the consolidation of objectives into a single supervisory institution holds the promise that eventually increased supervisory stringency will, by means of signaling the trustworthiness of the banking system, lead to positive effects on credit.

Finally, it would seem that the drive towards implementing the Single Supervisory Mechanism as a highly unified system with strong influence from the Central Bank seems to be a correct endeavor, as it is this type of system that produces the best results both in terms of financial supervision and credit. Furthermore, on the long run, EU countries that have not yet switched to such a system may be encouraged to do so by the prospect of being able to achieve supervisory consolidation and strengthening with positive effects on credit.

APPENDIX: Empirical Bayes' estimator, by country, 1999–2012 timeframe

Table A. Model 1. Traditional macro-economic variables

Parameters	Country	Coeff	T-Stat	Country	Coeff	T-Stat	Country	Coeff	T-Stat
Const	AUT	9,94	0,48	DEU	-21,58	-1,17	NLD	-6,57	-0,32
Fin_dep		13,39	9,10		12,46	5,54		16,51	20,23
Inv		2,24	3,32		4,15	7,01		2,22	2,96
Bk_margin		0,17	0,23		3,12	3,63		0,44	0,50
Const	BEL	5,33	0,25	GRC	8,79	0,48	PLD	-17,76	-2,98
Fin_dep		12,93	3,74		12,53	11,31		21,81	21,19
Inv		2,68	2,51		2,23	3,68		1,30	6,71
Bk_margin		1,00	0,84		-0,70	-1,08		-0,55	-1,29
Const	BLG	-4,74	-1,09	HUN	-29,30	-1,74	PRT	-20,76	-0,88
Fin_dep		17,54	14,17		15,86	11,49		16,85	15,03
Inv		1,18	6,71		2,73	5,22		2,60	3,63
Bk_margin		-2,70	-7,25		-0,95	-1,28		0,41	0,71
Const	CYP	-26,35	-1,10	IRL	-45,68	-2,18	ROM	-1,17	-0,08
Fin_dep		17,95	11,78		10,19	13,52		22,81	11,14
Inv		2,41	2,56		5,06	6,99		0,55	1,38
Bk_margin		-0,19	-0,13		1,90	2,24		-0,66	-0,88
Const	CZE	24,30	1,46	ITL	-9,32	-0,52	SVN	-18,10	-1,11
Fin_dep		20,13	12,81		24,46	21,62		17,61	11,54
Inv		-0,04	-0,07		0,70	0,98		1,83	3,77
Bk_margin		-1,88	-2,45		0,18	0,21		-1,75	-2,56

Const	DNK	-18,97	-0,89	LTV	-26,94	-2,02	SPA	-48,59	-3,42
Fin_dep		15,30	15,85		14,46	8,36		21,69	29,76
Inv		2,94	3,33		2,43	5,60		3,18	6,78
Bk_margin		0,80	0,68		-2,92	-4,63		3,00	10,14
Const	EST	-19,91	-1,37	LTU	-7,48	-0,87	SWE	-28,60	-1,67
Fin_dep		17,27	9,97		12,51	9,45		17,52	15,79
Inv		1,78	4,51		1,83	6,44		2,31	2,65
Bk_margin		-2,45	-3,94		-4,41	-7,58		-1,23	-0,96
Const	FIN	-40,88	-2,95	LUX	-31,52	-1,43	SWZ	-13,25	-0,58
Fin_dep		19,06	20,20		20,62	18,85		18,75	12,32
Inv		2,46	4,08		1,41	1,73		1,93	2,84
Bk_margin		-1,00	-1,17		-2,80	-2,95		0,14	0,20
Const	FRA	-23,25	-1,46	MLT	67,28	6,53	UK	-27,15	-1,67
Fin_dep		19,82	8,41		8,57	9,57		15,45	27,98
Inv		2,03	2,15		1,09	3,19		2,51	3,49
Bk_margin		0,11	0,10		-0,90	-1,90		-1,86	-1,68

Table B. Model 2. Traditional variables and prudential supervision

Parameters	Country	Coeff	T-Stat	Country	Coeff	T-Stat	Country	Coeff	T-Stat
Const	AUT	-13,00	-0,70	DEU	-28,72	-1,64	NLD	-13,68	-1,11
Fin_dep		15,24	10,23		14,62	6,65		15,85	26,87
Inv		2,21	4,78		3,13	6,04		2,43	5,67
Supervis		1,20	3,04		1,85	3,49		1,10	3,02
Const	BEL	-17,23	-0,94	GRC	-7,29	-0,42	PLD	-17,22	-3,34
Fin_dep		11,31	3,95		12,87	11,57		22,04	28,04
Inv		2,84	4,69		2,02	4,13		1,42	6,92
Supervis		2,49	2,66		1,69	3,59		-0,57	-2,02
Const	BLG	-24,06	-3,41	HUN	-41,09	-2,68	PRT	-36,11	-1,78
Fin_dep		18,30	22,24		15,09	12,76		16,71	18,39
Inv		1,08	7,65		1,90	4,13		2,45	5,37
Supervis		0,62	1,31		2,00	4,17		1,53	2,80
Const	CYP	-36,33	-1,79	IRL	-53,90	-3,14	ROM	-25,63	-2,66
Fin_dep		17,61	11,49		9,80	16,16		18,34	8,62
Inv		2,40	3,23		3,86	8,44		1,26	5,03
Supervis		1,25	1,86		3,97	8,23		0,76	0,96
Const	CZE	-2,84	-0,21	ITL	-45,24	-3,26	SVN	-29,54	-1,89
Fin_dep		21,32	11,82		23,28	14,49		19,04	14,56
Inv		1,01	2,39		2,68	4,61		1,64	4,05
Supervis		-0,81	-2,16		0,18	0,28		0,50	0,87
Const	DNK	-24,36	-1,34	LTV	-60,51	-4,36	SPA	-40,43	-3,08

Fin_dep		14,79	14,22		16,35	12,41		21,25	25,74
Inv		2,72	4,03		2,22	6,17		3,04	8,67
Supervis		1,67	2,61		2,25	3,80		0,40	0,83
Const	EST	-41,97	-3,02	LTU	-29,30	-2,66	SWE	-37,52	-2,66
Fin_dep		18,39	11,50		16,45	9,37		17,02	13,72
Inv		1,69	5,18		1,16	3,27		2,29	3,41
Supervis		1,13	1,96		1,20	1,81		1,42	2,26
Const	FIN	-28,71	-2,88	LUX	-30,00	-1,53	SWZ	-5,00	-0,27
Fin_dep		19,60	25,87		20,72	20,11		18,96	14,52
Inv		1,53	3,87		1,16	2,27		1,63	3,79
Supervis		0,39	1,26		0,07	0,13		-0,25	-0,53
Const	FRA	-32,49	-2,90	MLT	37,83	3,17	UK	-25,11	-1,41
Fin_dep		16,08	6,07		8,66	10,33		15,81	25,69
Inv		2,81	5,00		1,39	3,99		1,30	2,24
Supervis		1,66	2,01		1,66	3,86		1,23	2,50

CHAPITRE 2 :

THE EFFECTS OF PRUDENTIAL SUPERVISION ON BANK RESILIENCY AND PROFITS IN A MULTI-AGENT SETTING

Abstract

This chapter utilizes multi-agent modeling to study the effects of prudential supervision on bank resiliency and profitability within a simulated environment of persistent crisis conditions. It focuses on the stabilizing effect of prudential supervision introduced alongside three "traditional" regulatory instruments: a norm, a market-based CDS insurance mechanism and a tax in the form of a bail-in instrument. The results show that: (i) supervision enhances the regulatory instruments' efficiency, (ii) the regulatory norm can postpone the bank's default, but not avoid it, (iii) the CDS mechanism only produces positive results on resiliency and profitability if the regulator supervises, and (iv) the tax bail-in instrument is the most powerful tool in the regulator's arsenal as it potentiates profitable bank operation under long-lasting crisis conditions.

Chapter Overview

The severe economic recession of 2008 led to an increased focus on the importance of banking sector regulation in preventing crises. The downturn revealed that traditional theoretical and empirical models were ill adapted to crisis conditions and produced flawed results especially at turning points in the economic cycle. As such, the very methodology used in constructing theoretical models came under attack for not having been able to predict or measure the extent of the crisis. Increased attention was therefore devoted to finding alternative methodologies capable of more accurately determining the evolution of macroeconomic indicators.

Multi-agent modeling is a relatively new but rapidly growing programming methodology that allows researchers to create virtual economies in which economic agents of various types (customers, enterprises, banks, governments and regulators) are created and interact. In this simulative environment, micro-founded macro-economic aggregates emerge as a result of agent interactions. Since the dissection of the causes leading to the 2008 financial crisis indicated a deficiency in the functioning of prudential instruments, it is of interest to consider the role that irrationality plays in the decisions taken by agents (as the theoretical literature

suggests that during crises agent behavior may not be completely rational). Given that traditional modeling techniques cannot incorporate irrationality into the analysis, it is beneficial to perform the analysis in a multi-agent environment which allows for limited rationality and complex behavior such as “sunspots” and “herd instincts”.

Furthermore, multi-agent modeling allows different types of reactions (or behaviors) to be assigned to agents based on various criteria thereby allowing for a study of the possible responses to the crisis and a comparison of their efficiency. It is possible to include learning algorithms that allow the agents to improve their decision-making abilities or become better at performing pre-defined tasks. Concurrently, agents can be programmed to change their behavior in innovative (and unscripted) ways to respond to the environmental stimuli that they receive.

In general, multi-agent models comprise a number of strengths over other modeling techniques, the most pertinent ones to our study of the financial sector being: the ability to incorporate individual characteristics within agent groups, to study the interactions between agents within a competitive environment and the possibility of performing robustness checks in the presence of randomness. These advantages allow for a richer analysis than what would be possible in a purely representative agent model.

Within this chapter we will utilize multi-agent modeling to perform an analysis of the effects of prudential supervision on bank resiliency to shocks and the profitability of the bank within different regulatory set-ups. At first, we look at the main reasons leading to the 2008 crisis and present references to the existing literature. We then describe the model, its purpose, structure, agents, their affiliations and accounts. Since this is a programming methodology, we also present the order in which events are executed and in which agents make their decisions. Finally, we delve into analyzing the different regulatory instruments implemented in the presence (and, if appropriate, absence) of regulatory supervision and their effectiveness at preventing the bank’s default and ensuring its long-term profitability. We describe in each section the functioning of the instrument and how it is implemented in our model.

At the end, we provide a comparison of the instruments and offer concluding remarks as to the best suited tools for regulating the banking system in conditions of long-lasting crises and elaborate on the bank’s adaptation to such harsh operating environments. We also discuss the side-effects of implementing each one of the instruments in the presence and absence of supervision.

1. Introduction

From a prudential perspective, the 2008 financial crisis highlighted the weakness of the deregulated financial system within an environment of growing risk and convoluted market instruments that failed to achieve their objective of risk diversification. As a consequence of the severe economic recession that followed the 2008 crisis, regulators in western economies and the United States concentrated their focus on the re-regulation of the financial sector. The theoretical and empirical literature largely followed suit. Whereas some researchers focused their attention on traditional prudential tools such as capital requirements and how they may be improved in order to produce a less pronounced restrictive effect on credit and growth, others began to investigate whether alternative instruments and transmission channels could be used to ensure the same objective of risk reduction, but with lesser negative consequences¹⁹. In this context, increasingly growing attention has been given to the role of prudential supervision both in directly ensuring the regulatory objective of risk reduction, as well as in complementing and increasing the efficiency of other instruments implemented by the regulatory authority.

Indeed, recent papers such as Delis and Staikouras (2011) begin to question the effectiveness of traditional tools such as capital requirements in reducing risk. As an alternative, they focus on the efficiency of prudential supervision in terms of bank audits and sanctions. They find that the usage of such “alternative” tools contributes significantly towards ensuring the stability of the financial system where more “traditional” instruments such as capital requirements falter. Hardy and Nieto (2008) suggest that increased supervisory stringency contributes positively towards risk reduction and therefore improves the stability of the financial system. The prudential effect of supervision is confirmed by Bassett et al. (2012) who conclude that increased supervisory stringency increases the quality of loans by incentivizing banks to lend to relatively risk-free clients. Aside from the direct effect of supervision on risk reduction, the role of prudential supervision in complementing other instruments is also documented in the literature. Ratnovski (2013) finds that it is possible, by means of using “alternative” regulatory methods geared towards increasing transparency in the banking sector, to improve the resiliency of the sector to shocks, as well as to enhance the efficiency of prudential instruments such as the liquidity ratio. Furthermore, Maddaloni and

¹⁹ see Agenor and da Silva (2014), Gertler and Kiyotaki (2010), Benigno et al. (2012) for examples of prudential instruments such as Loan-to-Value (LTV) ratios, liquidity and reserve requirements.

Peydro (2013) argue that reducing supervisory stringency diminishes the risk of a credit crunch appearing under tighter lending conditions resulting from higher capital requirements or liquidity ratio constraints. Their conclusions are of particular interest since they are indicative of supervisory measures and traditional macro-prudential tools coexisting and producing better results when coordinated and utilized together.

The objective of this chapter is to look in more detail at the effects of prudential supervision introduced alongside regulatory instruments in an environment of persistent crisis conditions. We do so within a multi-agent framework that allows us to better integrate the persistent crisis conditions into the model and to study the behavior of the financial sector. Persistent crisis conditions in the model are defined as a situation in which the proportion of high risk clients in the economy remains elevated even after an initial shock, thereby placing a strain on the bank's ability to cope with its clients' defaults. We focus on the effects of different prudential supervision configurations on bank profitability and default rates. The study is conducted in an environment of costly monitoring and informational asymmetry where the bank is unable to gauge the exact risk level of its clients. As such, the model simulates the bank's response and financial situation under long-lasting crisis conditions and determines whether the prudential regulator is able to offset the negative effects of persistent crisis conditions. We focus specifically on crises emerging from the default of the bank's debtors when the bank is faced with severe liquidity shortfalls.

We adapt Diamond's (1984) "Financial intermediation and Delegated Monitoring" framework to a multi-agent setting consisting of the bank, its clients, the prudential regulator (that can coincide with the Central Bank) and, where applicable, an insurance agency that will interact in the economy. We calibrate the model based on IFC data and the data resulting from empirical studies related to the subject.

We put three "classic" visions of regulatory intervention to the test: a simple prudential norm, a tax-subsidy mechanism and a market-based CDS insurance scheme. These instruments will fulfill the prudential objective of the regulator and may be regarded as alternatives to the commonly used prudential measures of the Basel frameworks. We adapt the tax-subsidy mechanism to reflect a "bail-in" instrument, as the one recently proposed to deal with the financial crisis in Cyprus²⁰. Whereas it is evident that the bank is always better off when the

²⁰ The bail-in mechanism was proposed by the European Commission and the ECB to deal with the banking sector crisis in Cyprus in March 2013 (see Ewing (2015) and Gumbel (2013) who reported on the issue). Since

prudential supervisor intervenes, it would seem that different supervisory techniques are better adapted to various economic conjunctures.

Imposed regulatory norms that include credit-rationing provisions only have temporary stabilizing effects on the economy in crisis situations and inevitably falter and allow the bank to default when the credit rationing becomes more stringent. More advanced monitoring techniques used by the bank can extend the stabilizing effect of the supervisory mechanism to a longer period of time, but with unchanged finality. Still, provided that the bank has access to sufficient market information to formulate a more advanced monitoring plan, the norm's effect may last long enough to steer the bank out of a crisis situation. Of course, such methods bear the advantage of not imposing any burden on the tax-payer, but require that the prudential institution determine an appropriate numerical value for the norm that would balance the risk level undertaken by the bank with the activity-stifling effects of credit rationing.

A market based CDS mechanism curated or supervised by the regulator can serve as an equally powerful tool and may be even better adapted to situations where the bank is able to integrate sufficient information about its clients to formulate advanced monitoring methods. Unlike the norm which imposes the bank to follow a prescription, this mechanism incites the bank to participate with the prospect of cost-reduction. Being market based, the mechanism allows for price fluctuations of the CDS instrument according to the bank's demand. The efficiency of such a system that allows the bank to insure against the risk of its clients' default is highly dependent on the bank's ability to integrate the price structure of the insurance instrument. Under the assumption of limited bank access to information, it is impossible for the bank to accurately deduce the price structure – which leads to inefficient allocation of (CDS purchase) funds. Given its unconstrained access to information in the economy, the supervisor's role is to observe the bank's decision model and to correct it by serving as an intermediary between the bank and the CDS market, guiding the bank's decision towards the optimal level. Indeed, provided that the bank has an advanced client monitoring method, it seems that market-based mechanisms are more efficient at stabilizing the bank's situation and at eliminating the negative effects of the crisis conditions by

then, the idea of using bail-in instruments has become more widespread in Europe, as evidenced by the European Bank Rescue Plan (see Petroff (2013)) and the ongoing efforts of tracking down various bail-in style rescue plan implementations, similar in nature, but sometimes differing in scope or instrumentation from that of Cyprus (see Snyder (2013)).

reducing the bank's costs associated with the defaults of its clients. In fact, the bank can operate at increasing profit under long-term crisis conditions when such a supervisory system is applied. It must be noted, however, that if the bank operates an uninformed monitoring model, the market based method performs worse than even the regulatory norm. This is caused by the bank's inability to correctly allocate resources between its monitoring and CDS-purchasing activities. For the same reason, the sole introduction of a CDS mechanism without regulatory supervision to guide the bank in its CDS purchasing choice results in a worsening of the bank's financial situation.

Finally, the tax-subsidy instrument taking the form of a "bail-in" mechanism in which it is those who benefit from the bank's credit activities that are also expected to contribute towards saving the bank when it encounters difficulties - seems to be the most powerful tool in the regulator's arsenal. The role of the supervisor here is to monitor the bank's financial situation and implement a tax on borrowers when the bank reaches dire conditions. Here, the entirety of the social cost (of the bank's default) is borne by the production sector. This method is efficient under all circumstances and regardless of the complexity of the bank's monitoring method and the underlying informational asymmetries present in the economy. The major drawback, however, of this method is that it imposes a very high cost on the firms' profits, with taxes having, at times, to reach close to 100% of the firm's profits in order to ensure the safety of the financial intermediary. Also, this method creates very high fluctuations both in the bank's revenues, as well as in the instrument itself. This can be a negative factor if the prudential regulator is also the Central Bank and pursues a concurrent objective of stability in the economy. It is also noteworthy to mention that whereas the efficiency of this method generally allows the bank to continue operating at a profit under conditions of long-term financial crisis (unlike the only temporary effects of the prudential norm), due to the fluctuations caused by the system, the bank risks plunging into negative territory in terms of liquidity and may require additional punctual credit facility interventions from the Central Bank in order to continue operating.

Therefore, we find that prudential supervision serves to improve the financial situation of banks faced with long-lasting crisis conditions. The method of choice, however, depends on the objectives pursued by the prudential regulator, its interactions with the Central Bank and the monitoring efficiency of the banking sector.

The rest of this chapter is structured as follows: Section 1 has provided an introduction into the importance of studying the effects of supervision on the resiliency of the banking sector. Section 2 presents the structure of the model, the various interacting agents, and explains the functioning and processes that determine the dynamics of the model. Section 3 explains the various regulatory set-ups envisaged and provides in-depth simulation results for both the baseline scenario, as well as for the model runs containing prudential supervision. Finally we conclude by presenting the main findings.

2. Purpose, Agents and Agent Variables

Within the model we will have three “main” types of agents: the firms, the investment bank, the Prudential Regulator and one auxiliary agent: the CDS fund, whose presence is conditional upon the usage of CDS instruments in the Prudential Regulator’s toolset. It is noteworthy that in many advanced economies, the Central Bank coincides with the prudential regulator thereby giving the regulator additional tools that can be used in unison. To this matter, Schoenmaker (2011) presents a detailed depiction of the regulatory structure of multiple countries. However, we note that it is not our objective to study monetary policy and the specific instruments associated with it for the purposes of this simulation, and we will only make brief general remarks about it where necessary.

2.1. Purpose

The purpose of this model is to study the extent to which prudential supervision accompanied by regulatory instruments can serve to improve the bank’s financial situation in terms of profitability and liquidity, as well as the efficacy of such measures in reducing the number of bank default episodes in the context of long-term and short-term crises.

To define a banking crisis we may look at Northcott (2004) who, in a Bank of Canada Working Paper, states that banking crises represent episodes of either financial institution insolvency or illiquidity. Concurrently, Angkinand and Wihlborg (2005) and Duttagupta and Cashin (2008) propose that banking crises appear when the bank loses most or all of its reserve assets, capital or liquidity. Given the setup of our model, we will be focusing primarily on liquidity issues that the bank may face as a result of the crisis situation. We will therefore define a crisis situation as the instance in which a bank is facing a severe liquidity shortfall and has a client portfolio of doubtful quality. These are the two necessary conditions for a crisis to emerge. With respect to the bank’s liquidity, we will allow for the bank to have

just enough resources to finance one last group of clients. This condition is required for the model to be able to initialize. However, the presence of lower-quality clients with higher default probabilities in the bank's portfolio will then contribute to a potential further deterioration of the bank's financial standing. This will allow us to introduce prudential supervision under different forms and gauge its overall effectiveness under conditions of both short-term and long-term crises.

The length of a crisis will depend primarily on the behavior of the bank's clients and the risk level of the projects that they decide to undertake. During crises, it is assumed that a significant number of agents have undertaken projects of high risk, thereby compromising the stability of the bank. If, subsequently, the agents tend to rapidly converge towards undertaking projects of moderate or low risk – then we can conclude that we have been faced with a short-term crisis, or a crisis episode. Once the crisis event has passed, the bank should, by means of its regular credit activities, be able to replenish its liquidity reserves and continue operating at a profit. If, on the other hand, we do not see a clear tendency of the agents to converge towards some equilibrium and their project risk levels continue to fluctuate over time, then we are to conclude that the underlying conditions causing the crisis have not dissipated and that we are confronted with a long-term (or enduring) crisis which may have negative long-term effects on the bank's financial indicators or even pose a threat to the bank's existence. We do not delve into the factors that have generated the crisis. Instead, we utilize the dynamics of the firms' project decisions as a consequence of the crisis situation to investigate the bank's behavior. The firm dynamics influence the bank's response to the crisis and allow us to study how the prudential authority can improve the bank's situation by implementing prudential supervision and instruments.

2.2. Firms

The firms in our model represent the bank's clients. True to Diamond's (1984) formulation, each firm requires one unit of bank credit in order to finance a project that has a certain probability of success in the next period. In the event of success, the firm obtains a reward allowing it to reimburse the bank loan and maintain a profit, whereas failure is characterized by a situation in which the firm obtains a reward equal to the loan amount, thus rendering impossible the repayment of the interest on the contracted loan. The structure of the firm's risk-reward configuration is given by:

$$V = \begin{cases} V_H, & \text{with probability: } (1 - p) \\ V_L, & \text{with probability: } p \end{cases} \quad (18)$$

Where V_H is the “high” reward in the event of success, $V_L = 1$ is the “low” reward in the event of failure, p is the probability of default and $(1-p)$ is the probability of success.

We notice that, as in Diamond, the bank is able to liquidate the firm if it does not pay back an amount f that at the very least equals the bank’s invested unit plus interest spent on crediting the firm. This dispels any attempt of the firm’s management to announce earnings lower than the bank’s expected payoff f , which depends upon the economy’s interest rate R , as well as the default probability p of the project that was undertaken by the firm. As such:

$$f = \frac{R}{p} \Leftrightarrow R = p * f \quad (19)$$

As we can see, this condition reflects the risk neutrality of the bank which expects to obtain, on average, the (base) interest rate R in exchange for crediting a firm’s project of p riskiness.

A resulting firm variable is the profit that the firm obtains after paying back the bank’s loan. It is expressed as: $\pi_f = V_H - f$ in the case of success, whereas if the firm defaults and is liquidated by the bank, its profit is null $\pi_f = 0$.

In our model, the origins of the crisis that the bank is confronted with stem in part from its client portfolio. We assume that in times of crisis, the bank is confronted with clients of different risk levels, with some significant presence of high-risk project-bearing clients. This means that we must depart from Diamond’s framework and divide the clients into multiple risk groups. We find that it is more commonplace to divide bank clients into 3 credit risk-groups: low, medium and high-risk clients, although more detailed classifications also exist. For instance, Experian (2014) and CA Technologies (2014) prefer to use 3 risk groups in their credit risk assessment models and their project risk scores. On the other hand, PricewaterhouseCoopers utilizes a finer categorization totaling 5 risk levels, as described in Gillespie et al. (2010). The theoretical literature also seems more inclined towards the usage of 3 categories. This is best illustrated in an IFC study performed by Dickson and Einstein (2010). For the purposes of our model, we shall retain the 3 group classification as we have no need to delve into the level of precision that a 5 group classification would offer.

With respect to the probability of default variable, we shall calibrate our model based on the data provided in the IFC study. In Table 3.1, we notice the probabilities of default, which in our model will also determine the firm's reward:

Table 3.1. Client risk-groups classified by probability of default

Risk-Group	Probability of Default (p)	
High	p_h	$> 10 \%$
Medium	p_m	$1 - 10 \%$
Low	p_l	$< 1 \%$

source: Dickson and Einstein (2010)

Table 3.1 presents the probability of default intervals for *the bank's low, medium and high* risk clients.

Besides the firm's individual probability of default, recognizing the fact that the majority of firms have some sort of linkages with counterparts of various nature (competitors, partners, clients, etc.), as evidenced by Koenig et al. (1979), we introduce a global probability of default calculated as the average of the firms' individual default probabilities. This global variable will influence the individual probability of default by a measure $\varphi \in [0;1]$ whereby a value of $\varphi = 0$ means that the global variable exerts no influence whatsoever on the individual firm's probability of default and an extreme value of $\varphi = 1$ would amount to the individual firm's probability of default value coinciding with the global one.

Deriving from the riskiness of an undertaken project, the reward in case of success (V_H) for each firm will be given by:

$$V_H = \frac{R}{1 - \bar{p}_g} + R * \bar{p}_g \quad (20)$$

Where \bar{p}_g is the average probability of default for the given group $g = \{h, m, l\}$. And we remind that $V_L = 1$ in all instances of default and for all risk groups.

Depending on their probability of default, each period, the firms will either succeed or default. This reflects a one-period credit maturity that applies throughout the model. In the

event of success, the firm is likely not to change project risk groups, but we account for a small chance that the firm manager may voluntarily wish to change project types (for personal reasons, because he believes that firms pursuing other project types are more profitable, etc.). This small chance is determined by a group cohesiveness variable (γ). If the firm defaults, however, a new agent will appear in place of the old one with a potentially different type of project.

2.3. Bank

In our model, the investment bank is the sole source of funding in the economy. It provides entrepreneurs with financing so that they can implement their projects. The bank starts off in a crisis situation with low liquidity reserves and an unsound client portfolio. Our bank acts as an investment bank. Hence to avoid the issues arising from the moral hazard that the bank may manifest as a result of catering both to its investors and acting for its own account, the bank funds clients utilizing only its own resources. This type of modeling approach allowing for a segregation of the bank's investment activities from its deposit unit in order to study more minutely the bank's own investment decisions can be found in papers such as de Walque (2010). By reducing the number of processes and actions to be modeled, this framework presents the advantage of focusing our work on the area of prudential supervision without worrying about adverse selection issues on the bank's behalf, but prevents us from implementing leverage-dependent regulatory tools.

In terms of its activity, the bank undergoes a series of processes through which it manifests its credit, monitoring and corrective actions.

Figure 3.1. Bank decision processes

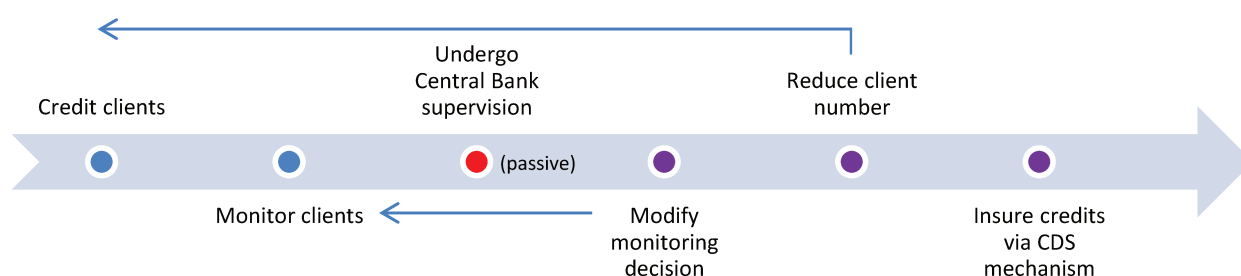


Figure 3.1 displays the two initial decision processes that the bank undergoes with respect to crediting its new clients and subsequently deciding on the number of clients to monitor, as

well as the three potential corrective actions that it may take as a result of Central Bank supervision that it undergoes.

The bank initially finances all of its clients, since it cannot determine which (if any) of its clients undertake high-risk projects.

Subsequently, the bank monitors a portion of its clients. Monitoring is assumed to be costly, as evidenced by the literature on the matter. Booth (1992) confirms Diamond's (1984) assumption of high monitoring costs. However, monitoring allows the bank to recover the unit invested into the client (firm) and to avoid additional costs (such as costs arising from reputation loss, etc.). In fact, the role of monitoring in reducing client default costs is evidenced in multiple studies. Baxter (1967) estimates bankruptcy costs at around 20% of the market value of a client. Stanley and Girth (1971) and Van Horne (1976) later confirm this result. Furthermore, it would seem that financial institutions must also deal with reputation costs arising from the default of their clients. These costs are also proven to be considerable as shown in Infosys (2012) and Deloitte (2014). However just as with bankruptcy costs, they can be reduced via monitoring, as described by Gopalan (2010) and Lin (2011). Furthermore, Vanston (2012) provides evidence that Central Bank supervision may also serve to reduce reputational costs incurred by the bank as a result of its client's default. Finally, Barnett and Harder (2014) argues that banks that do not monitor may be faced with negligence charges in lawsuits initiated by the defaulted clients. The only way of eliminating such costs is for the bank to monitor its client. As we have seen, there is ample incentive for the bank to monitor, however depending on information that the bank has of its clients the decision process may be more subtle. In our model we are able to vary monitoring costs in order to determine their impact on the bank's financial situation and monitoring decision.

The bank disposes of several monitoring techniques that it may use depending on the informational asymmetries associated with the economy in which it operates. If the bank suffers severe informational asymmetries that prevent it from gaining ex-post precise insights into the risk-level of the clients that it credits, then the bank adopts an approximate method of monitoring based largely on the information that it can obtain from the clients that it monitored in the previous period. If informational asymmetries are relaxed and the bank is able to obtain information about a larger portion of its clients, then the bank can implement more advanced monitoring techniques, such as expecting that some clients will remain stable, being more vigilant towards both high-risk and brand-new clients that emerge as a result of

firm defaults. These more advanced techniques allow the bank to better adapt to the economic context that it finds itself in and allow for a more efficient usage of the expensive monitoring process.

With respect to agent variables, for our study of the bank's financial standing, we focus on three key indicators that reflect the bank's situation: the number of default episodes, the bank's total liquidity and the ROI (Return-On-Investment). The ROI follows the evolution of the profit variable very closely and we will primarily be using it as a control variable. As such we will refer to it only very briefly. A default episode is defined as being a time period (year) at the end of which the bank has negative liquidity. This indicator is a measure of the length of the bank's distress and, consequently, of the severity of the crisis. For simulation purposes we allow the bank to continue operating even at negative liquidity, but count the period with negative liquidity as a "bank default episode" which would otherwise have led to the failure of the bank and a halt of all its operations. Such an assumption would be justified if the bank had access to some form of external credit (perhaps a credit line of last resort) that it could contract in the event of illiquidity. However, as documented by Allen et al. (2009) as well as by Freixas et al. (2011), it is often the case that during systemic banking crises, financial institutions are unwilling to lend to one another and the interbank market often dries up – thus confronting the individual bank with a lack of external funding options. Still, the bank could be allowed to temporarily continue operating at a loss in the instance in which the Prudential Regulator coincides with the Central Bank and has the option of extending exceptional credit facilities to the afflicted financial institution.

The bank's total liquidity indicator gives us a sense of the bank's capacity to finance new clients and perform the various monitoring and, if required by the regulator, insurance activities. This is our indicator of the financial institution's health. The prudential regulator (usually the Central Bank with regulatory functions) may act upon this variable by providing the bank with stimulus, if such an intervention method is chosen. Finally, the ROI may be of interest since it gives us an indication of the bank's profitability. It is one of the indicators commonly used to compare the performance of both corporate and banking sector entities.

Table 3.2 presents a sketch of the bank's simplified income statement, including the elements related to the regulator's intervention:

Table 3.2. Bank income statement

Category	Amount
Revenue	Total
Interest (including principal reimbursement) paid by clients (f)	
Revenue from monitoring in the event of client defaults	
Regulator's liquidity injections	
Expenses	Total
Cost of crediting new clients	
Costs of client defaults <ul style="list-style-type: none"> - bankruptcy cost - reputation cost - negligence cost 	
Monitoring costs	
Insurance costs (if required by the regulator)	
Revenue — Expenses	Profit

Table 3.2 details how the bank's profit is formed, by component. As such, it presents the variables that constitute the revenues and expenses of the bank.

As for variables pertaining to the bank's internal processes the bank also chooses the number of clients to monitor within its monitoring function, and if a CDS insurance mechanism is implemented by the regulator, then the bank will also choose the number of CDS units to purchase. On the other hand, if the prudential authority enforces supervision of a regulatory norm regarding the number of clients that the bank must monitor, then the bank will also dispose of a variable that allows it to calculate the number of clients (if any) that it must abandon in order to conform to the norm, subsequently utilizing an internal process to determine which clients to abandon.

2.4. Prudential Regulator

The Prudential Regulator (in the literature, often coinciding with the Central Bank) performs both supervisory and intervention functions. One of the main roles of the regulator is to

observe the bank's financial situation, as well as the decisions that it makes in order to ensure its uninterrupted operation. This means that the regulator will be privy to all the internal operations of the bank, its processes and variables. On the other hand, the regulator may also be lead to take corrective action to resolve deficiencies that it observes. Herein lies its second role of actively pursuing the implementation of the chosen regulatory method. We propose three different models of regulatory supervision and intervention that cover the "traditional" intervention mechanisms studied in the literature on market regulation, adjusted for some newer methods of banking crisis resolution circulated within the EU. We provide a brief description of each method here in order to introduce the associated variables and processes and further expand the subject in its appropriate section.

The first regulation method tasks the prudential regulator with supervising the bank's financial variables and determining if the bank may be faced with a problem of illiquidity. If, indeed this turns out to be the case, then the regulator (either by coinciding or by coordinating with the Central Bank) will perform a liquidity injection into the bank to save it. We implement the liquidity injection as a "bail-in" instrument to resemble the EU creditors' proposition in the case of the Cyprus bank defaults of 2014. However in our case we consider a tax on firms' profits. The reasoning behind this is that, as in any bail-in instrument, it is those who benefitted from the activities of the bank that must contribute towards saving the bank, should the financial institution encounter difficulties. And, in the model we present, it is specifically the firms who benefit from bank credit that enables them to obtain profits. Consequently, it is only fair that they support the burden of the bail-in mechanism. The regulator determines the amount of liquidity needed by the bank in order to avoid a default and imposes a tax on firms' profits. This tax is stored in a variable that the regulator will control. The tax evolves in fixed increments. As such, if the regulator raises slightly more money than what is required to save the bank, then the remainder of the taxation proceeds is deposited in a reserve fund. If, after having subjected firms to the maximum imposition level, the regulator is still unable to save the bank, then the regulator will utilize the previously accumulated reserve funds. Finally, if after having depleted its reserves, the regulator is still unable to save the bank, then the bank will be allowed to default.

A second method involves the creation of a CDS insurance market to allow the bank to hedge against the risk of default of its clients. An insurance fund is created and will control the CDS price variable which will depend on the bank's demand for CDS units. The bank, which, as mentioned earlier is confronted with informational asymmetries, is unable to correctly

integrate the price structure of the CDS instrument. This opens up the way for the regulator which will now be tasked not only with supervising the bank's financial indicators, but also with overseeing the CDS market and helping the bank to integrate information about the price structure of the CDS tool. The regulator's intervention is performed by a sub-model through which it determines the optimal quantity of CDS units that the bank must demand in order to minimize its costs for any given objective level (in terms of risk reduction). This means that within this supervision method, the regulator obtains an additional variable that stores the optimal quantity of CDS units that the bank must purchase. Furthermore, the prudential authority communicates this value to the bank which corrects its own value of CDS units to purchase.

The third regulatory method involves the implementation of a monitoring norm that constrains the bank to monitor a given number of clients each turn. Failure to do so results in an immediate termination of the bank's activities. In this situation, the norm may be fixed, or it may be enunciated as a percentage of the total number of clients that solicit bank credits. Although time invariant, the norm can be considered as an additional regulator variable that is controllable by the observer and is set at the beginning of the simulation. It must be noted here that a smaller number of clients to monitor reduces the financial strain placed on the bank by the regulator by means of reducing the per client monitoring costs that the bank supports. However, the reduction in the regulatory number of clients to monitor also reduces the efficiency of the method since it increases the chance for non-monitored firm failures to appear. This method could be expanded to include sanctions for non-conformity as opposed to immediate termination, but that would somewhat undermine the strictness of the norm and would allow the bank to disregard regulation as it sees fit – which is contrary to what the regulator hopes to achieve by introducing the norm.

3. Model and Simulations

Before we can proceed to the simulations, we must first take a look into the scheduling of the various processes described in the first part of the chapter, as their order will impact the functioning of the model.

3.1. Model structure and initialization

Initially, in the very first period (t_0), the bank is endowed with sufficient liquidity to finance all of its clients. Optionally, the bank can be bestowed with some extra liquidity above its

strict minimal necessity in order to avoid the bank defaulting in the immediately subsequent period as a consequence of a random or chance event. Still the extra cash assigned must be limited in size given the fact that we are modeling a liquidity-constrained bank in the middle of a crisis. If, because of the selected monitoring algorithm, the bank also needs to expend resources on monitoring during the setup phase, then those costs will also be covered.

Clients are generated according to the setup conditions where the observer determines the proportion of low, medium and high risk clients in the economy. The clients determine their desired risk level within the confines of their risk-group which translates into their individual probability of default. Afterwards their actual probability of default is automatically determined based on their individual characteristic, the global default probability and φ .

Finally, the bank credits the new clients and, if required by its algorithm, proceeds to immediately monitor the firms.

The described structure will also be present in the following periods, however a number of new elements will be introduced. Table 3.3 illustrates the timing of the processes in all subsequent periods and focuses on the bank's monitoring processes, as well as on the regulator's supervision. The line number represents the order in which the events are processed. We begin by determining the project realizations of the firms credited in the previous period and then proceed to operating with the (new) clients that the bank is faced with in the current period.

Table 3.3. Model structure and order of events

Nr.	Event title	Event description
Events related to previous period proceedings		
1.	Project realizations become known to the firms	Some firms (mostly the ones with higher probabilities of default) will go bankrupt (obtaining $V_L < f$), whereas the others will obtain positive rewards such that $V_H > f$.
2.	Statistical data is gathered by the regulator	The regulator now knows information about the defaulted clients, their number, group origins, whether they were

		monitored by the bank or not, etc.
3.	The bank's financial situation is updated	All non-defaulted clients pay the bank its expected payoff (f), defaulted but monitored clients reimburse the borrowed unit of credit (but without interest) and the bank suffers default penalties for the defaulted and unmonitored clients.
Events related to the current period		
4.	<p>New clients appear</p> <ul style="list-style-type: none"> - clients are reset - their new risk group is determined (if it changed) - their probability of default is determined 	Defaulted clients will be replaced with new clients. Successful firms will tend to undertake new projects of the same risk-level as before. However, some of the successful firms may decide to change risk level for various random internal reasons or (in the case of more advanced firm rationality algorithms) because of external linkages with other firms.
5.	Bank crediting operations	The bank credits its new clients
6.	Bank monitoring occurs	The bank decides how many clients to monitor and (informational asymmetry levels allowing) determines specifically which clients to focus its efforts on.
7.	Regulatory supervision occurs	The prudential authority (or the Central Bank) monitors the bank's situation and determines its viability. If necessary, the regulator intervenes by utilizing the instruments available to it.
8.	Has the bank defaulted?	After all is said and done, we look at whether the bank survived the tribulations of the current period or whether it succumbed to the pressures facing it. We register the eventual default of the bank and either allow the model to continue or

		stop it (according to our setup).
Auxiliary processes		
9.	Verification	We verify some of the variables dynamically calculated throughout the model to check for errors.
10.	Plotting and graphs	We display the results of the model within the graphical interface.

Table 3.3 presents the sequence of events that comprise the foundation of the model. These processes are executed in the same sequence within each time period of the model. The events are grouped into 3 categories: one related to processing previous-period information, another to performing current-period actions and a third that comprises auxiliary functions.

This sequence of events will repeat every time step and will allow us to study the dynamics of the system by observing the outcomes of the agents' behaviors under different circumstances. In what follows, we will present in detail the simulation results for each of the three regulatory scenarios and will investigate the effect of different parameter values on the evolution of the system. We will be most interested in varying those parameter values for which there is either limited scientific coverage or for which multiple potential values are suggested by the literature.

3.2. Baseline scenario and bank monitoring

We define the baseline scenario, which will later on be expanded by including regulatory supervision, as a model simulation with no bank monitoring or regulatory intervention, taking place in a system characterized by the parameter values shown in Table 3.4:

Table 3.4. Baseline scenario parameter values

Parameter	Description	Value	Parameter	Description	Value
N	Number of clients	121	R	Interest rate	1.05
NL	Low-risk clients	30%	k	Initial bank liquidity	12
NM	Medium-risk clients	55%	mc	Cost of bank monitoring	0
NH	High-risk clients	15%	bc	Bankruptcy costs	0.2
φ	Influence of global	0.1	rc	Reputation cost	0.2

	default rate				
γ	Group stability parameter	75%	nc	Negligence cost	0.1

Table 3.4 presents the parameter values used in the baseline scenario of the model, in which neither bank monitoring, nor regulatory supervision are active.

We select a sufficiently large number of clients for the bank, but not too large in order to limit the simulation time. We assume that the crisis-hit system manifests itself through larger number of high-risk clients and medium-risk clients totaling 15% and respectively 55% of the firm population. This leaves low-risk clients at just under a third of the economy. With respect to the financial indicators such as the interest rates and the bank's costs, we follow Diamond's prescriptions as well as the ones mentioned in the aforementioned literature. We mention that the costs incurred by the bank as a result of client defaults are highest when neither the bank monitors, nor the regulatory institution supervises. These costs will diminish rather significantly, as stated in Gopalan (2010) and Lin (2011), when the bank starts monitoring. Finally, with respect to γ and φ which are indicative of the interaction amongst firms, we assume that firms have a strong tendency to maintain their project risk level in case of success (as evidenced by the group stability parameter) but, at the same time have default rates that are largely uncorrelated (as indicative of the low φ value).

We should note that as a result of our model calibration, the time periods that we study here are, in general, expressed as years. However, given the simulated nature of this economy, one must be very careful with the interpretations attributed to the temporality of the model. Also, with respect to the units of measurement of financial variables, they are similarly abstract, but, for convenience can be thought of as millions of a particular currency.

Let us first look at the results produced by the model under both absence of regulatory intervention, as well as the following client monitoring configurations emanating from the bank: (1) a situation of no monitoring whatsoever (the baseline scenario), (2) a context of low-cost monitoring under heavy informational asymmetry, (3) a situation of costly monitoring under heavy informational asymmetry, and (4) a more advanced monitoring method possible due to diminishing informational asymmetries however maintaining the hypothesis of costly monitoring. In all situations in which monitoring occurs, the costs associated with the client's defaults are automatically diminished for the monitored clients.

As such, $rc = 0.1$ and $nc = 0$. What has been described could be visualized graphically in Figure 3.2.

Figure 3.2. Baseline model simulation scenarios

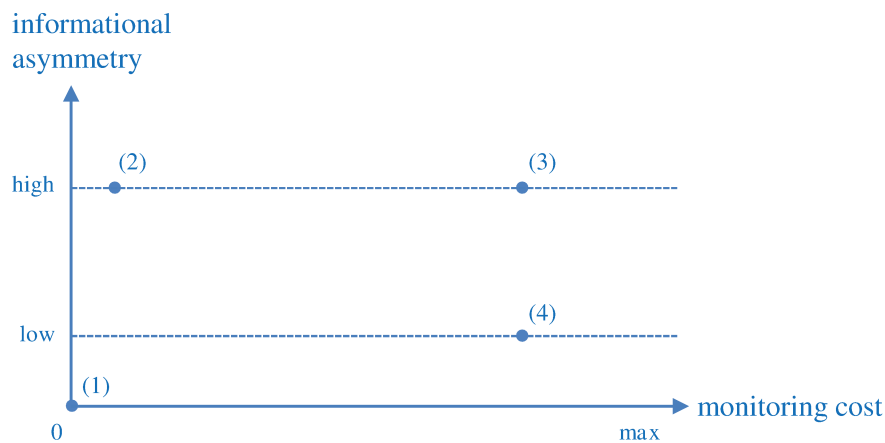
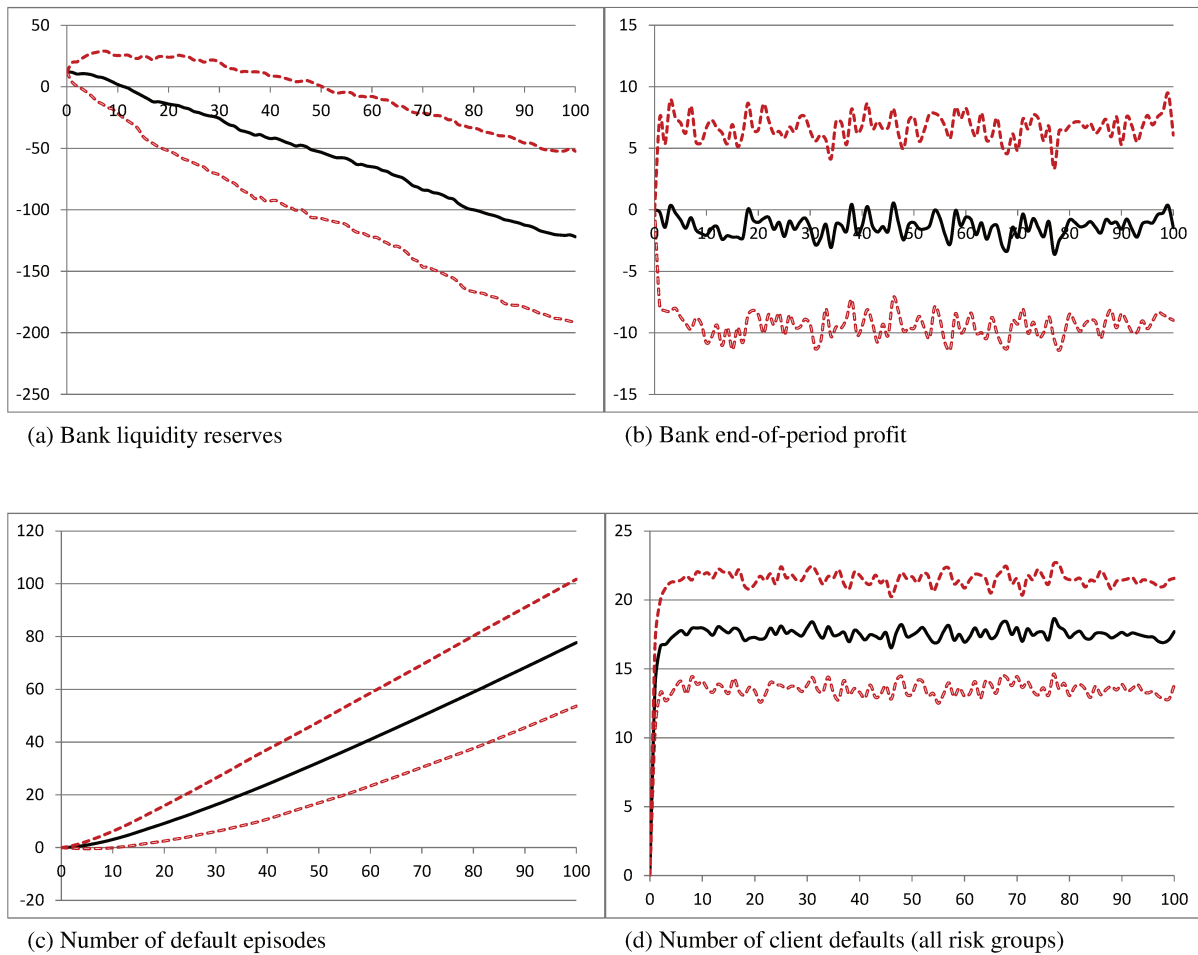


Figure 3.2 outlines possible simulation scenarios based on varying the costs associated with monitoring, as well as the informational asymmetries that the bank is faced with.

We must note that whereas monitoring costs (mc) represent a parameter value that can be modified by the observer, informational asymmetry is a qualitative measure based on the information that the bank has access to in its monitoring function.

In the first scenario characterized by an absolute absence of monitoring, the firms' behavior is characterized by a significant, although not overly high, attraction towards their risk group, characteristic of entities looking primarily to their internal processes and goals to determine the type of project to undertake. As shown in Figure 3.3, this results in a rapid decline in the bank's liquidity reserves past the point at which the bank must declare bankruptcy. The bank's average profits lie well below zero, which corresponds to the significant number of high-risk client defaults. The described situation is a consequence of the unstable environment in which low-risk and medium-risk projects compete for dominance, however with a relatively large proportion of high-risk projects in the economy. On average, high-risk enterprises constitute 22.18% of the total number of client submitted projects, within the designated study period.

Figure 3.3. Baseline model simulation without bank monitoring or regulatory supervision



Note: The solid lines represent the mean and the dotted lines denote \pm one standard deviation from the mean, the x-axis denotes time, results are based on 100 repetitions of the simulation.

Figure 3.3 presents the results of the baseline scenario in the form of the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. It reflects the dire situation of the bank in absence of monitoring and regulatory supervision, as bank liquidity declines under conditions of negative profit.

We notice, therefore, that the long-term as well as short-term activity of the bank in these economic conditions is unviable, as by the 7th period, the bank defaults in over 50% of the simulation runs and by the 10th period it defaults in over 2/3 of the total number of repetitions performed. Furthermore, the bank's profits rarely peak above zero, as the bank's expenses generally surpass its income. This underscores the necessity for the bank to monitor its clients

in order to reduce default-related costs and recover the invested funds from unsuccessful projects.

As part of a second scenario, we now insert bank monitoring into the equation. We first assume that the environment in which the bank performs its monitoring is characteristic of severe informational asymmetries. As such, the bank is entirely oblivious to the new clients that it faces each period. Besides the absence of any sort of signaling information (that the bank may make use of), the bank is also unable to infer any information regarding the future choices of current clients. These two assumptions amount to the bank operating under conditions of very high uncertainty. Still, the bank has access to general statistics regarding the number of clients and their adherence to the existing risk groups. Given this information, the bank's choice regarding the number of clients to monitor in the current period is based on the proportion of previous period clients from each risk group that the bank detected as part of its monitoring activities. Concurrently, the bank is aware of the value of monitoring a given client group. More precisely, the value of monitoring is equal to the default probability of the given group. As such, the bank monitors that specific group of clients only if the value of monitoring exceeds the cost of monitoring.

$$M_g^c = \frac{C_{g \ t-1}^M}{C_{t-1}^M} \text{ if } \bar{p}_g > mc, \text{ where } C_{t-1}^M = \sum_{g=\{h,m,l\}} C_{g \ t-1}^M \quad (21)$$

M_g^c is the percent of clients from group “g” that the bank will monitor in the current period. C_{t-1}^M is the total number of clients that the bank monitored in the previous period, and it is comprised of the sum of clients belonging to each risk group that were monitored in the previous period ($C_{g \ t-1}^M$).

In other words, the bank operates under the assumption that what was characteristic of yesterday still holds true today, and makes corrections to its number of clients to monitor based on the new information that it receives each day (information regarding the previous period).

This monitoring method is highly sensitive to the monitoring costs, since these determine the total number of clients that the bank will decide to monitor. If monitoring costs are low, then the bank will monitor most of its clients and, as such, manage to significantly reduce costs and recover most of its investments in the event of client defaults. However, under the

assumption of high monitoring costs, it is conceivable that the bank may only wish to monitor its riskier clients. This, however, coupled with the informational asymmetries that prevent the bank from properly determining which individual clients pose a threat to the bank's operations leads to a deterioration of the bank's financial situation when compared with the baseline scenario.

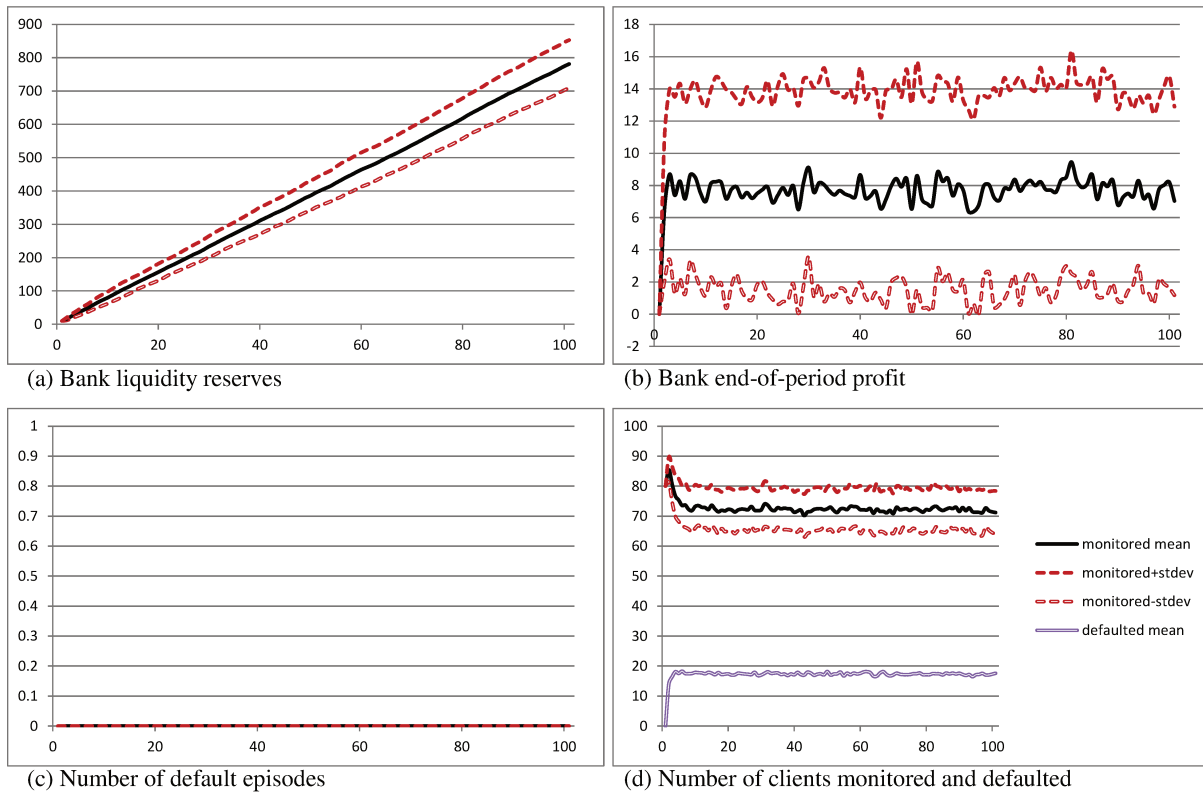
Indeed, if we look at Figure 3.4, we notice that in the case of low monitoring costs (the situation corresponding to point (2) in Figure 3.2), the bank is able to verify a large proportion of its clients, thereby ensuring that most of the defaulted clients are being monitored. This translates into lower expenses for the bank and higher profits which stabilize at a level sufficiently far away from the null value, that even in relatively extreme cases of profits falling at one standard deviation away from the mean value, bank profits remain positive or null. This has a positive effect on the bank's liquidity reserves which progress linearly towards infinity with increasing variability. As can be seen from point (c), the bank does not default in this context. The reason for this highly profitable situation is made clear in point (d) where we see that the number of monitored clients largely surpasses the number of defaulted clients at all points throughout the simulation. Although, because of the asymmetries facing the bank, it is not guaranteed that the monitored clients are also those clients who are defaulting, the odds are in favor of the bank when it comes to monitoring a risky client.

The same favorable situation does, however, not remain true for the scenario in which monitoring costs are high. Indeed, the assumption of costly monitoring has for effect a reduction in the number of monitored clients, given that the value of monitoring condition is not satisfied for all client risk groups. Under these circumstances, monitoring of low-risk and medium-risk clients becomes unprofitable for the bank and the bank reduces its monitoring target. The consequences of this decision can be seen in point (h) where the average number of monitored clients stabilizes at roughly 27 clients (constituting around 22% of the total population). The evolution of the average number of monitored clients is now much closer to that of defaulted clients and indeed can fall below the number of defaulted clients.

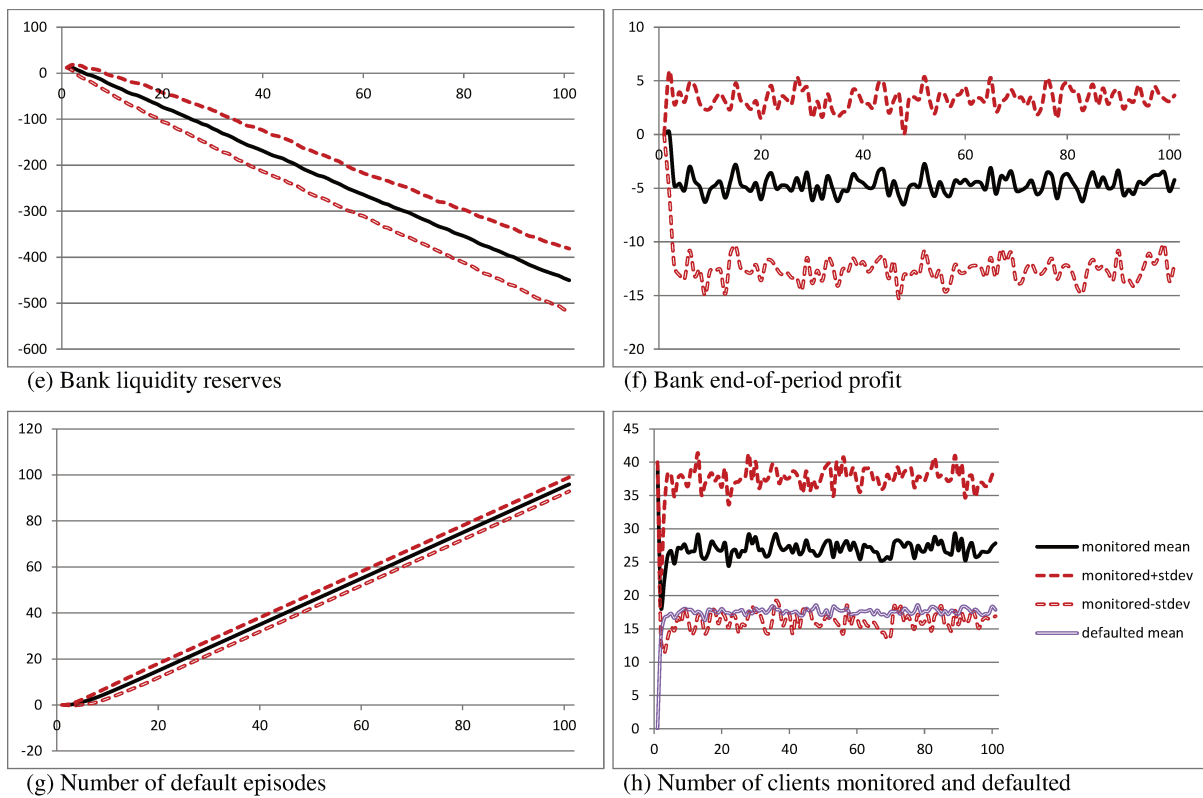
This means that the bank is now in a much tougher predicament, as it inadvertently faces the increasing risk of not being able to target the correct clients for its monitoring activities.

Figure 3.4. Baseline model simulation with high informational asymmetry monitoring

For monitoring costs: $mc = 0.05$



For monitoring costs: $mc = 0.3$



Note: The solid lines represent the mean and the dotted lines denote \pm one standard deviation from the mean, the x-axis denotes time, results are based on 100 repetitions of the simulation.

Figure 3.4 presents the results of the baseline scenario in the form of the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. It shows that, if the assumption of costly monitoring holds true, when bank monitoring occurs *under high informational asymmetries, the bank's financial situation is worse off than in the baseline scenario without monitoring or supervision.*

The situation translates itself negatively on the bank's profits which now stabilize in negative territory and at lower values than even the base-line scenario containing no monitoring whatsoever. Similarly, the bank's liquidity reserves register a faster drop as the bank now defaults in over 50% of the simulation runs by the 5th period (twice faster than in the case of the baseline scenario). We also see this in point (g) where the average number of default episodes per period is shown to increase linearly, after a short early phase in which the bank's initial reserves stabilize the situation and prevent the bank from failing.

We thus notice that monitoring can provide a way for the bank to reduce costs and recover investments, only under the assumption of reasonably low monitoring costs. Under the assumption of high monitoring costs, however, the process of costly monitoring itself places the bank in a worse off situation than the baseline scenario. As such, it is not recommendable for, nor indeed should it be expected from, a bank to entertain costly monitoring in an environment of high informational asymmetries. Forcing a bank into monitoring would only produce worse results than attainable in its absence.

In a final monitoring-only scenario, we allow for a decrease in informational asymmetries which allows the bank to better gauge the risk level of its clients. Now, after having monitored its clients, the bank will have enough data regarding their risk level in order to formulate expectations regarding the future risk level of each client. The bank will now be able to target high-risk clients in its monitoring efforts, as well as novice clients who have never yet been credited by the bank. This will allow the bank to better target those clients which pose an actual risk and to avoid squandering precious resources on low and medium risk clients. At the same time, since the bank can now accurately target clients based on their previous risk level, we now no longer impose the value of monitoring constraint on the bank and allow it to monitor as many clients as deemed necessary, provided the bank has enough financial

resources for the task. The business environment (or the evolution of the clients) remains unchanged. We will also assume that the bank operates under costly monitoring conditions and will utilize the same parameter value as before.

Figure 3.5. Baseline model simulation with costly low informational asymmetry monitoring

For monitoring costs: $mc = 0.3$

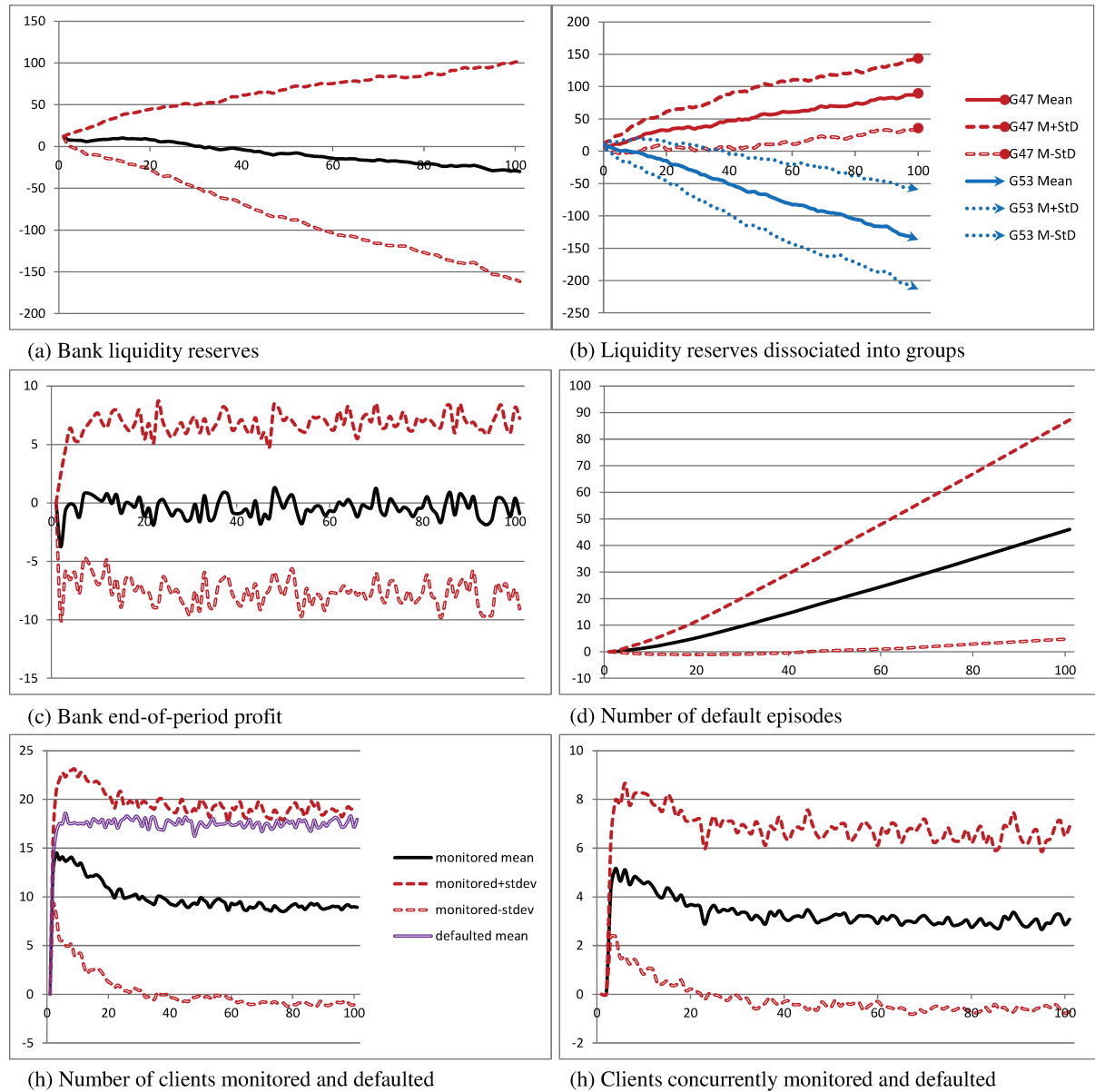


Figure 3.5 presents the results of the baseline scenario in the form of the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. It shows that when the bank monitors its clients under conditions of low informational asymmetry, the decline in the bank's liquidity is slower, and there is possibility for the bank to avoid default if it is faced with fewer high risk clients initially.

Given these conditions, upon first look at the evolution of the bank's financial situation variables, we notice a slight improvement versus the baseline scenario. However, we also remark a significant increase in volatility. Upon closer inspection, we notice that this is because of the duality in the trend of the profits and liquidity indicators. This is best seen in Figure 3.5, point (b) where we decompose the sample of 100 repetitions into two groups: one containing 47 runs and the other, the remaining 53 ones. In this graph, we notice that in a number of our repetitions, the liquidity indicator, after a short period of volatility (visualized in the average indicator as stagnation, but consisting of both ups and downs, sometimes even in negative territory, symbolizing the default of the financial institution), proceeds to an upward trend of steady growth. This is usually the case when the bank is faced with relatively mild early conditions consisting of lower default rates and/or lower number of high-risk clients. The bank, therefore manages to monitor enough clients in the early periods of its operations to avoid accumulating losses that would send its liquidity reserves below zero. In the event in which the bank faces tougher starting conditions because of higher default rates and a larger numbers of high-risk clients, its initial losses deplete its liquidity reserves rapidly and cause the bank's cash to dip below zero, which leaves it in the impossibility of further monitoring its clients, thereby sending it into a vicious circle of losses amounting and not permitting it to monitor. If we had elected to terminate simulation upon bank default, we would interpret this result as the inability of the monitoring process to save the bank in over 50% of our simulation runs.

As for the other indicators showing the bank's profits and default rate, we must note that, just as in the case of the bank's liquidity, we can see two separate groups of results, one located roughly between the mean and plus one standard deviation, and the other trend located between the mean and minus one standard deviation. We also notice that the bank is now able to monitor fewer clients than before, while maintaining roughly the same number of clients that were concurrently monitored and that defaulted as in the case of costly monitoring with high informational asymmetry. This amounts to a higher targeting precision for the bank's monitoring process. In other words, the bank monitors fewer clients, but out of those clients who were monitored it finds just as many who defaulted as in the previous scenario. This means that the bank has become better at finding the risky clients.

Indeed, we notice that even by reducing informational asymmetry, the hypothesis of costly monitoring does not allow the bank to ensure its safety – which raises the question of external intervention in the form of prudential supervision and instruments.

3.3. Prudential supervision and instruments

3.3.1. Supervision with regulatory norm

We will first test the efficiency of bank supervision coupled with a regulatory norm imposing the bank to monitor a certain percentage ($m\%$) of its clients²¹. The regulator will supervise the bank in order to ensure that it monitors the appropriate number of clients. To ensure an absolute lack of moral hazard on the bank's side, the bank is made aware that its activities will be terminated in the event in which it fails to comply with the norm. Also, the regulator constrains the bank to have sufficient liquidity for monitoring activities and initially informs the bank that it will not receive any form of credit from the Central Bank. This motivates the bank to try to keep its liquidity reserves above zero for as long as it can, only faltering in the event of impossibility to continue to do so. Beforehand unbeknownst to the bank, if the financial institution does indeed falter, then the Central Bank will either allow it to continue operating (as it has done in our previous simulations by extending a special long term credit facility) or it may alternatively choose to terminate the bank (if such action is specified in the model setup). For the bank to be able to satisfy the requirement of having sufficient cash destined towards monitoring purposes, a special mechanism is introduced: the bank is allowed to abandon some of its clients if it does not have enough money to monitor the percentage of total clients prescribed by the regulator. The bank cannot, however abandon clients that it has already willingly decided to monitor (since this would go against the very purpose of the regulator's intervention). Furthermore, if the bank has negative liquidity, before the bank can monitor the remaining difference of clients between the regulator's norm and its own internally determined optimal number of clients to monitor, it must abandon a sufficient number of clients in order to obtain the required cash to monitor the discrepancy. To give a simple example of the regulatory intervention, if the regulator imposes the bank to monitor an additional 15% of its clients, but the bank only has enough resources to monitor 5% of its remaining clientele, then the bank will be forced to abandon (or not credit) as many clients as required in order to, at the end of the day, be able to monitor the discrepancy. We can view the abandonment process as one of two possibilities: the first of which consists in the bank not crediting its clients before having decided on the number of clients that it will be

²¹ We refer here to the initial clients that request credit from the bank and not to the remaining number of clients after the bank's abandonment procedure. We enforce this specification since our objective is for the bank to monitor and obtain information about its clients, so that it may use this information to make future decisions. As such, the target number of clients to monitor will be invariable, as long as the total population of clients is fixed.

unable to finance. Such a scenario is consistent with the bank being aware of a monitoring rule set forth by the regulator. A second possibility is one in which the regulator does not immediately inform the bank of the existence of the norm, but will rather discretely inform the bank each time step of the existence (or not) of the regulatory norm. In such a case, the bank will first credit its clients and then have to abandon some of the credited clients. This imposes a recovery rate (rr), where $rr \in [0;1]$, that determines the amount of the initial investment that the bank will be able to recover as a result of abandoning the client. For our simulation purposes we will assume the former case, in which $rr = 1$. Also, we notice that supervision is inseparable from the norm since, in the absence of supervision with threat of liquidation, the bank will never be incited to monitor the number of clients prescribed by the regulator, and the simulation results will revert to the baseline scenario with monitoring.

For our simulation, we will therefore fix the two parameters controllable by the observer as follows: $m^{\%} = 0.5$ and $rr = 1$. We note that once fixed, the regulatory percentage can no longer be changed internally by the prudential authority, as it becomes a long term rule. Also, from now on, we will only be referring to the hypothesis of costly monitoring.

As we can notice, in the case of supervision with a regulatory norm and monitoring under high informational asymmetry depicted in Figure 3.6, by means of the regulatory norm, the supervisor is, on average (however, with relatively low deviation), able to stabilize the bank's financial situation for 11 time periods, after which the negative trend of the bank's financial resources continues, as in the baseline scenario with monitoring. When, as shown in point (b), we zoom into the liquidity graph to focus on what happens at the very beginning of the simulation run, we notice that although the bank's liquidity resources fall as a consequence of the high monitoring costs, they are stabilized by the fact that the bank monitors a larger number of clients and therefore reduces its client-default associated costs. We notice that the bank's liquidity reserves remain low, but positive until period 11, after which they dip irreversibly towards negative infinity.

We also notice that during the period in which the norm is effective, the deviation of indicators is minimal. We notice this both in the very low variance of the bank liquidity indicator, as well as that of the profits and bank default rate indicators. The number of default episodes remains at zero before period 12, which is consistent with the results seen in the bank liquidity indicator graph. We observe an initially higher discrepancy between the norm fixed by the regulator and the number of clients that the bank wishes to monitor on its own,

but this discrepancy gradually diminishes and stabilizes, as the bank's internally determined number of clients to monitor also evens out. We notice that the number of clients to monitor decided on by the bank is not the final number of clients that it will monitor, since the regulator will impose the bank to monitor the difference between the norm's prescribed number and that decided on by the bank.

Figure 3.6. Supervision with regulatory norm under high informational asymmetry monitoring

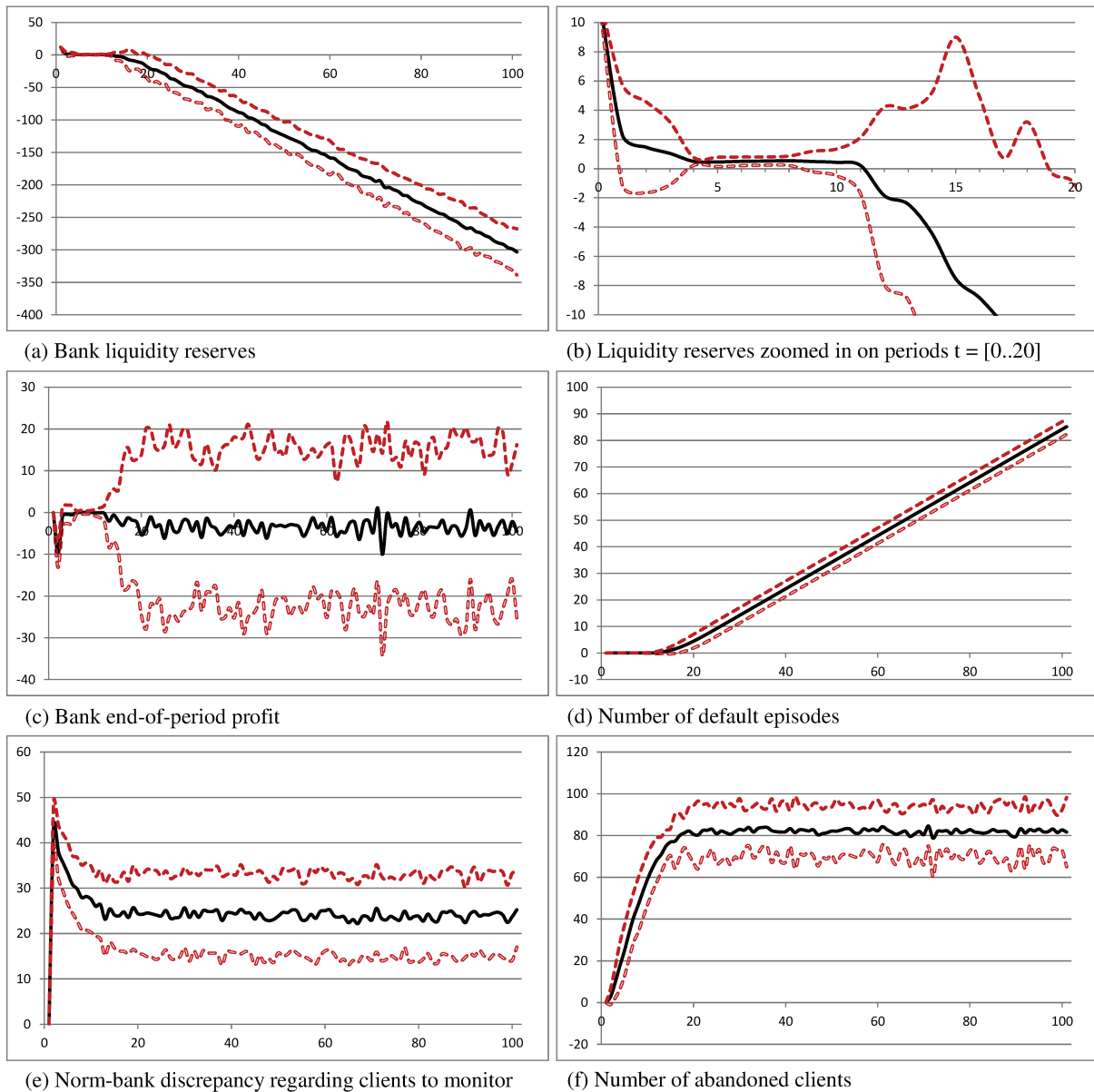


Figure 3.6 presents the results of the scenario in which the regulator introduces a norm accompanied by prudential supervision under high informational asymmetries. The results are presented as the means and standard deviations of the analyzed variables for 100

simulations of the model, over 100 time periods. We notice that when informational asymmetries are high, the norm only has a short-term stabilization effect, after which the bank inevitably defaults. Applying this instrument also produces severe credit rationing.

We notice that the bank does not get rid of all of its clients and stabilizes its client abandonment number at a number inferior to the maximum. This is a consequence of the bank's monitoring process which stipulates that the bank always monitors if its monitoring value condition is met. As such, the bank is ready to monitor its internally determined desired number of clients even if it faces default on the short term. This is because, due to the lack of information, the bank expects that by monitoring on the short term it will have long-term benefits in terms of general risk reduction – an expectation rendered unnecessary when the bank gains access to more information and is able to directly form expectations on a client-by-client basis (as in the case of monitoring under low informational asymmetry).

Looking at the situation in which prudential supervision is introduced alongside a regulatory norm and monitoring under low informational asymmetry, as shown in Figure 3.7, we notice that the stabilizing effect of the norm is much longer. Indeed, we can see in point (a) that after an initially high drop in liquidity owing to losses associated with the bank trying (in the beginning) not to abandon clients (f), the bank's financial situation is stabilized. We notice low volatility in the bank's profit, liquidity and default rate indicators up to around period 40. In this period, the bank facing increasing losses compensates by abandoning clients. Client abandonment produces two positive results: it reduces default-related costs and recovers resources for the bank. This process however is not sustainable, as by roughly period 40 the bank runs out of clients to abandon. This can be seen in point (f). In this monitoring method, the bank obtains enough information to form conclusions on a client by client basis and, thus, its monitoring method is not dependent on the monitoring value condition, but rather on the availability of bank liquidity. As we can see from point (e) by period 10, the bank no longer has enough resources to monitor its clients and the discrepancy between the norm and the number of clients willingly monitored by the bank is maximal. The number of clients effectively monitored by the bank will, however, still coincide with the norm as the bank is forced to abandon clients to meet the norm's requirements. Still, as depicted in point (d), all periods subsequent to time step 10 decrease the revenue obtained by the bank from its monitoring activities, since the bank is forced to abandon an increasingly high number of clients. Also, conditioning regulatory monitoring on available liquidity allows the bank to reduce the number of monitored clients to an extreme – to all but one clients. The finality of

the enhanced monitoring method made possible by lower informational asymmetries is that it the regulator was able, through the same norm, to keep the bank running for a period roughly four times larger. This is a positive achievement, as by the time the norm's efficiency wanes away, the crisis conditions of a real (as in non-simulated) economy may dissipate.

Figure 3.7. Supervision with regulatory norm under low informational asymmetry monitoring

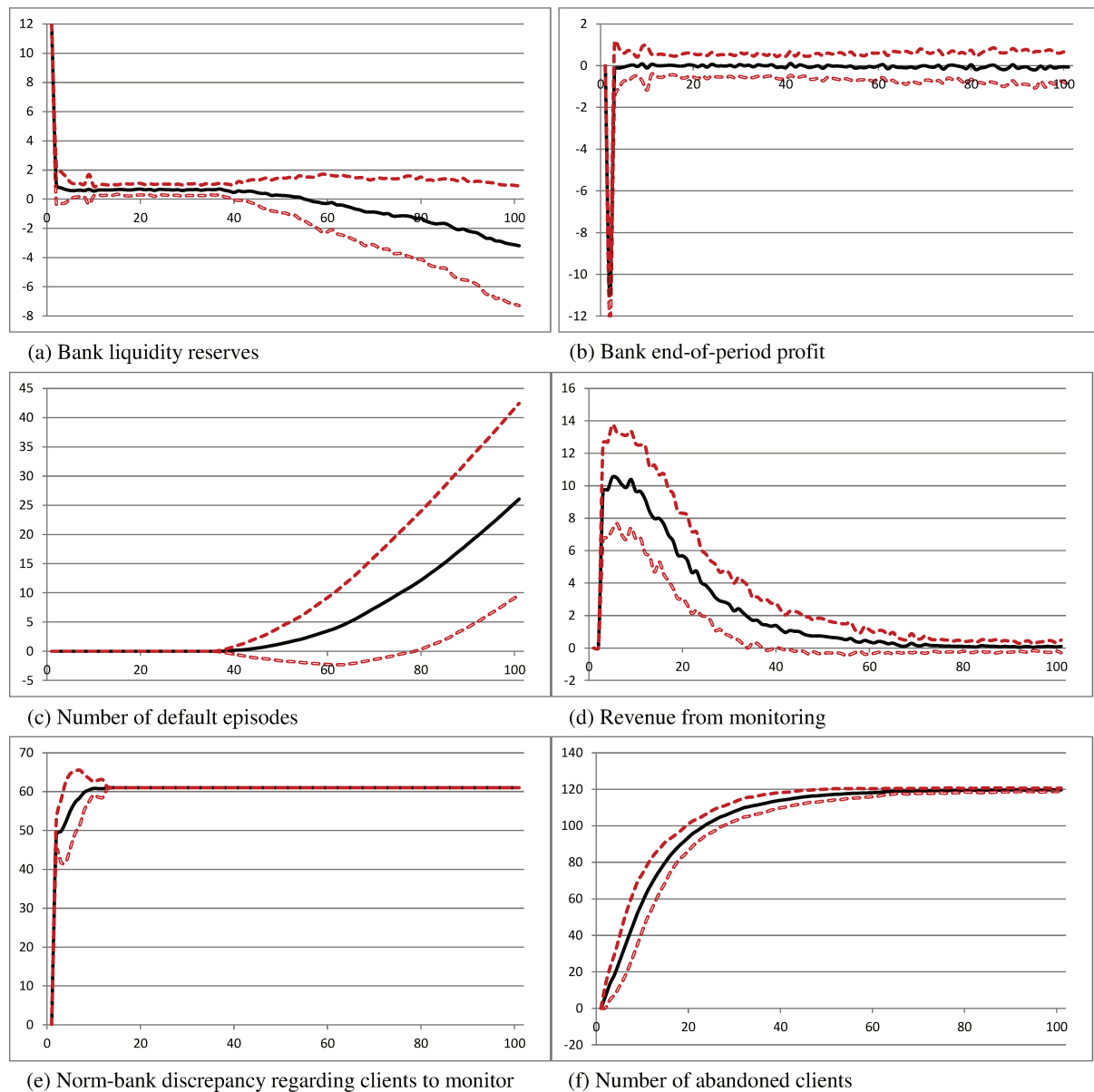


Figure 3.7 presents the results of the scenario in which the regulator introduces a norm accompanied by prudential supervision under conditions of low informational asymmetry. The results are presented as the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. We notice that the stabilization effect of

the norm is now more long-lived, but eventually, the bank still defaults. Applying the instrument produces severe credit rationing.

As we have seen from our analysis, the norm is able to postpone the negative effects resulting from the crisis for a certain period of time. Yet this delay is only achievable by means of severe credit rationing, which is introduced as a method of last resort for the bank to use in absence of any other internal or external instruments to fulfill the norm. The duration of the postponement is dependent on the bank's internal processes and its effectiveness at detecting and eradicating risk. However, under persisting crisis conditions, the finality remains the same – the bank eventually is no longer able to compensate and defaults due to a lack of liquidity.

3.3.2. How supervision renders a CDS-market operational

We again take to the baseline scenario with monitoring and, this time, inquire as to whether market-based regulation would be more efficient at improving the bank's situation. We thus introduce a market-based CDS instrument purchasable by the bank to insure against the risk of client default. We study two scenarios: one in which the regulator simply introduces the CDS mechanism and one in which the regulator actively supervises the market and the bank's actions to help it make optimal decisions. We thereby determine whether supervision improves or hinders the functioning of the market.

The regulator creates an insurance company (which we will refer to as the CDS fund). This CDS fund emits CDS units that the bank can purchase. We model the introduction of our CDS units in a manner that is inspired by Coase's (1960) vision for the distribution of rights on the environment. We similarly create a market structure in which the bank can freely trade, only in our case it is not buying pollution rights, but it's buying insurance rights (i.e. the bank buys the right to not default). The bank decides regarding the number of CDS units that it wishes to purchase. The CDS price is determined and the bank buys the desired number of CDS units, provided that it has sufficient funds to do so. Otherwise, the bank buys as many CDS units as possible within its liquidity constraints. The bank buys CDS units ex-ante, basing its choice only on the information that it has regarding previous period clients. The bank goes to the CDS market to solicit a quantity of CDS units equal to the number of non-monitored and defaulted clients $B_{\text{CDS},D} = C^{M \cap D}$, where $B_{\text{CDS},D}$ is the bank's demand for CDS units and $C^{M \cap D}$ is the number of clients who were both left un-monitored in the

previous period and subsequently defaulted. The bank purchases CDS units at a variable price from the CDS fund. One CDS unit insures that the bank obtains R (the risk-free interest rate) from a defaulted client. CDS units are assigned to individual clients, are non-transferable among clients and expire at the end of the period. The money accumulated in the CDS fund is used to pay the bank a total of $B_{\text{CDS},R} = R * C^D$ in the next period (when we find out if the clients that the bank bought CDS units for have defaulted or not). Here, $B_{\text{CDS},R}$ is the bank's reward from purchasing CDS units and C^D is the number of defaulted clients. We now give an example of how the bank's reward functions on a per client basis. If the bank did not monitor the client, then the difference between the per client reward that the bank would have obtained in the event it used the CDS instrument and that in which it didn't use the instrument is: $R - 0 = R$ which is a clear gain for the bank since $R > 0$. However, if the bank did monitor a client and also decided to ensure him (because, for instance, the bank had purchased a very large number of CDS units), then the bank's per client reward would be $R - v_l > 0$ since $R > v_l$. We notice that the bank still obtains positive gains, albeit smaller than in the previous case.

To implement the described regulatory mechanism, we make two assumptions. The first is that the bank knows the risk-group of all clients after they pay back the bank loan. The second is that the bank does not know the price structure of the CDS instrument. Only the regulator is aware of this price structure.

As such, we must therefore look at the price formation mechanism that exists on the CDS market. Black and Scholes (1973) and Merton (1974) set the basis for relating the pricing of instruments to the key economic determinants of financial distress and the loss given default. Further works expand upon their theoretical models to specific instruments such as CDS. Indeed, if we look at the main theoretical determinants of the CDS premium, as evidenced and verified empirically by Ericsson et al. (2005), we find that the risk-free interest rate plays an important part. In particular, three key variables are mentioned: firm leverage, volatility and the riskless interest rate. In what follows, we will propose a formula that integrates these three components into the CDS price.

First, the CDS insurance fund, in order to ensure its own sustainability establishes a minimum and a maximum price for the CDS units that it offers. The maximum price must correspond to the amount that it will have to pay in the event in which the bank only purchases one CDS

unit from the insurer. Since, the damages that the CDS fund must pay to the bank in the event of the default of one client equals the risk-free interest rate, it follows that the maximum price of a CDS unit paid when the bank only purchases 1 unit equals R . The minimum price must allow the CDS fund to pay the promised amount $B_{CDS,R} = R * C^D$ to the bank in the event in which the bank purchases CDS funds to insure all of its clients (C). However, the CDS fund cannot know how many of the bank's current clients will default (since it cannot see into the future), so it must base its decisions on the default statistics of previously credited bank clients. We assume that the fund can obtain these statistics directly from the bank or by some other external means (i.e. ratings agencies, etc.). The formula allowing us to satisfy these two conditions is the following:

$$CDS.P = R - R * \frac{B_{CDS,D}}{C} + CDS.minP * \frac{B_{CDS,D}}{C} \quad (22)$$

$$CDS.minP = R * \frac{C^D}{C}, \quad (23)$$

where $CDS.P$ is the CDS price established on the market based on the bank's CDS unit demand ($B_{CDS,D}$), and $CDS.minP$ is the minimum CDS price that the fund requires from the bank and is based on the number of defaulted clients that the bank registered (C^D). We remind that R also represents the maximum CDS unit price and that C represents the maximum number of buyable CDS units, since the bank will never buy more CDS units than it has clients (which derives from the aforementioned condition that the CDS units expire).

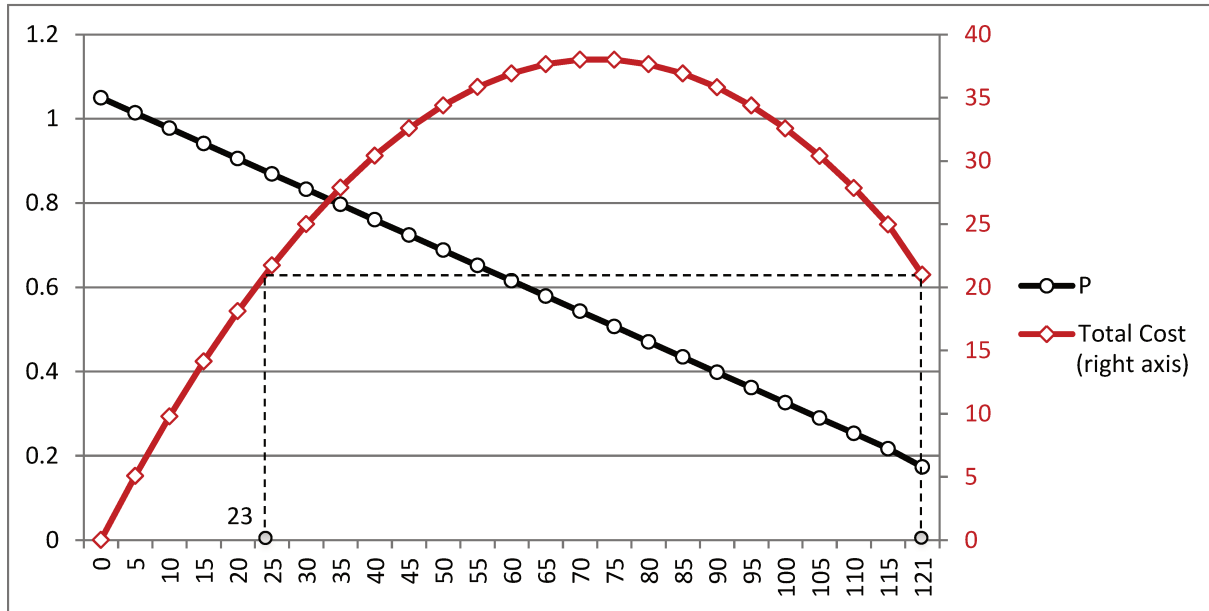
The proposed formula conforms to the literature, as it contains:

- the risk-free interest rate
- the risk level of firms (this uses C^D to encompass the "volatility" and "firm leverage" indicators that are not directly present in our model, but are prescribed by Ericsson et al. (2009)).

The bank, however, is not aware of this formula, nor is it able to integrate it into its demanded quantity of CDS units announcement decision. This means that the bank, inevitably reaches sub-optimal decisions when it comes to the number of desired CDS units to announce. As a consequence, the CDS price that the bank has to pay is oftentimes larger than the one it would actually have to pay in the event in which it could integrate the price-

structure in its decision-making processes. Regulatory supervision should help the bank to overcome this impediment as the supervisor monitors the bank's decision and informs it of the optimal CDS unit quantity that the bank should announce on the market.

Figure 3.8. Number of CDS units requested by the bank and total purchase cost



Note: On the x-axis we have the number of clients for whom the bank purchases CDS units; on the left-y-axis we have the price for one CDS unit determined by the CDS fund according to its formula; on the right-y-axis we have the total cost in monetary units for purchasing the respective quantity of CDS units.

Figure 3.8 shows the price structure of the CDS instrument. It reflects the declining per unit cost of the CDS instrument when the purchased quantity increases. It also shows the total cost for any given solicited quantity of CDS units.

Figure 3.8 shows the per CDS unit purchase price for varying amounts of CDS unit demand on the bank's behalf, on the left axis. We notice that this is a linearly decreasing amount which starts off at the maximal value of $R=1.05$, as per our model calibration, and descends up until the minimal price point which depends on the number of defaulted clients that the bank was previously faced with (in this exemplifying graph, the minimal CDS unit price is slightly less than 0.2). The graph also shows us the total cost of purchasing the desired amount of CDS units on the right axis. As we can see, this sum increases until a certain point, after which it begins to decrease as the decreasing price allows for savings on the bank's behalf. We, thus, notice that (in this exemplifying graph) any quantity of CDS units

demanded by the bank in the interval $B_{CDS,D} \in [23;121)$ is suboptimal since if the bank demands any quantity of CDS units in this interval, due to the price that the CDS fund will fixate, the bank will end up paying more for the desired amount of CDS units than it would pay if it purchased the maximum amount of CDS units purchasable (equal, as per our model specification to $C=N=121$), which is the optimal CDS demand amount ($B_{CDS,D}^*$) for this interval. We notice that if the bank were to, say, wish to purchase 70 CDS units, then it would end up paying about 37.5, whereas if it purchased 121 CDS units, it would only pay 21. At the same time, all CDS demand choices in the interval $B_{CDS,D} \in [0;23)$ are optimal because the bank would pay less than the total cost for C CDS units.

As we can see, the role of the supervisor is to guide the bank's CDS demand announcement to ensure the optimality of its CDS purchasing decision. The bank should benefit, and the CDS fund should be able to maintain its sustainability (at least, as is the case for most CDS issuing entities, for a while).

As such, if supervision is introduced to complement the CDS mechanism, the regulator helps the bank to make better CDS buying decisions, by sharing with the bank its knowledge of the CDS price structure. The regulator integrates into the scheme described by Figure 3.9. We notice that when supervision is introduced, three steps are added in the functioning of the CDS market. Specifically, a feedback process between the bank and supervisor is inserted which allows the supervisor to inform the bank of the optimal CDS demand for the bank.

Figure 3.9. Integrating supervision into the regulatory CDS mechanism

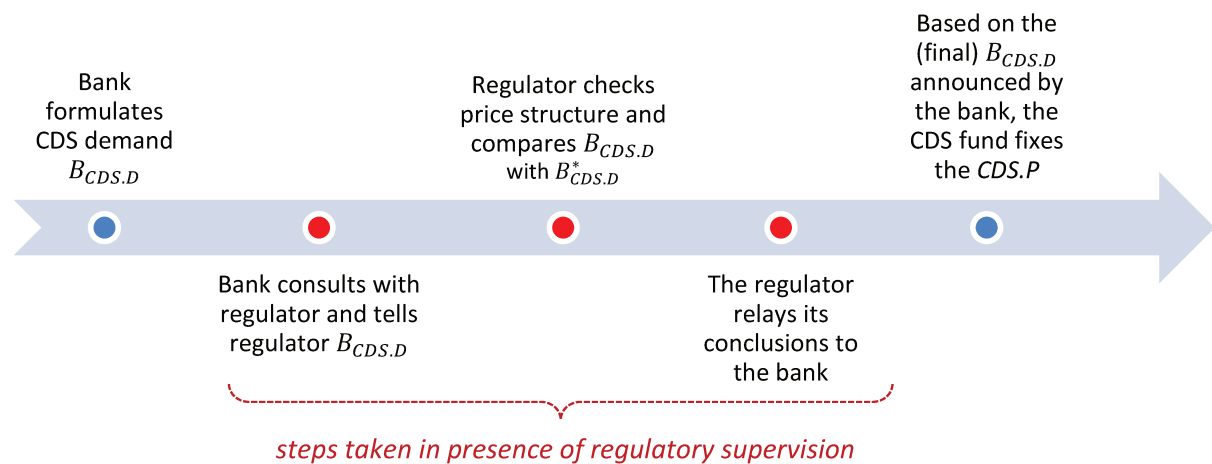


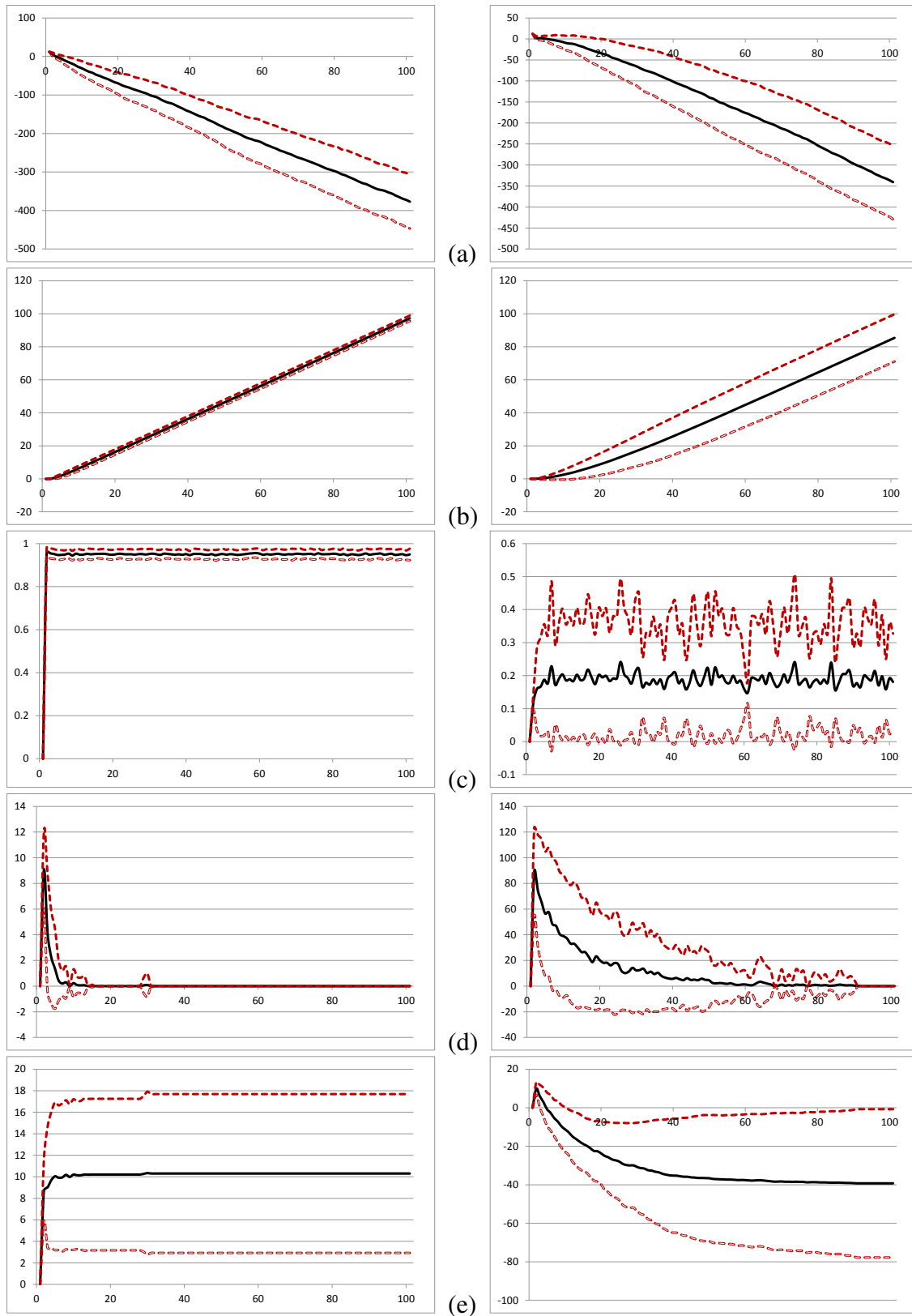
Figure 3.9 explains how supervision is integrated into the model and explains the steps that the regulator takes to ensure that the bank makes the optimal choice regarding the quantity of CDS units to purchase.

Let us now turn our attention to what happens in practice when we apply this new form of regulatory intervention to the baseline scenario with monitoring. We first look at the situation with bank monitoring under high informational asymmetry. In this case, shown in Figure 3.10, we notice that the monitoring inefficiency characteristic of the difficult to gauge business environment hinders the bank's ability to hedge against risk both when the regulator only introduces a CDS mechanism without supervision, as well as when the added supervisory role is assumed by the regulator. The main reason for this outcome is the high costs of monitoring coupled with the inefficiency of the bank's ability to target risky clients. In absence of supervision, the demand for CDS units expressed by the bank on the CDS market leads to the establishment of a high price equilibrium. This, in turn, rapidly pushes the bank's liquidity reserves into negative territory which no longer allows the bank to participate on the CDS market, thereby rendering the regulatory instrument inactive as the quantity of CDS units purchased by the bank drops to zero, as seen in Figure 3.10 point (c). A consequence of this is the rapid fall in liquidity (a), profit values stabilizing at negative values (around -3) and a rapidly increasing number of bank defaults (b). As for the CDS fund, since the bank is no longer able to purchase CDS units, the CDS fund's resources freeze. They remain at a positive number since the fund has not yet operated for a sufficiently long time and so it has principally collected resources and thus far hasn't distributed them.

If supervision is introduced, the regulator now monitors the situation on the market and intervenes to guide the bank's CDS demand decision. This allows for a lower price equilibrium to emerge on the CDS market (c-right). This extends the period in which CDS units continue to be purchased by the bank (d-right) since it removes some of the negative pressure on the bank's liquidity reserves. This has for effect a dampening of the rapidity in the bank's liquidity reserve decline (a-right), the stabilization of profits at an initially higher but still negative level, which further declines in time, and an increase in the volatility of the default rate indicator (b-right) signaling that under certain client risk level configurations the bank may avoid default for at least 10 periods. Since the CDS fund is forced to cover the high costs associated with the bank clients' defaults and the bank's CDS unit purchases gradually decline after a significantly higher purchase volume (because of liquidity constraints on the

bank's side), the CDS fund finds that it does not sell enough insurance units to be able to reimburse the bank for its clients' defaults.

Figure 3.10. CDS market with and without supervision under high asymmetry monitoring



(a) Bank liquidity, (b) Nr. default episodes, (c) CDS.P, (d) CDS units purchased, (e) CDS Fund cash

Figure 3.10 presents the results of the scenario in which the regulator introduces a CDS market with (right) and without (left) supervision, under conditions of high informational asymmetry. The results are presented as the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. We notice the positive *effect that the presence of supervision produces on the bank's resilience, but conclude that* high informational asymmetries prevent the bank from operating profitably.

As such, the fund's operations become unsustainable as the reimbursements it faces surpass its revenues. Therefore, under this scenario, the regulator would be faced with the dilemma of saving or letting the fund default very quickly after its introduction.

It is noteworthy to remark that in this monitoring context, the regulator is unable to improve the situation vis-à-vis the baseline scenario regardless of whether supervision is implemented or not. Supervision does help to attenuate the bank's losses, but fails to bring the bank back to profitability.

The next step in our analysis is to investigate the situation in which the regulator introduces a CDS market in presence and absence of supervision when the bank's access to client-related information is improved so that the bank can form anticipations regarding the quality of the clients it will have in the following period. It is expected that the better risk management that the bank is endowed with should lead to an improvement in the bank's situation.

Figure 3.11. CDS market with and without supervision under low asymmetry monitoring

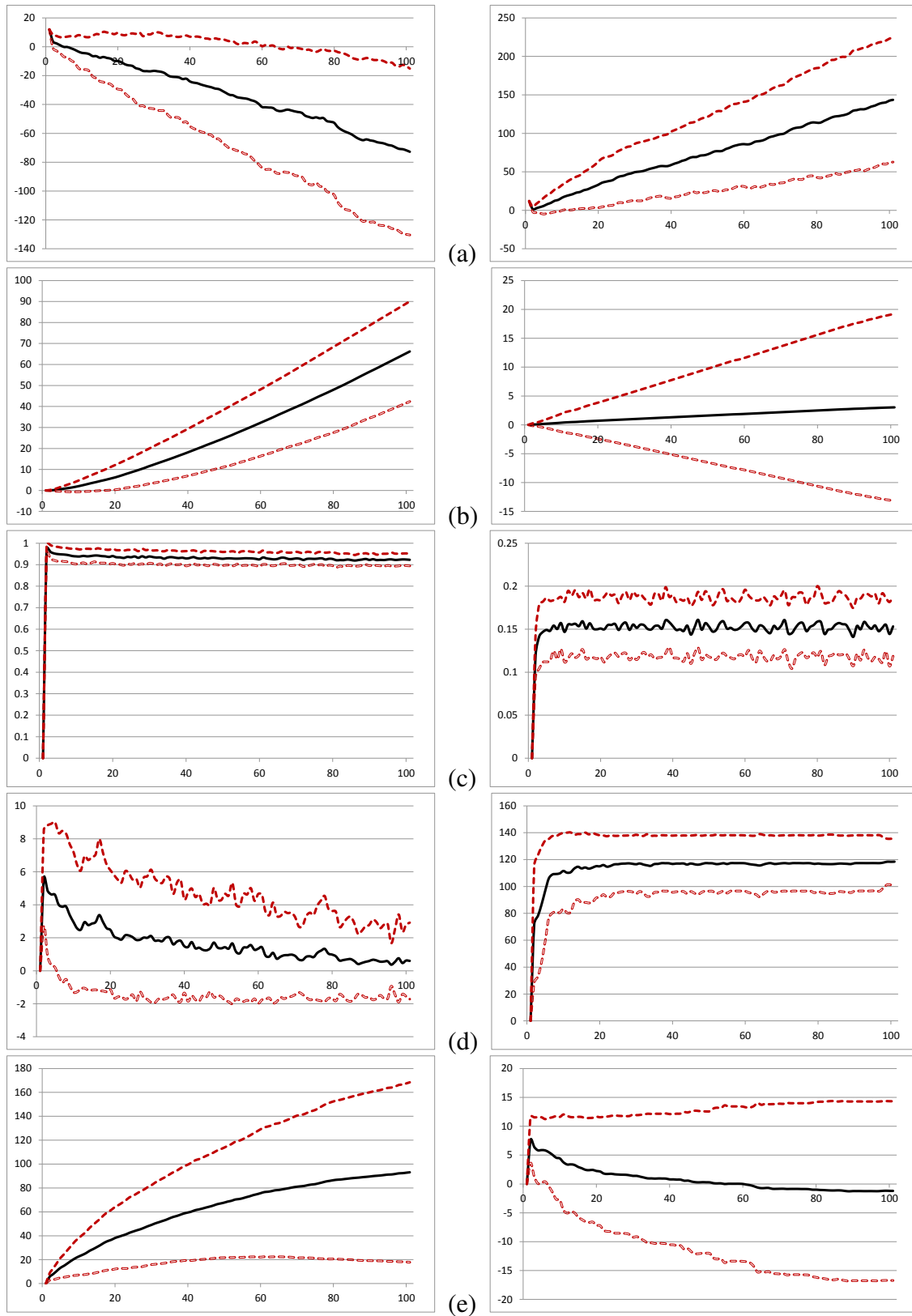


Figure 3.11 presents the results of the scenario in which the regulator introduces a CDS market with (right) and without (left) supervision, under conditions of low informational asymmetry. The results are presented as the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. We notice the positive effect that the presence of supervision produces on the bank's resilience, as the bank's profit becomes positive and potentiates profitable bank operations.

We notice that, now, even under lack of supervision, the bank fares better than in the baseline scenario, as both profits and liquidity are higher. Figure 3.11, point (a) confirms this. Because of the lack of supervision, as before, the price of a CDS unit stabilizes at a high level and the number of CDS units effectively purchased is also low (d). However, this time, it is rather rare for the purchase of CDS units to completely stop thereby rendering the CDS mechanism inactive. Furthermore, now, under the best of conditions, the bank's default is postponed until around period 20 (bottom dashed line in point (b)). Notice that this result obtained in the absence of supervision is a marked improvement over the result obtained when supervision was implemented but in an environment of high asymmetry monitoring. Finally, because there is no supervision to help the bank to integrate the price structure, the CDS fund takes advantage of the situation to improve its financial standing and accumulate resources. Indeed, whereas the bank's default is postponed more than in previous CDS market scenarios, it would seem that the only absolutely safe institution in this economy is the insurance agency (the CDS fund).

When supervision is introduced however, the tables are turned on the CDS fund. Since, the bank's CDS unit demand announcement is influenced by the supervisor which now informs it of the optimal quantity, the price of CDS units stabilizes at a lower point (point (c-right)). Now, no longer able to demand exorbitant prices for the CDS instrument it sells because of the regulator's supervision of the market, the fund must content itself with lower revenues. This translates into the lower CDS Fund cash variable depicted in point (e-right). However, we notice that despite the lower values, the fund remains sustainable for a relatively long time – specifically, for approximately 60 periods of our simulation run. We might ask ourselves why this is the case when in the presence of supervision with high asymmetry monitoring, the CDS fund defaulted miserably within five turns of the start of its operations. In fact what changed is that because of the lower liquidity constraints that the bank faces under low asymmetry monitoring, it is able to purchase the entirety of the announced CDS demand quantity (whereas before it was limited by its lack of liquidity). As such, the bank ends up

purchasing a very high number of CDS units (d-right). And since CDS unit purchases constitute the revenue of the CDS fund, the insurer is now able to fulfill its obligations for a much longer time. Still, eventually, because of the bank's client defaults, the CDS fund runs out of resources and may need to be saved, or replaced with a new insurance fund. As expected, in this scenario, the bank's liquidity reserves are now largely positive (a-right) and the number of bank default episodes is significantly reduced (b-right). Now, the bank will default only rarely. Still there is significant volatility in the number of default episodes, as the bank is still dependent on the initial configuration in terms of client risk levels. Multiple periods characterized by high upper-risk client density and high client default rates may still cause the bank to default. Regardless of singular incidents, the situation is significantly improved when compared to the baseline scenario. Furthermore, this is the first time that we are able to ensure sustainable (and profitable) bank operations under persistent crisis conditions.

As we have seen, the introduction of a CDS market is not enough to stabilize the financial situation of a bank facing persistent crisis conditions. Not only does its mechanism unable to save bank, but the insurance fund also risks either termination by abandonment or default. The key towards ensuring the sustainability of the bank's operations is to concurrently ensure supervision of the introduced instrument's market, as well as to perform all possible actions towards reducing the informational asymmetry present in the economy. If such steps are taken, then the bank will operate at a profit on the long-term. This is an improvement not only over the baseline scenario, but also over the regulatory norm which manages to stabilize the bank for a shorter time-span, albeit with lesser fluctuations, but, on the other hand, with very severe credit rationing and close to zero profits for the entirety of the duration of the stability period of bank operations. We therefore conclude that a CDS market without supervision will always produce worse results than a regulatory norm. With supervision also in the mix, the CDS market stands a chance of producing better results than the norm, provided that the bank has access to sufficient information allowing it to form anticipations regarding the risk levels of its future clients.

3.3.3. Supervision with taxation. Can a bail-in mechanism save the bank?

Our last supervisory set-up includes a tax in the form of a bail-in mechanism. This means that it is those who benefit from the bank's activities that must contribute towards saving the bank. In our model it is the bank's clients (or the firms) who reap the rewards of the bank's

operations. As such, the regulator introduces a tax that they must bear. For our tax to be fair, however, the regulator will have to keep in mind two key elements that derive from the bail-in mechanism formulation. The first regards the category of beneficiaries that must be taxed – in our case it is very straightforward that clients of all risk groups who have benefitted from the tax must contribute. And the second is slightly more subtle in that only those clients who were successful must be taxed, thereby excluding from our taxation the defaulted clients. We may ask ourselves why some of the clients should be excluded from the tax. Indeed, why it is those clients who will have led to the crisis that must escape from repairing the damages? The simple answer to this is that we are implementing a punctual tax that only applies in the event of difficulties faced by the bank. As such, the supervisor who will be monitoring the bank's and the firm's situation has no way of knowing which clients will default or even if a tax will be necessary in the given time period. Therefore, since we are not implementing a permanent tax that is collected regardless of the bank's financial state, the supervisor collects the tax from firms ex-post, after the bank will have financed the clients and only when the bank's default will have become imminent. Another consequence of this implementation of the tax is the necessity of supervision of the bank's financial situation by the regulator. In the absence of supervision, the regulator would not be able to coordinate the tax level with the bank's deficit. Furthermore, since the regulator is unable to raise money from defaulted firms, only successful clients can contribute in a bail-in mechanism. This is similar to the European Commission's and ECB's proposals for the Cyprus bail-in scheme whereby only "successful" clients having deposit accounts of more than 100000€ were forced to contribute towards saving the bank. In order to avoid defaulting successful firms, we introduce the bail-in mechanism as a tax on firm profits (and not revenues). The regulator's taxation is dependent on the financial situation of the bank. As such, if the supervisor detects that the bank is in a situation of negative liquidity, immediate action is taken. A tax corresponding to the amount needed to save the bank is raised. The tax is distributed proportionately to all clients' profits. This means that clients from all risk groups have to dedicate the same percentage of their profits towards saving the bank. The regulator calculates which percentage of profits is to be contributed towards paying the tax by the process depicted in Figure 3.12. As we can see, the loop which will determine the tax contains an increment size (A) which will be responsible for the accuracy of the tax value. An increment value of $A = 0.05$ means that the regulator would jump from tax size 0% to 5% to 10%, etc. If the bank were to need, for instance a tax of 12% of firm profits to be saved, then the regulator would collect 15% and the remaining 3% would go towards establishing (or replenishing) the reserve fund.

Figure 3.12. Bail-in mechanism tax determination process

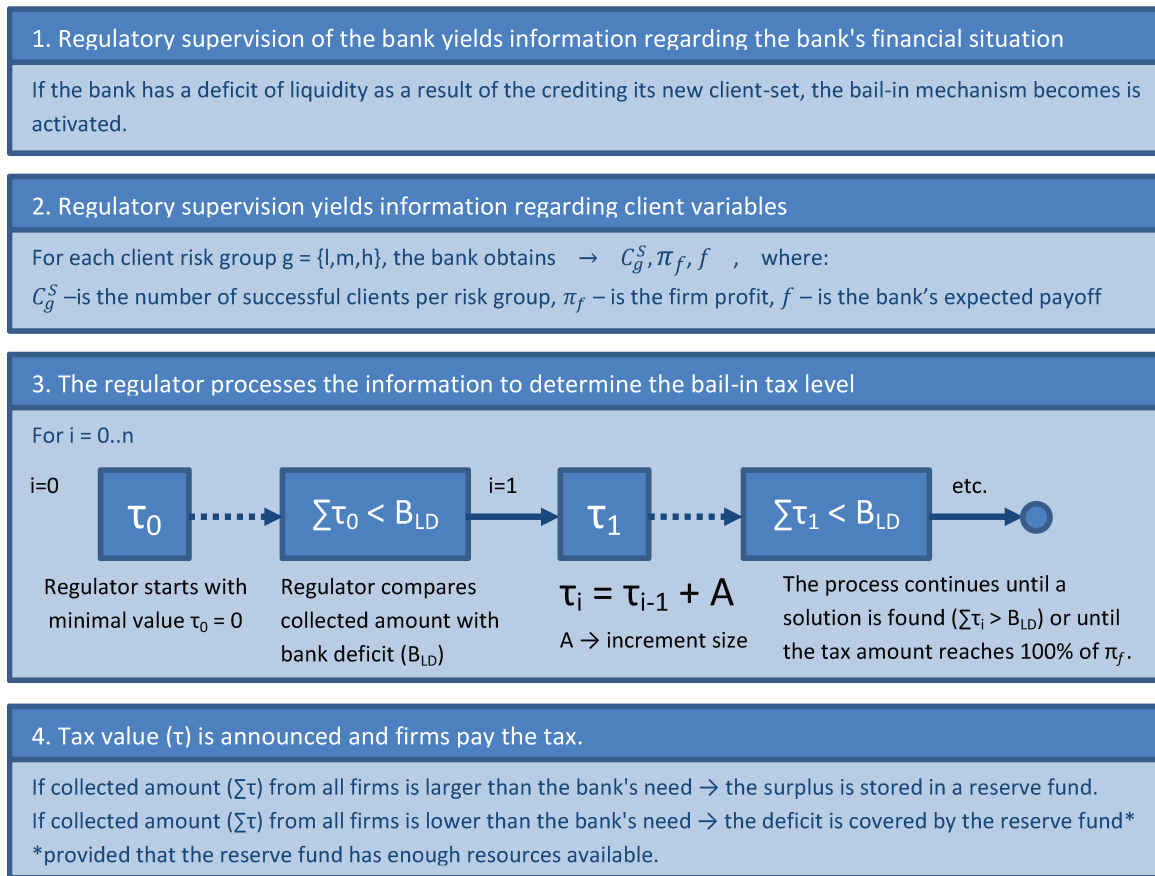


Figure 3.12 presents the steps followed by the regulator in the bail-in scenario.

Larger values of A allow for larger reserve fund accumulations, but also more rapid simulation run times. On the contrary, lower values of A allow for more precise taxation, but slow down the accrual of funds in the regulator's reserve.

For simulation purposes we will maintain a relatively large value of $A = 0.05$ which allows the reserve fund to play a role in saving the bank in the event of a 100% tax on firm profits not being enough to replenish the bank's liquidity reserves.

Now that we are aware of the functioning of the bail-in mechanism, we can investigate its effects on the bank's financial standing and compare the results with the other supervisory implementations that we have discussed. At the same time, it is also interesting to investigate what will transpire as a result of the prudential instrument with the firms' profits. We would like to know whether saving the bank can be achieved with moderate levels of taxation or if we must jeopardize the welfare of the firms to save the bank. This, naturally, raises the issue of striking a balance between keeping the productive sector sheltered from regulatory

interventionism in the form of over-taxation and ensuring the continuity of the banking sector's activities.

Figure 3.13. Supervision with bail-in mechanism in high asymmetry environment

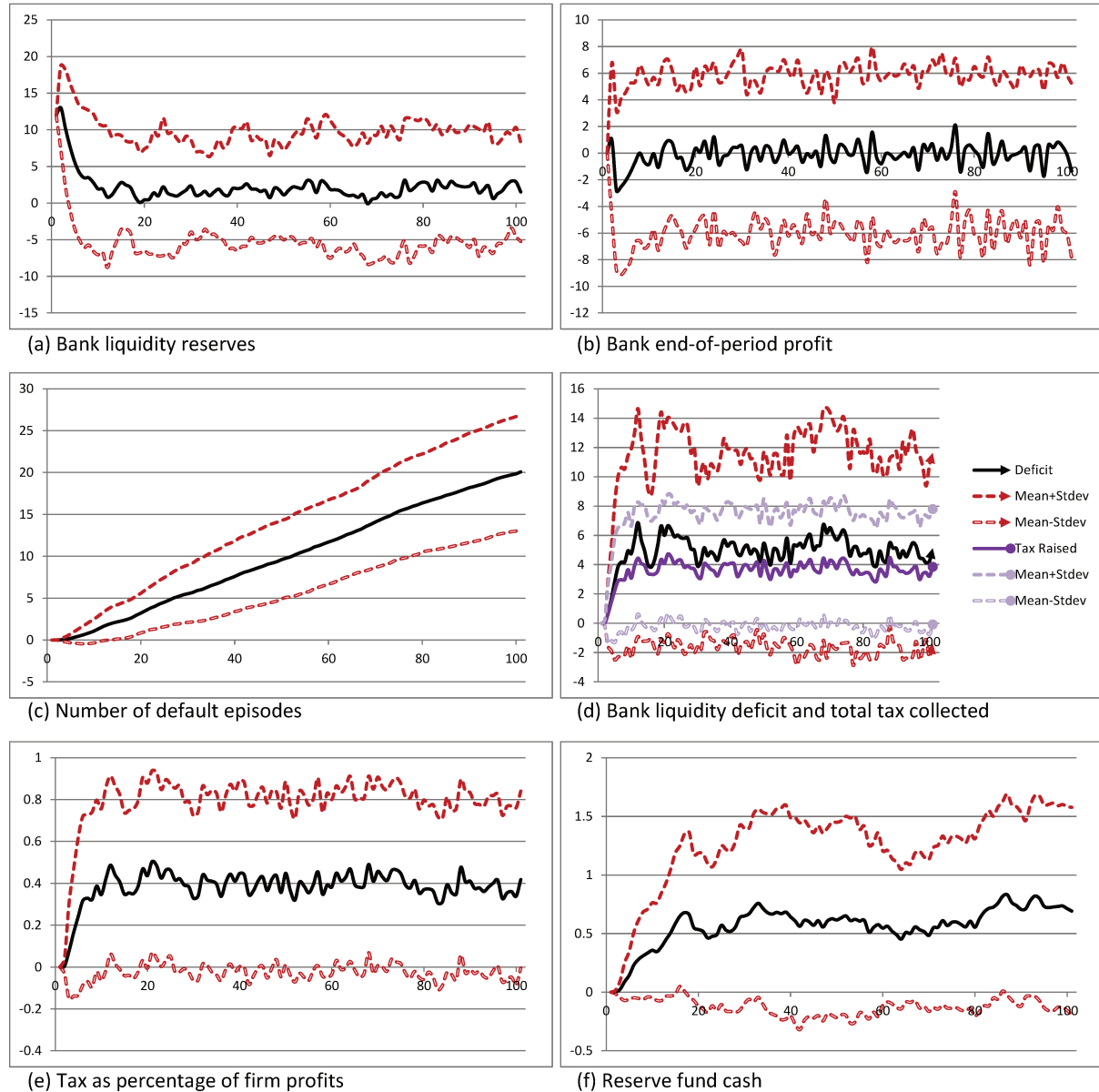


Figure 3.13 presents the results of the scenario in which the regulator introduces a bail-in mechanism under conditions of high informational asymmetry. The results are presented as the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. We notice the positive liquidity levels maintained by the bank even under the harsh conditions of high asymmetries. Also, we notice the decline in the number of default episodes.

In the event in which the bail-in mechanism is introduced in a context of great difficulties for the bank to obtain information about its future clients, the high costs and monitoring inefficiency lead to, on average, a higher liquidity deficit than the regulator can compensate for via the bail-in mechanism, point (d) in Figure 3.13. Indeed, even with a tax of 100% of the firm's total profits, the regulator is at times incapable of saving the bank. Unfortunately, due to our representation of averages and standard deviations, we cannot remark the cases in which the tax constitutes 100% of firm profits. This is the case because it is very rare that for any given time period (t) all 100 of our model repetitions should produce the same result of a 100% tax on profits decided by the regulator. There is, in fact, a very great volatility of the regulatory instrument which risks swinging between 0 and 100% from one period to the next, as depicted by the upper and lower bounds of the possible interval at one standard deviation from the mean. Indeed graph (e) slightly misrepresents the reality by not including the peaks of 100% which, under this configuration, are the only instance in which the number of default episodes indicator (c) can increase. Still, when we look at the number of defaults, we realize that the bank now defaults much less often than in the previous scenarios. Indeed, only the CDS market with supervision could produce better long-run results in terms of default risk reduction. The regulatory norm also provided highly efficient short-term default risk relief, but in the end faltered as the final number of default episodes after 100 time periods surpassed the number produced by the taxation method. The generally positive bank liquidity reserves shown in point (a) also attest to this. We do, however, remark that the liquidity reserves initially increase, but afterwards are attracted towards zero and have good odds of falling in negative territory, as the lower bound is well below zero. When looking at the bank's profits (b), we also find that the indicator fluctuates around zero. When we look at the reserve fund cash indicator, we notice that the reserve fund is continually expanding (it is on a slowly increasing trend). We would expect to see this if the regulatory instrument were continuously used. Since, because of the bank's heightened instability, this is indeed the case, we confirm our expectations. However, it must be noted that this indicator cannot rise indefinitely, as there is only so much firm profit to tax.

We now switch to the bail-in mechanism introduced in an environment of low informational asymmetry, whereby the bank can extract more information about its clients, thereby enhancing its monitoring method. In this instance, the higher monitoring efficiency, as before leads to lower scarce resources being wasted and therefore reduces the bank's overall

expenses. This means that crisis control on the supervisor's behalf becomes a lot more manageable.

Figure 3.14. Supervision with bail-in mechanism in low asymmetry environment

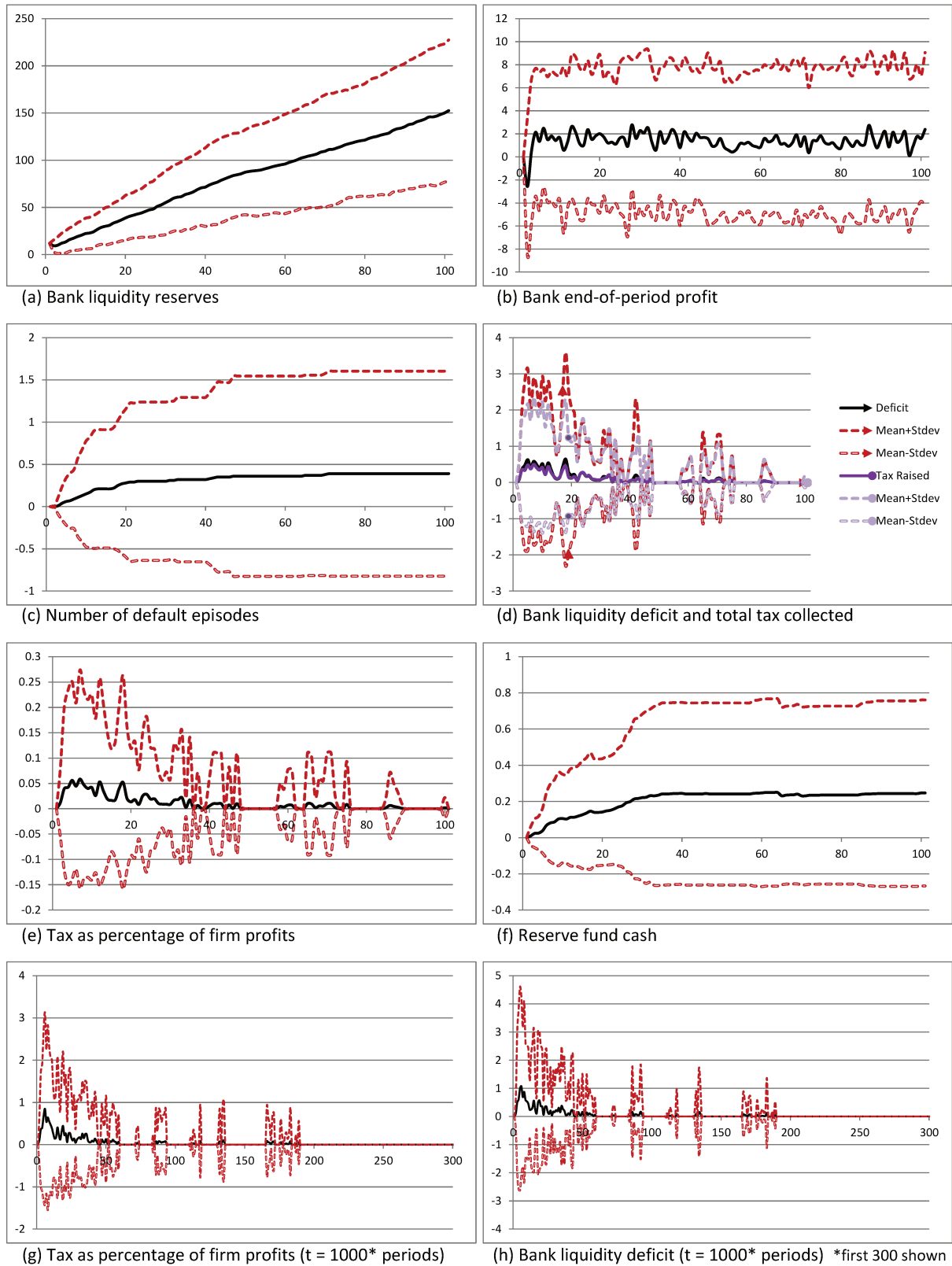


Figure 3.14 presents the results of the scenario in which the regulator introduces a bail-in mechanism under conditions of low informational asymmetry. The results are presented as the means and standard deviations of the analyzed variables for 100 simulations of the model, over 100 time periods. We notice the positive profits, liquidity and close to null default rate of the bank. Furthermore, when we run this scenario over 1000 time periods, we notice *that given the improvement in the bank's financial situation, regulatory intervention becomes completely unnecessary after around 200 time periods, even under persistent crisis conditions.*

As we can see from Figure 3.14, point (d), it is now the case that the bank's deficit is almost always identically matched by the regulator's instrument, as sufficient resources can be collected via the tax. We also notice that the bank's deficit tends to have a higher volatility than that of the instrument which is a welcome finding. In the previous bail-in mechanism scenario, we noticed that the regulatory instrument manifested very high volatility and would therefore be proscribed if the prudential authority coincided with the Central Bank and promoted a concurrent stability objective. In this case, as evidenced by both point (d) and (e), we observe much lower volatility in the prudential tool, and indeed, we see periods in which volatility is reduced to zero, as the instrument is at very low percentage values or is left completely unused. We notice a more intense usage at the beginning of the simulation period, as the bank faces the severe liquidity shortage that is characteristic of the crisis environment. However, as the supervisor manages to stabilize the bank's situation, the bank is able to accumulate resources and, eventually, no longer necessitates the regulator's intervention. In order to confirm this, we extend the model simulation period to 1000 and look at the instrument's usage levels. We notice that by period 200, the instrument ceases to be used which denotes that the bank has managed to push through the crisis and can now continue to operate individually, without external help, even under persistent crisis conditions. Indeed, the riskiness of the new clients that the bank will be facing will not have changed, but, due to the increasing reserves, the bank's ability to withstand client default related shocks will have increased past the point at which the bank no longer faces any risk of failure. To confirm this, we also find, in point (g), that the bank's liquidity deficit will have permanently gone down to zero by period 200.

Finally, we remark that the bank's liquidity reserves (a) are on an increasing trend and stay positive throughout the simulation run. The number of default episodes (c) is less than 0.4 which is the lowest value seen so far and which means that, on average, the bank will default

0.4 times over the simulation period. This is the best result so far, with the exception of the low monitoring cost baseline scenario which is deemed unlikely by the literature. As for the reserve fund (f), it increases up to a point after which a small correction occurs after period 60 when the last significant incidence of liquidity deficits occurs. Afterwards, the fund remains largely stable, as the usage of the bail-in mechanism declines.

We, therefore, have seen that under conditions of costly monitoring, the bail-in mechanism, implemented as a tax on bank clients, is the strongest possible tool. It manages to stabilize the bank's situation and significantly reduce the number of bank defaults in an environment where informational asymmetries are predominant. The cost, however, is felt in terms of two major shortcomings of this method: the high tax levels that firms must incur (sometimes having to cede the entirety of their profits in order to save the bank), as well as the very high volatility of the prudential instrument. If it is possible to increase the bank's access to information by means of policies conducive of market transparency, then it is the bail-in mechanism not only stabilizes, but also ensures long-term bank operation sustainability at positive profits and increasing liquidity reserves. The more fortunate economic climate diminishes the negative effects of the regulatory instrument by reducing its fluctuations, as well as by significantly lessening the burden placed on the production sector.

4. Conclusion

In this chapter, we have studied the effectiveness of prudential regulation in terms of supervision coupled with three different regulatory tools: a norm, a CDS insurance market and a bail-in mechanism taking the form of a tax on bank clients. Taking as given the both theoretically stipulated, as well as empirically verified hypothesis of costly monitoring, we placed the bank in an environment of high informational asymmetry where its client monitoring abilities are severely hindered by its inability to obtain sufficient information about its clients. We then relaxed this constraint to allow for more market transparency and saw that the bank generally fared better, as the increased availability of client information allowed it to engage in more efficient monitoring activities. Still, we noticed that without regulatory intervention, the bank was eventually drawn into a bankruptcy situation at some point of our simulation run. As such, in order to ensure the bank's sustainability, we resorted to utilizing prudential instruments coupled with supervision. We started with a norm that imposed the bank to monitor a fixed proportion of its clients. The initial simulation results were promising, as the bank's financial situation was stabilized, but we noticed increasing

credit rationing throughout the period of stability. Indeed, at the point at which credit rationing reached critical levels, the bank finally faltered and its liquidity reserves turned negative with a long-term trend towards negative infinity. This meant that saving the bank was now out of the question. The only difference that the informational asymmetry environment made was that of the length of the default postponement, with lower asymmetry levels allowing the bank to operate for a longer period of time under conditions of almost-zero, but positive profitability. We then turned to a more advanced market-based instrument – a CDS fund. In this scenario, the regulator introduced a supplementary agency, a CDS fund, which allowed the bank to purchase CDS to insure against the risk of its clients' default. Introduced without supervision, the CDS market would crash leaving behind not only a defaulted bank, but also a failed CDS-emitting agency. When the regulator, however, decided to concurrently become involved in supervising the market by calculating both the amount of resources required for the CDS-fund to survive, as well as the quantity of CDS units needed by the bank in order to avoid failure, we noticed a stabilization of the CDS market. When information was scarce, the CDS fund failed to compensate for the bank's monitoring inefficiencies, which lead to the survival of only the fund. When access to information was facilitated, the bank was able to make good use of the extra instrument available for it to efficiently manage its client risk levels. Indeed, in an environment of transparency, the CDS market produced better results than the regulatory norm. Finally, we introduced a tax-based instrument in the form of a bail-in mechanism that saw the regulator taxing the bank's clients in the event of difficulties encountered by their creditor. Here, we noticed the strength of taxation as the instrument was both able to handle environments devoid of information, and shone when asymmetries were rooted-out of the economy. Indeed, in the latter case, the taxation instrument proved that it was able to protect the bank sufficiently long enough for the financial institution to be able to stand on its own in an environment of persistent crisis. We noticed that after a lengthy period of intervention, the bank was eventually able to operate without external intervention and returned to long-term profitable activity. All in all, we have seen instruments with a very good short term effect, but with nefarious consequences on credit rationing, as well as efficient market instruments dependent, however, on particular set-ups and economic conditions. However, our results suggest that the tax remains a very powerful instrument that the regulator can use to reach a desired outcome. Furthermore, by means of a bail-in mechanism, it is those who benefit from the bank's activities that contribute towards saving the institution, and not the tax-payer. Not without its own faults, however, the tax requires fluctuations in the regulatory instrument, as the prudential authority

must constantly adjust the instrument to the ever changing financial landscape. Also, the bail-in part of the mechanism raises the question of whether the regulator does well to sacrifice the profitability of the productive sector in order to save the financial institution, in particular, when it is the productive sector who is the beneficiary.

CHAPITRE 3 :

CASE STUDY OF THE MOLDOVAN BANK FRAUD: IS EARLY INTERVENTION THE BEST CENTRAL BANK STRATEGY TO AVOID FINANCIAL CRISES?

Abstract

In this paper, I study the means by which a billion dollar fraud that was perpetuated in the Moldovan banking sector evolved into a severe financial crisis in which the Central Bank's inaction came under scrutiny. I examine the financial operations through which money was taken out of the banking system and reconstruct the fraudulent schemes that led to the demise of three systemically important banks. I then create an agent-based simulation of the banking system which replicates the pre-crisis environment and the undertaken fraudulent actions to determine whether Central Bank intervention could have improved the outcome of the crisis. Finally, I propose three composite prudential indices that facilitate the supervisory authority's task of quantifying, analyzing and comparing the risk undertaken by financial institutions.

1. Introduction

In the world of finance and economics, the term "fraud" can refer to different types of criminal activities perpetuated with the objective of gaining certain benefits or privileges as a result of providing false information or data. In the financial sector, "fraud" is generally perpetrated on either the bank's products and services or its ownership structure. Generally, as detailed in Bolton and Hand (2002), fraud perpetrated onto a bank's products is classified into one of the following categories: i) credit card and other financial instrument fraud; ii) money laundering; iii) electronic services fraud; iv) identity theft and computer intrusion. Concurrently, control over a bank can also be acquired by means of fraudulent activities. As such, Central Banks introduce regulation aimed at limiting take-overs within the ownership structure of financial institutions or at increasing supervisory stringency at institutions with one majority shareholder. This is done for prudential reasons and with the aim of limiting market monopolization. In this instance, the fraud occurs when multiple entities act in a concerted manner to buy the stock of the targeted financial institution. An example of the mechanisms underlying such operations can be found in Zey (1993).

The Moldovan case presents particular interest because it combines these two forms of fraud into one global scheme that allows a controlling entity to take over three of the country's largest banks, issue credit to a network of affiliated firms belonging to itself with collateral cross-issued amongst the three banks, and, finally, to wire the money off-shore through shell companies and banks residing in non-OECD countries²².

The existing literature on banking sector fraud has mostly focused on preventing and identifying small-scale operations oftentimes undertaken by separate entities without the bank's knowledge. Kovach and Ruggiero (2011), Raj and Portia (2011) and Mahdi et al. (2010) are examples of papers that investigate fraud detection at the micro-operational level. The focus of these papers is on internet transactions and e-banking, but their results also apply to the banking sector more generally. Indeed, in such cases, detection of the fraudulent operations by means of various statistical and computational methods aimed at finding patterns of transactions in bank data is the best method to combat the phenomenon. Papers such as Wei et al. (2013), Hand and Weston (2008) and Soral et al. (2006) present statistical means of detecting fraudulent operations in the banking sector and discuss their possible implementations in prudential regulation. However, in the Moldovan case, because of being taken over by a controlling entity, the banks themselves are the perpetrators of the fraud, and, as such, are unwilling to engage in monitoring activity. In this instance, only the Central Bank, as an external, impartial supervisor can attempt to prevent, detect and reverse any illicit operations. Indeed, a few papers such as Levi (2014), Wiszniowski (2011), Lee (2008) or Lipman et al. (1977) discuss the subject of internal fraud in the banking sector and its potential implications for financial regulation. However, none of these papers investigate the mechanisms through which fraudulent operations are perpetrated, nor do they study the effects of these operations on individual bank stability or on the soundness of the financial sector. Within this paper, I focus precisely on studying the types of fraudulent transactions that occurred, as well as the Central Bank's intervention options in order to minimize the economy's exposure to the resulting crisis. As such, I provide an analysis of the consequences resulting from the enactment of fraudulent operations both on the banks involved in the schemes, as well as on the financial sector in its entirety.

²² The reason why non-OECD countries are chosen for the final stages of the fraud in which the money is laundered off-shore – is that these countries often have weaker regulatory frameworks and poorer financial supervision.

The paper is structured in four sections. In the first one, I present the economic and financial context in which the fraud schemes and resulting crisis occurred. In the second one, I detail and analyze the mechanisms through which the fraud schemes were undertaken. The third section presents the description and simulation results of the multi-agent model that reproduces the fraudulent transactions. It is here that I also present three composite prudential indices aimed at facilitating the regulator's task of quantifying, analyzing and comparing the risk exposure of banking institutions. Finally, I conclude in the last section.

1.1. The Moldovan economic context before the fraud

Before the beginnings of the crisis, in 2011, Moldova remained one of Europe's poorest countries in terms of its GDP which constituted around 7Bln USD. While GDP growth was higher than the regional average in 2011, the sources of growth were drying up as European foreign investment was gradually declining following the sovereign debt crisis. This conjecture would plunge the Moldovan economy again into recession in 2012, with growth resuming in 2013 after a sudden easing of monetary policy. At the same time, Moldova is a small, open economy that has very tight economic and financial links with the EU. With the country's exports in process of reorientation towards European markets and away from the former CIS block, the country's reliance on the EU for trade, financial services and aid were further rising. Highly reliant on remittances from the EU and Russia, the country would see their volumes decrease significantly²³ in the wake of the crisis following the banking sector fraud, which culminated in 2015.

With regard to the financial sector, ahead of the debut of the fraudulent schemes, the Moldovan banking system was comprised of 14 banks – one of which was state-controlled. The state-owned bank was the largest financial institution and was also one of the three banks targeted by the fraud. In 2011, the financial context that the country was facing was relatively somber with inflation rates having picked up and reached values of around 9%, after a short respite related to the global financial crisis of 2008. Monetary policy was adjusting to the increasing trend with interest rates rising. One of the consequences of the high interest rates was a weak demand for credit by businesses and households. After the higher inflation rates of 2011, there were deflationary expectations for 2012 which signaled to financial institutions that credit demand should increase in the following quarters. In anticipation of this increase,

²³ the country registered a 4.9% decrease in 2014 versus the same period in 2013, followed by a 32.4% decline in remittances in 2015 versus the same period in 2014.

the strategy of banks was to maintain their market share and hoard sufficient liquidity to accommodate the influx of demand once it arrived. Indeed, many of them pursued an objective of maximizing their market capitalization. At the same time, banks were highly leveraged which, in the context of low credit demand, made it difficult for them to maintain profitable operations. Lastly, many banks were very close to reaching the normative limits of their prudential regulation indicators. This is somewhat normal because, given the infrequent occurrence of banking crises and the relative novelty of the banking sector of a country that was founded only 27 years ago, local banks did not have a longstanding tradition of maintaining excess buffers to protect against the risk of prudential indicators plunging below or rising above their respective admissible limits. Furthermore, with a relatively non-interventionist Central Bank in charge of prudential supervision and regulation, financial institutions may have not felt the need for such supplementary buffers given the Central Bank's tolerance towards weakening indicators that slightly surpassed the regulatory norms. This stance taken by the regulatory authority may have been part of a global strategy, but inexperience and indecisiveness may have also played a role.

1.2. Understanding the specifics of Moldovan prudential regulation and supervision

In Moldova, the Central Bank is responsible both for monetary policy, as well as the prudential regulation and supervision of the banking sector. There are additional regulatory bodies that are entrusted with the supervision of financial markets. However, given the relatively low importance and volume of operations on these markets, we can classify Moldova as country with a Cross-Sector Functional supervisory system in which the Central Bank is the main supervisor of the financial sector²⁴. This means that the Central Bank must concurrently follow two objectives: inflation targeting, as well as financial stability. It is possible that this regulatory set-up implies that the Central Bank is slower to react to financial crises, and specifically is more averse towards bailing-out troubled institutions because of the monetary policy objective. Indeed, if the Central Bank suspects that bailing out a financial institution may put significant upward pressure on inflation, it may postpone or altogether avoid taking such action.

In an effort to prevent future financial crises from engendering losses as high as those following the fraud schemes of 2013 – 2015, the Moldovan Central Bank is currently

²⁴ see Schoenmaker (2011) for a detailed classification of prudential supervision systems.

undergoing a transition towards the Basel III framework. Previously, prudential regulation was founded on a mix of Basel I, Basel II and national Moldovan financial sector legislation. Regulation was updated from time to time as new developments occurred and/or international standards evolved. From 2015 onwards, a push for regulatory transition towards the Basel III framework was made with the support of the Romanian and Dutch Central Banks. In 2016 the transition is still ongoing.

The Moldovan Central Bank requires that banking institutions submit monthly reports containing financial and statistical data required for the construction of a number of prudential indicators that the authority then follows in order to assess the financial health of the banking sector. The Central Bank receives standardized balance sheets, financial reports and statistical data related to the bank's subsidiaries, affiliates, recruitment and employment, etc. Aside from the general data that it collects, the Central Bank also requires banks to nominally identify entities towards which the bank has large exposures, as well as the ownership structure of the bank. However, off-shore entities are allowed to own shares in banks and the Central Bank has little means to monitor and identify the final beneficiaries of companies registered in off-shore locations. As seen in the next section, this is one of the caveats that was exploited in order to defraud the banking system of 1bln USD which represents more than 12% of the country's GDP.

The main prudential indicators utilized to assess the financial soundness of financial institutions are:

- Capital Adequacy Ratio
- "Large" Exposures / TRC²⁵
- Sum of Ten Largest Net Credit Liabilities minus Deductions / Net Credit Balance
- Total Exposure to Affiliated Persons / Tier I Capital
- Tangible Assets / TRC
- Tangible Assets and Participating Preferred Stock / TRC
- Long Term Liquidity Ratio
- Short Term Liquidity Ratio

The Capital Adequacy Ratio, Long Term Liquidity Ratio and Short Term Liquidity Ratio are all principal indicators that, respectively, represent the: sufficiency of the bank's capital vis-à-

²⁵ TRC – Total Regulatory Capital represents an un-weighted sum of tier 1 and select tier 2 assets.

vis the riskiness of its assets; the liquidity of the bank's long term assets; and that of its short term assets. These three indicators are key to evaluating the bank's financial situation. The "Large" Exposures / TRC and the Sum of Ten Largest Net Credit Liabilities minus Deductions / Net Credit Balance indicators largely vary in the same direction and, as such, one of them is sufficient to analyze the bank's standing. Whereas the Total Exposure to Affiliated Persons / Tier I Capital is an important indicator per se, in the case of credit fraud where the borrowing entities dissimulate their ownership structure such as to appear non-related, this indicator is of little use. The two "Tangible Assets" indicators are less affected when large financial operations occur within a relatively short time span and therefore will not provide sufficient insight to analyze the banking fraud crisis that is investigated in this paper. As such, this study focuses on four key prudential indicators: the Capital Adequacy Ratio; "Large" Exposures / TRC; Long Term Liquidity Ratio; Short Term Liquidity Ratio.

When the Central Bank, as a result of its supervisory activities, detects irregularities in the operations of a financial institution, the literature has documented a number of general intervention options available to it. These general intervention methods are outlined in Table 4.1 where additional bibliographic information is also provided. In Moldova, whereas the Central Bank is not formally bound to any given set of intervention methods or criteria, it has traditionally utilized three means of intervention:

- Institution of special surveillance regime
- Institution of special administration regime
- Long term liquidity injections

The "special surveillance" regime is a regulatory tool that allows the Central Bank access to a much vaster set of data related to the bank's operations. For instance, once such a regime is instituted, the Central Bank has access to data on individual bank clients and can see (and act upon) individual operations. The Central Bank also receives more detailed financial reports and can perform more frequent and detailed on-site inspections.

"Special administration" is very similar to a Central Bank take-over of control without allocation of public funds. In itself the "Special Administration" regime does not entitle the controlled bank to receive liquidity injections or capital. However, the Central Bank may decide to allocate additional aid to the ailing bank in order to stabilize its situation as part of Long term liquidity injections.

Under “Long term liquidity injections” an affected bank receives financing either directly from the Central Bank’s reserves or from emergency funds. These injections can come in the form of domestic or foreign currency, as required by the distressed institution. Furthermore, such injections can also be issued through the government with the Central Bank’s consent. At the same time, the Central Bank is not proscribed from monetary creation to bail-out distressed institutions, but must nonetheless continue to conform to its inflation target.

The establishment of these regimes has so-far been conditioned by the worsening of prudential indicators beyond the normative limits, but there are no automatic rules or fixed guidance as to when a given regime must be implemented. For instance, there is no specification as to how much time must pass after a prudential indicator has surpassed its regulatory limit for intervention to kick in. Also, there is no rule as to the number of prudential indicators that need to be surpassed in order for the special regimes to be invoked. In theory, the Central Bank would be morally authorized to act immediately after one prudential indicator has risen above (or fallen below) its maximum (or minimum) admissible value.

Table 4.1. Central Bank Intervention Methods - a Review of the Literature

Intervention Method	Description and Effects
Short-Term Liquidity Injection	The Central Bank provides a cash-constrained bank access to liquidity for short periods of time. If expected by financial institutions, this type of intervention method can encourage risk-taking. The higher lending rate associated with the increasing risk raises the default rate of firms.
“Open Bank” Operations	Imply a transfer of capital without transfer of control. The Central Bank offers financial assistance in the form of “capital”. If anticipated, encourages “over-leveraging” of the banking system. Banks’ debt increases as they increase lending. This puts upward pressure on the bank’s borrowing rate. If the bank is profit maximizing and expects financial assistance in case of default, it will credit the riskiest projects thereby putting upward pressure on the lending rate. Bank profits take a hit from the increasing firm default rate and may suffer a further blow if credit demand is negatively impacted

	by the interest rate differential.
Announcement of a 100% guarantee of a bank's liabilities	Usually occurs in developing countries where the Central Bank lacks the means (liquidity or capital) to save an ailing financial institution. Leads to an increase in the borrowing rate of non-guaranteed financial institutions. The non-guaranteed institutions must increase their borrowing rate to continue to attract deposits as they are considered riskier than the guaranteed institution. This results in lower profitability for non-guaranteed banks. Furthermore, this can evolve into a vicious cycle if the increase in the borrowing rate is high and the reduction in profits places formerly healthy banks onto a trajectory towards default. Another guarantee must then be issued for the newly afflicted institutions.
Bail-in mechanism	Bank stakeholders must participate in saving the bank by compensating its losses. Usually, the shareholders and the bank's depositors foot the bill. The mechanism may also be accompanied by another intervention method.
Bank take-over through purchase agreement	The bank is sold off within a publicly organized auction. If the bank's financial situation is severe, it may be difficult to find a purchaser willing to accept the bank's liabilities. Furthermore, the bank's assets may not present sufficient interest for potential buyers (other banks, international organizations and/or private investors).
Bank take-over through modified purchase agreement	The bank is in effect bought by the state with or without the participation of the Central Bank. Depositors are reimbursed only to the extent of the recovered / reimbursed funds. The process generally implies a deleveraging of an overleveraged financial institution. The effects on the economy are similar to those of "Open Bank" Operations. If the government actively promotes its newly acquired bank by offering firms better terms on credit, other banks may need to decrease their lending rate to remain competitive – which has a negative impact on profitability.

Bank take-over without allocation of public funds	This is a temporary solution aimed at taking control over an institution that has performed poorly or has suffered from significant managerial mishaps. If the bank's financial situation mandates it, then another intervention method may also be applied.
Asset cleansing	Separation and transfer of "non-performing" assets to a state-run asset management company (deemed "the bad bank").
Nationalization of the bank	The government forcefully seizes control over the bank and its assets. This choice must be accompanied by another intervention method, but in this case, the taxpayers are likely to compensate the bank's losses, with depositors remaining unaffected.
Liquidation of the bank	The bank's assets are sold at auction and depositors (followed by other stakeholders) are reimbursed from the proceedings.

Sources: Freixas (1999), Diamond and Rajan (2002), Hakenes and Schnabel (2010)

Table 4.1 shows the different choices that the Central Bank is confronted with when faced *with a financial institution in distress*. Depending on the bank's financial situation and the severity of its losses, the Central Bank determines the appropriate course of action. However, when deciding, the Central Bank also factors in the impact of market anticipations regarding its future actions.

In the case of the Moldovan Central Bank, its failure to swiftly intervene to block fraudulent operations, to take over control and, finally, to bail-out the affected institutions came under scrutiny. Some analysts blamed the Central Bank for the failure of the three financial institutions and the financial losses resulting from their default. However, the Central Bank defended itself by stating that it followed existing prudential rules and regulation very closely and that it undertook all possible efforts to minimize the losses to the financial sector as a whole. In this paper, I investigate whether this is indeed the case, and whether through its postponement of intervention the Central Bank achieved its stated objective of financial stability and the minimization of financial losses.

2. Unraveling the schemes that led to the crisis

The large theft of money that occurred in the Moldovan banking sector was the result of a carefully planned process which took close to four years to come to fruition. Its success relied on perpetrating fraudulent operations both on the bank's ownership structure and its products. The process unfolded in two phases. In the first phase, three of Moldova's largest banks were taken over by a holding company which owned a myriad of small local and foreign firms, as well as off-shore shell companies that gradually entered into position of the three financial institutions. In the second phase, a number of fraud schemes were perpetrated on the banks' products which resulted in a significant amount of money being offered in the form of credit (Non-Performing Loans) to firms controlled by the holding company, only to be later laundered in off-shore locations with the aid of foreign banks located in non-OECD countries. In this section, I present the two phases and focus on elucidating the product-related fraud schemes which constitute the object of this paper.

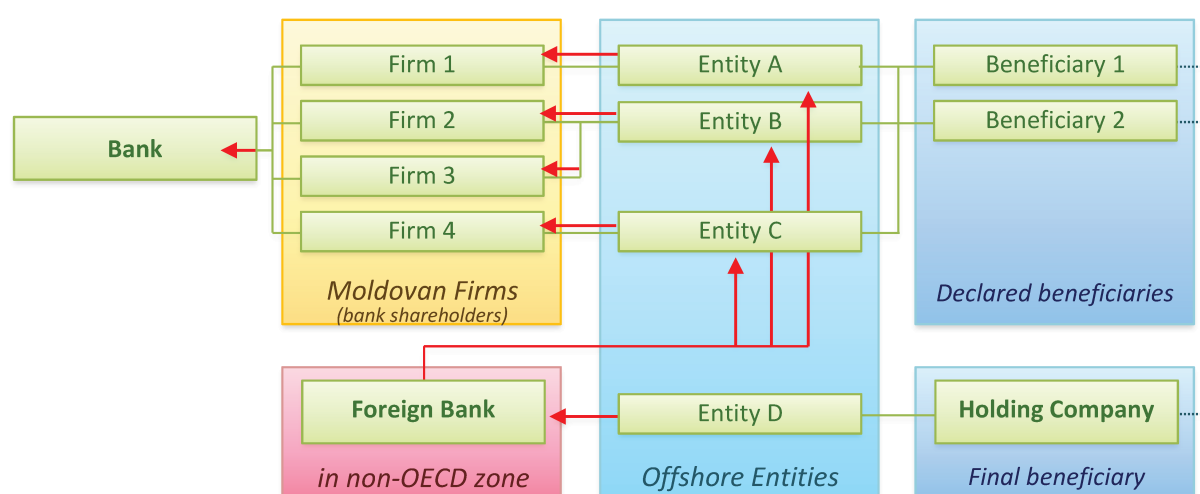
2.1. Acquiring control over the three banks 2012 – 2013

Within the 2012 – 2013 timeframe, three very important financial institutions were taken over by the entity perpetrating the fraud, which I have conventionally called “the Holding Company”. This denomination was chosen because of the way in which the take-overs occurred. In each of the three cases, the financial institution was acquired by a number of small local firms which had no apparent connections towards each other. However, these companies were later found by Central Bank investigations to have financed their purchases from the same sources – all of which coming from companies and lending institutions located abroad. As such, it has become clear that the companies that purchased shares in the three financial institutions did so in a coordinated manner in order to take control over the bank and to influence its operational decisions.

In the case of two of the three banks, the shareholder structure changed significantly following the take-overs: from banks having one or a few majority shareholders to banks with a disperse ownership structure in which each shareholder generally owned less than 5% of total shares. The holding company instituted a purchasing cap at 5% of total shares for each of its subordinated firms because any larger stake would be considered “large” and would require approval from the Central Bank. Furthermore, smaller stakes avoid raising suspicions from the Central Bank which, in the case of larger shareholders, may require full disclosure of shareholder ownership structure, parent-companies and final beneficiaries. The third bank, the largest one, in which the state had a majority stake of 56.1%, had a significant liquidity

shortfall following a number of previously issued Non-Performing Loans. A solution that was agreed upon by government officials in order to both solve the problem of liquidity, as well as to allow for better governance of the financial institution was to privatize the bank by means of issuing new shares in the purchase of which the government agency owning the bank would not partake. In this way, following the share issuance, the government agency would simply retain a 33.3% blocking stake. With regard to the bank's ownership structure following the share issuance – it largely remained the same with the sole exception of the government stake which decreased and the stake of one smaller shareholder which increased by the same amount reaching 33.8%. This made the smaller firm the bank's new majority shareholder. Later investigations into the origins of the funds used to purchase this significant stake indicated that the money came from the same sources used to purchase the other two banks.

Figure 4.1. Ownership structure of the Holding Company and financing of bank share purchases



This figure shows the ownership structure of the Holding Company that perpetrated the fraud, as well as the flow of funds utilized to purchase shares in Moldovan banks. Ownership links between companies are depicted in straight lines. Arrows show the flow of funds utilized to purchase shares in the targeted banks. Dashed lines represent hidden ownership ties. The Holding Company attempted to obfuscate its status of final beneficiary in order to avoid Central Bank inspection and surveillance.

Figure 4.1 illustrates the take-over scheme that was perpetrated by the holding company. In order to avoid detection of its attempt to take-over the three banks, the Holding Company

concealed information regarding the fact that it was the final beneficiary of the Moldovan firms that participated in the share purchases. To do so, the Holding Company resorted to nominees who assumed the role of beneficiaries of the off-shore entities that owned the Moldovan firms. The ties between the nominees (or the declared beneficiaries) and the Holding Company were kept secret. To finance the share purchase, the Holding Company instructed a number of off-shore firms owned by itself or nominees to wire funds through non-OECD banks to the off-shore entities that directly controlled the Moldovan firms. These entities then transferred the funds to the Moldovan firms which utilized the money to purchase shares in the three Moldovan banks.

Following the share purchase, the strategies of the three banks suffered significant changes: they engaged in maximizing liquidity in order to primarily credit firms controlled by the Holding Company. To do so, the banks attracted interbank deposits, lent to each other, attracted deposits beyond the maximum profitable value and substituted credit offered to non-controlled firms with credit offered to firms controlled by the Holding Company (which I will henceforth call “controlled firms”). Furthermore, the banks placed deposits from own funds in the name of third party beneficiaries from controlled firms. This allowed the deposited money to be withdrawn directly from the foreign banks by the third parties without further trace in the form of changes to the balance sheets of the Moldovan banks. This, in turn, produced statistical discrepancies which persisted until the collapse of the banks.

2.2. Financial product fraud and money laundering 2014 – 2015

I now analyze in greater detail the financial schemes that were perpetrated on the banks’ products and services following their successful take-over by the Holding Company.

The objectives behind the financial schemes implemented by the Holding Company after having gained control over the three banks were to:

- maximize available liquidity for the bank to lend to firms controlled by the Holding Company
- prevent prudential indicators from deteriorating in order to avoid additional supervision and monitoring from the Central Bank
- evacuate the money from the Moldovan financial system by laundering it to non-OECD banks

The first scheme that was utilized shortly after obtaining control over one of the banks was aimed at maximizing the capacity of the financial institution to lend to firms controlled by the Holding Company. To do so, the bank sold a part of its non-performing loan portfolio to an investment vehicle controlled by the Holding Company. The investment vehicle agreed to purchase the entire loan portfolio that was offered at no discount. The reason for this seemingly irrational decision resides in the subordination of the vehicle to the fraudulent entity. As such the objective of the investment vehicle differs from that of profit maximization. However, one caveat to the financial operation was that the payment for the purchase of the non-performing loan portfolio would be made in tranches with an upfront payment of around 10% of the total amount and later installments scheduled over a period of several years. Still, from the perspective of the bank's balance sheet, the non-performing loans had been erased and replaced with assets of different maturity and liquidity. This allowed the bank to issue further loans to entities controlled by the Holding Company, equal to the full amount of the sold-off assets without immediately apparent deterioration of prudential indicators. Figure 4.2 shows a simplified depiction of the flow of funds involved in the scheme.

Figure 4.2. Cession of loan portfolio to an investment vehicle

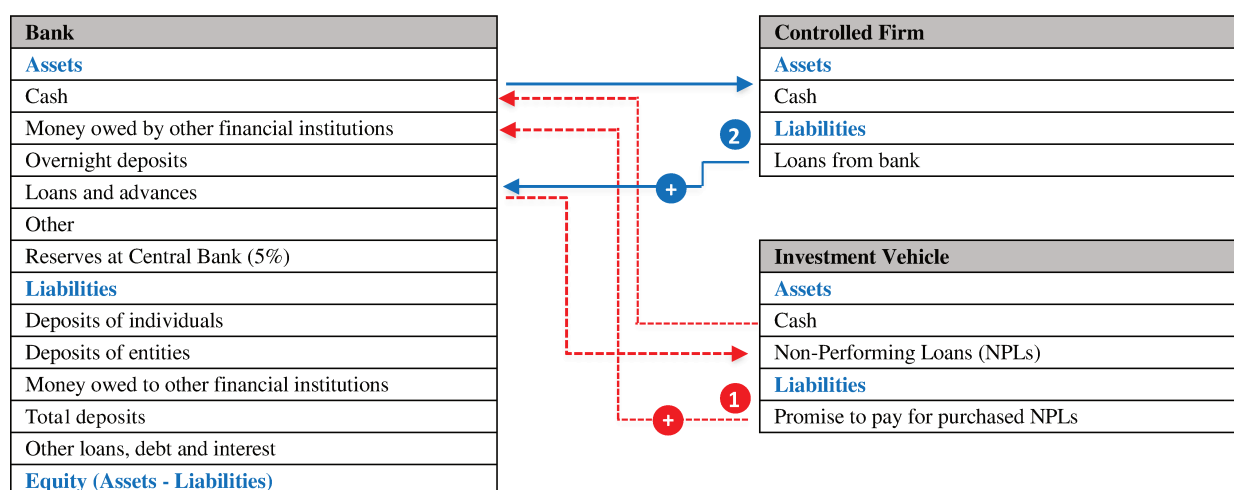
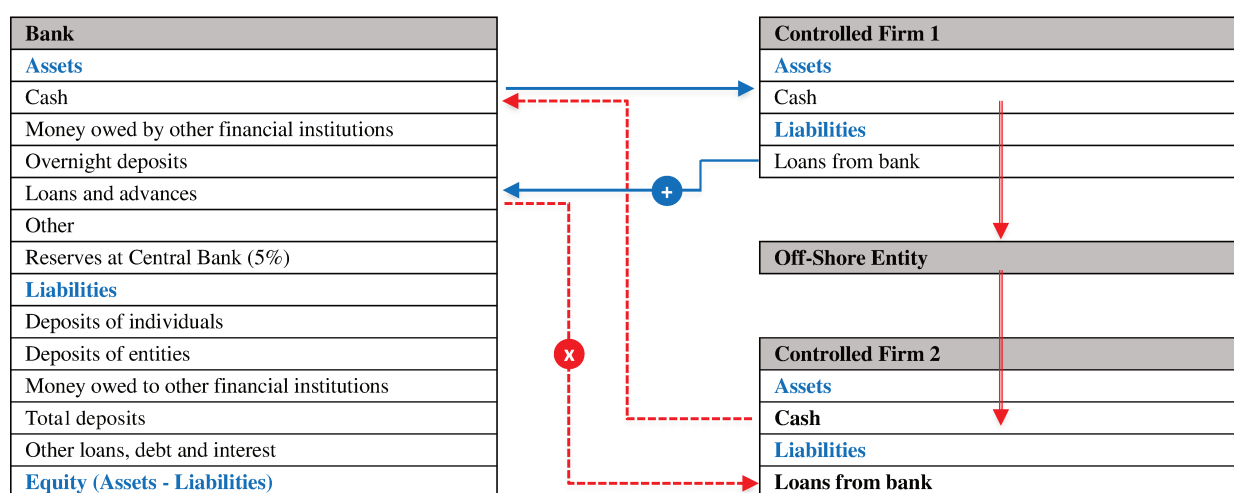


Figure 4.2 shows 1) the process through which the bank's non-performing loan portfolio was sold to an investment vehicle and 2) the resulting allocation of credit to firms controlled by the Holding Company. Dashed lines show the transfer of the non-performing assets to the investment vehicle which in return grants the bank: an initial cash transfer and a promise to pay in several tranches. Straight lines depict the crediting operations through which the

liquidity that was obtained, coupled with funds from other received client deposits was transferred to firms controlled by the Holding Company. Prudential indicators would see no *immediate deterioration because the bank's NPLs had been removed from the balance sheet.* The “+” indicator represents the appearance of a debt for the firm or of a promise to pay.

Furthermore, the Holding Company engaged in loan shifting between firms, banks and between client groups. In the first instance, the objective was to build trust in the form of a sound credit record allowing the controlled firms to request increasingly large amounts of credit without raising suspicion. To achieve this goal: 1) firms systematically borrowed money from any one of the three banks; 2) transferred the money to a firm whose credit was due to mature in the very near term and 3) the firm whose credit matured repaid the loan, only to 4) later borrow again to repay another firm's loan. With each iteration of the procedure, the amount requested would increase thereby showing no spikes in credit allocation statistics. The number of firms and banks involved in the procedure and the fact that the transfer of funds between firms controlled by the Holding Company was done through offshore entities – made it difficult for regulators to detect linkages between the firms. This allowed the scheme to perpetuate for a prolonged period of time without being detected. Furthermore, since the loans were being repaid, for a short period of time the banks' profitability increased thereby allowing the banks to increase lending. Figure 4.3 shows the process within a simplified balance sheet framework.

Figure 4.3. Loan shifting between firms



In Figure 4.3, solid lines represent credit issued to a firm controlled by the Holding Company. The money is secretly transferred through an Off-Shore entity to another

controlled firm which needs to pay back a previously obtained loan. Dashed lines represent the reimbursement procedure through which the bank is repaid. The “+” indicator represents the appearance of a debt for the firm or of a receivable for the bank as a result of a loan issuance. The “x” indicator indicates the disappearance of a debt for the firm or of a receivable for the bank as a result of a loan repayment.

The scheme could be perpetrated with the involvement of only one bank or of multiple banks. In the case of the involvement of a sole financial institution, the firms would borrow and reimburse to the same bank. In the case of multiple institutions, the borrowing firm would obtain credit from one bank whereas the repaying bank would reimburse the credit to another institution. Multiple firms could be involved if the amount of credit reaching maturity was sufficiently high. All actions undertaken by the firms were coordinated by the Holding Company which in effect constitutes the fraudulent component of the scheme. The money secretly transferred to and from the off-shore entity was written down in the form of sales and purchases (of various capital assets and consumables) which never took place.

Concurrently, the Holding Company performed loan-shifting among client categories. In this case, the bank’s credit exposure to non-controlled firms was gradually diminished in order to maximize available liquidity to credit controlled firms. Exposure to controlled firms was subsequently increased. Since there was a delay between the reimbursement of credit by non-controlled firms and the issuance of credit to controlled firms, this had the effect of temporarily improving the bank’s prudential indicators while the bank was hoarding liquidity. Figure 4.4 provides a visual depiction of this process.

Figure 4.4. Loan shifting between client categories

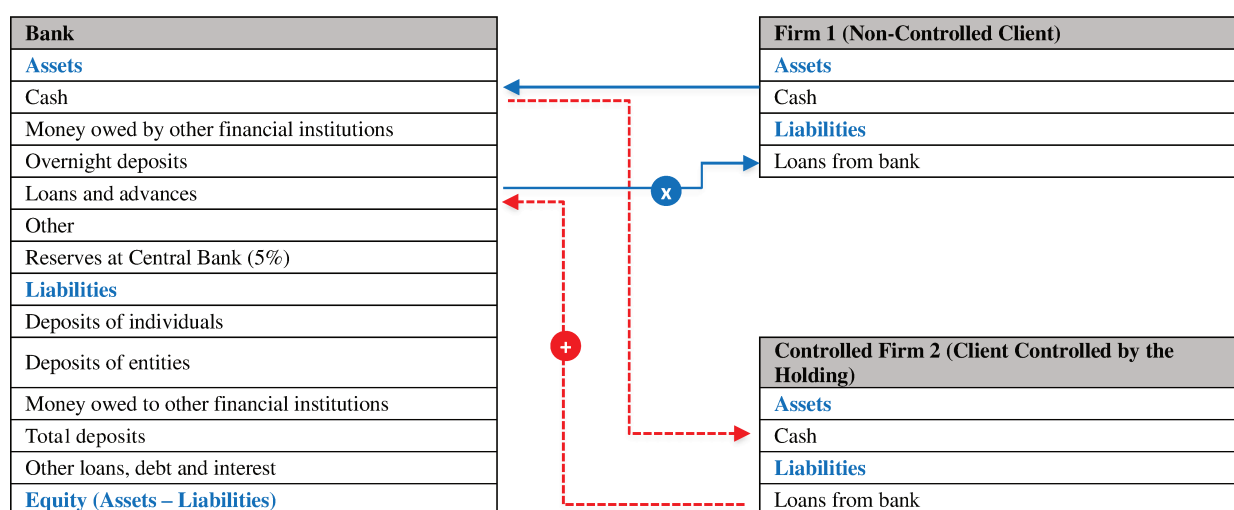


Figure 4.4 shows that, progressively, as non-controlled clients reimbursed the loans obtained from the controlled bank (solid line), the financial institution no longer credited this category *of clients*. It “opted” instead to increase its exposure towards controlled clients (dashed lines). The “+” indicator represents the appearance of a debt for the firm or of a receivable for the bank as a result of a loan issuance. The “x” indicator indicates the disappearance of a debt for the firm or of a receivable for the bank as a result of a loan repayment.

Because the number of firms that were owned by the Holding Company remained limited (albeit significant), the “Large” Exposures / TRC increased to reflect the growing lack of diversity in the bank’s credit recipients. This degradation of a prudential indicator would have signaled to the Central bank that something was amiss at the involved credit institutions. The other prudential indicators would not be affected by this scheme unless the credits offered to controlled firms were greater than those repaid by non-controlled firms.

Figure 4.5. Circular bank deposit scheme

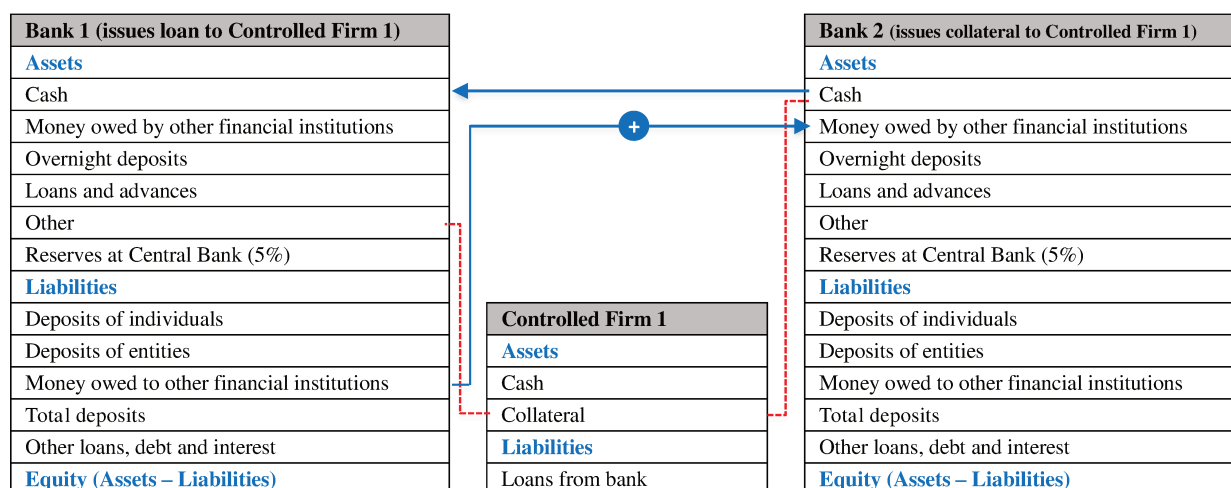


Figure 4.5 shows the workings of the Circular Bank Deposit Scheme. Within this construct, a bank places a deposit at another bank which is used as collateral to borrow from the second, or even potentially a third bank. Solid arrows show the flow of cash and obligations between the banks. Dashed lines represent the appearance of collateral that never actually enters the *Controlled Firm's balance sheet, but instead resides only in the accounts of the involved banks*. The scheme allows the bank that issues the loan to improve its prudential indicators by assigning a lower risk weight to the collateralized loans. The figure does not depict the *lending operation*. The “+” indicator represents the appearance of a debt for the receiving bank or of a receivable for the issuing bank as a result of a deposit being opened.

Another means by which the Holding Company dampened the worsening of prudential indicators as a result of credit issuance was the Circular Bank Deposit Scheme. This construction was founded on the regulatory norms stating that if a firm provides bank deposits as collateral for any given loan, then the loan's risk weighting is diminished to reflect the existence of collateral. This provision has direct impact on the bank's Capital Adequacy Ratio, which degrades slower towards the regulatory minimum as a result of credit issuance if the debtor provides collateral for the loan. However, finding capital to transform into bank deposits would normally be problematic for shell firms with little to no real activity. As such, the fraudulent scheme involved two or more banks of which one²⁶ would open a deposit account with own funds in the name of the firm to be credited. The firm would then present the paperwork to the bank from which it requested the credit. The bank issuing the credit would thus be allowed to lower the risk-weight of the issued loan in the Capital Adequacy Ratio formula. This would improve its prudential indicator therefore allowing it to issue more credit before hitting the minimum permissible bound. Furthermore, the bank receiving the deposit would later "return the favor" by issuing similar deposits to other controlled banks. This would allow the money to be "reused" indefinitely to lower the risk weights for issued loans. Figure 4.5 shows how this mechanism was implemented.

Finally, to maximize available liquidity, the controlled banks resorted to taking loans on the interbank market from other non-controlled banks. According to regulation and international practices, loans on the interbank market can be given for periods of up to 1 year. Non-controlled banks with excess liquidities would be willing to lend in an environment in which: credit demand is weak; interest rates are low or are expected to fall; and there is no significant default risk of the receiving institutions²⁷. Aside from these factors, a characteristic of the Moldovan financial environment was a general expectation that any failing banking institution would be bailed-out. In such a context, the supply of credit on the Moldovan interbank market was high and controlled institutions were able to borrow significant amounts of money for long periods of time. The interbank operations that

²⁶ any controlled bank could perform this operation with the exception of the bank which would actually credit the firm belonging to the Holding Company.

²⁷ in absence of domestic credit rating agencies, a suitable indicator for determining the risk-level of a financial institution would be the state of its prudential indicators. The absence of indicators surpassing their admissible threshold would be indicative of safe banks. Furthermore, if an institution were engaging in operations aimed at maximizing its liquidity, then this would show up as an improvement of prudential indicators – making the bank seem safer to other credit issuers.

occurred had the effect of exposing non-controlled financial institutions to the risk stemming from the fraudulent activities undertaken by the Holding Company. Figure 4.6 shows the positions affected by the transactions.

Figure 4.6. Interbank market scheme

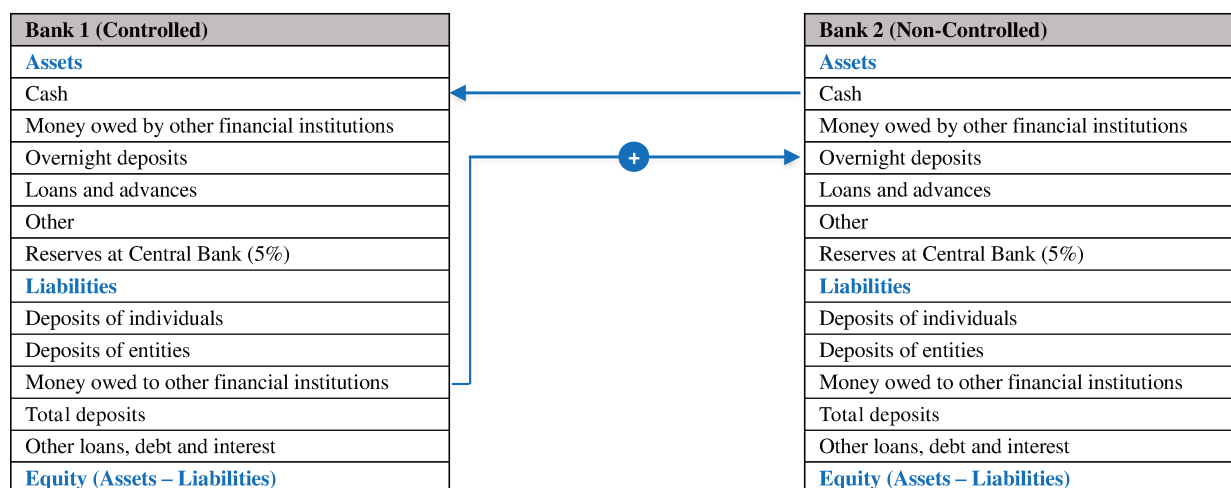


Figure 4.6 describes the Interbank Market Scheme. A controlled bank requests liquidity from a non-controlled financial institution. Solid arrows show the flow of cash and obligations between the banks. The transaction improves the prudential indicator of the controlled bank. *The “+” indicator represents the appearance of a debt for the receiving bank or of a receivable for the issuing bank as a result of the interbank transactions.*

As seen from the fraud schemes discussed above, the main goal of the operations was to maximize liquidity available for credit issuance to controlled firms, as well as to improve prudential indicators in order to allow more credit to be issued before the indicators hit their regulatory minimum or maximum admissible values. To achieve its goal, the Holding Company utilized to the full extent its arsenal of controlled banks, firms and off-shore entities. Some operations consisted of exploiting nuances in the regulatory framework towards the Holding Company’s advantage while others constituted outright fraud in the form of false records about inexistent assets being introduced into balance sheet items. The implementation of these schemes seems to indicate willingness on behalf of the Holding Company to prologue the scheme’s operation to the maximum possible extent. From the Central Bank’s perspective, this may have been an indicator for the regulator that the fraudsters may be willing to engage in reimbursing a part of the loans that they contracted in order to keep the scheme alive. This may have impacted the Central Bank’s decision to

interne or not. In what follows I construct an agent based model which reproduces the fraudulent schemes in a simulated environment. This will allow for an analysis of the optimality of Central Bank intervention throughout the progression of the fraudulent financial schemes.

3. Model and Simulation

The goal of this paper is to create a model that can be used to infer whether, in the event of financial fraud as perpetrated in the case of Moldova, the Central Bank is correct in taking no action to curtail the fraud schemes or indeed, if intervention is prescribed. To do so, I must analyze the losses in the event of intervention and compare them with the losses that transpire if the Central Bank does nothing and allows the banks to fail. The comparison will be used to formulate conclusions as to the optimality of the Central Bank's decision, and to provide insights into its thought process. Due to the necessity of comparing two sets of data, one of which does not exist in reality because of events that never happened, I must resort to simulative techniques in order to obtain the data that is required for the analysis. Agent-based models currently constitute a rapidly growing and developing methodological field that is highly adaptable to varying usage scenarios and allows researchers to design with great precision the environment, conditions and interactions of agents. The tool is specifically geared towards models in which significant importance is placed on the interaction between a larger than average set of agents. Given our model of a financial sector containing multiple banks, the interbank operations that we need to study, as well as the large number of state variables corresponding to the positions of the banks' balance sheets that must be integrated, the choice of an agent based model as the methodological tool for this paper is optimal as it is the only instrument that provides sufficient flexibility without sacrificing simplicity and usability.

In the model that I construct, the banking agents have balance sheets that evolve similarly to what one would find in an accounting model, only in this case, interactions between the agents in an environment of randomness and uncertainty also exist. The resulting construction is therefore a hybrid between an accounting model and an agent based model and could probably be coined as an A-ABM (an Accounting - Agent Based Model).

3.1. Model description – construction of the banking sector

The model that I construct recreates the environment and the fraudulent schemes used to perpetrate the financial fraud of the 2013 - 2015 timeframe. Three banks representing roughly a quarter of the total number of financial institutions are taken over by a fraudulent entity called the Holding Company. As initial assumptions regarding the environment in which banks operate, I take the conditions described in section 1.1. related to the interest rates, credit demand and anticipations of these two key variables, as well as the assumptions related to banks' heightened leverage, their lack of voluntary capital buffers in excess of the regulatory norms and their strategy of maximizing market capitalization. These factors determine the banks' profit and their optimal choice of duration and volume when allocating credit. Behavior-wise, a non-controlled bank which registers low or negative profits attempts to correct its situation by either reducing costs or increasing revenues. As such, when the bank needs to increase short-term profits, it allocates a maximum amount of funds to short-term crediting activity. This quickly yields dividends. As profits increase or become positive, the bank focuses on longer term endeavors. Alternatively, if credit demand is insufficient and losses worsen (profits become more negative), the bank may be forced to reduce the amount of deposits that it accepts. This lowers the interest paid to depositors thereby lowering costs and easing the downward pressure on profits. The cost reduction strategy is less preferred and will kick in only if losses continue to mount, as this is contrary to the bank's objective of maintaining its market share. Controlled banks, on the contrary, do not have the same profit-maximizing objective. Instead they have the objective of maximizing available liquidity (cash) so that this cash can be extracted from the bank at an opportune moment.

The model that I create presents a simplified financial system that operates in an environment calibrated to reproduce the conditions existing during the Moldovan fraud episode. For confidentiality reasons, when calibrating the constructed model, I refrain from utilizing the actual data and names of the three banks or the involved parties, opting instead to utilize standardized values for the banks' balance sheet compositions. I refer to the banks by numbers with the first three being the ones controlled by the fraudulent entity. Despite not utilizing the exact data of the banks, the model produces results that are very similar to the actual evolution of the banks' prudential indicators. This is due to the correct construction and sequencing of the fraudulent operations that transpired and allows one to generalize as to the effect of such fraud schemes on the health of financial institutions.

I construct the bank's balance sheets utilizing the same structure as that provided in the Central Bank's Financial Sector Reports. Based on the composition of its assets and

liabilities, each bank reports the four key prudential indicators that the Central Bank utilizes to determine the bank's financial state, as outlined in section 1.2. : the Capital Adequacy Ratio, "Large" Exposures / TRC, Long Term Liquidity Ratio and Short Term Liquidity Ratio. The Central Bank typically utilizes this information to determine whether intervention is necessary or not at a bank. In the event of intervention, it has the choice of either placing the bank under a special surveillance regime or a special administration regime, the latter corresponding to a temporary take-over of the financial institution by the Central Bank. Because the fraud schemes involve 3 banks being taken over by a single entity, it is safe to assume that intervention (of any form) at any one of the banks alerts the Holding Company that the Central Bank has caught wind of the scheme and may perform intervention at the remaining banks under the Holding Company's control in the near future. Whereas the liquidity (cash) belonging to the financial institution at which the Central Bank intervenes can be saved, intervention prompts the Holding Company to act quickly and to extract the maximum possible value from the remaining banks under its control. This means that liquidities (cash) from the remaining banks will be lost to the Holding Company. Credit previously given to firms affiliated to the Holding Company will be unrecoverable for all three banks. Similarly, deposits placed by any controlled financial institution in foreign banks will be unrecoverable, as this money will have been extracted by third parties from the foreign banks as soon as it was deposited via the fraud scheme described in section 2.2.

In order to analyze the Central Bank's actions, it is not necessary to study the process through which banks are taken over by the Holding Company, and I can instead start the simulation after this has occurred. This allows me to focus on modeling the fraud schemes and the bank's lending behavior.

The development and timing of the financial fraud is modeled to be representative of the operations that occurred in the Moldovan fraud case. The fraud transpires in several phases (each of them lasting around 3 months). All in all the simulation lasts for 21 periods (months) and phases can overlap.

Phase 1. Normal bank operations: All banks operate normally.

Phase 2. Interbank market operations and contagion: Controlled banks obtain funds from non-controlled banks on the interbank market.

Phase 3. Maximization of available liquidity by controlled banks.

Phase 4. NPL Issuance and Foreign Bank Deposits: Crediting controlled firms and placing deposits in foreign banks commences.

Phase 5. Reimbursements and reversal of interbank market operations

Phase 6. Sudden stop: Unexpected end of schemes whereby the Holding Company extracts the maximum attainable value from all three banks and reimbursements end.

Phase 7. Default of the three financial institutions.

In Phase 2, banks controlled by the Holding Company request liquidity from the interbank market in order to fund the issuance of non-performing loans to firms affiliated with the Holding Company and mitigate the resulting deterioration of prudential indicators. Non-controlled banks issue interbank loans to the controlled banks as long as the following conditions are met:

1. The non-controlled bank has enough liquidity to lend.
2. The non-controlled bank does not have any “bad” prudential indicators.
3. The controlled bank does not have any “bad” prudential indicators.

The first two conditions ensure that the non-controlled bank’s financial health allows it to engage in lending operations on the interbank market. The third condition ensures that the receiving bank is compliant with prudential regulation and that it is therefore likely to reimburse the allocated funds. The incidence on the banks’ balance sheets associated with the interbank transactions is presented in Figure 4.6. In this phase, contagion occurs within the financial system as non-controlled institutions become exposed to the controlled banks.

Phase 3 corresponds to the maximization of available funds by the controlled banks. This means that these banks do not issue credit to non-controlled firms, instead retaining the cash. They also continue to attract deposits regardless of their profit. This translates into an improvement of the banks’ prudential indicator as the liquidity reserves of the three banks increase. The scheme presented in Figure 4.4 is reflective of the 3rd phase.

Phase 4 translates into a rapid degradation of the banks’ prudential indicators. As the three banks engage in operations of different types (NPL issuance or deposit placement), volumes and maturities, the degradation of the three indicators is asynchronous and will occur more rapidly at some of the controlled banks than at the others. The fraud schemes utilized in this phase correspond to those described by Figures 4.4 – 4.6.

In Phase 5, the Holding Company reimburses some of the previously contracted loans, and reverses the interbank market operations through which the controlled banks siphoned money from the non-controlled banks. This phase ends the contagion as non-controlled banks are no longer exposed to controlled ones. From this point forward, the losses to the financial system stem only from losses associated with the three controlled banks.

Phase 6 signals the end of the scheme. The fraud was perpetuated over a period of almost two years after which it abruptly ended when a number of loans contracted by controlled firms were not reimbursed and funds were rapidly extracted from the controlled banks by means of off-shore deposits and direct cash extraction. The fraud schemes themselves were meant to function for a number of years. Whilst they were being perpetrated, the Holding Company resorted to reimbursing some of the loans and interbank operations in order to build “trust” and thereby potentiate a larger extraction of funds in the future. The exact reasons for the sudden stop that led to the end of the scheme are unknown but may be related to investigative journalism and a probe into the operations taking place at the three controlled institutions. To keep the simulation consistent with what happened in reality, we instruct the controlled banks to reimburse some of the loans and reverse the interbank operations roughly until period 20 or almost before the end of the fraud scheme.

Phase 7, sees the three controlled banks defaulting and represents the moment when the Central Bank decides to liquidate the banks. A depositor bail-out mechanism is put into place. The defaulting institutions are allowed to continue functioning for a period of time with their assets frozen in part: to recover some maturing loans, to work out a liquidation schedule, but also to avoid panic and a potential bank run on the other non-controlled banks. Because of the complexity involved in the bail-out plan following the fraud, we do not include it in our model which would otherwise have to incorporate a number of elements that only relate to this phase.

The calculation of losses is a key aspect in determining whether Central Bank intervention is recommendable. Two states must be compared – the losses at the moment of intervention (if indeed the Central Bank decides to act) [eq.(1) and eq.(2)] and the losses at the end of the simulation when the banks default (if the Central Bank remains passive) [eq.(3)]. Concurrently, because the controlled banks engage in interbank operations through which they acquire funds from the other banks, two series of losses are to be considered – the losses

of the three controlled banks [eq.(2)] and the global losses of the financial sector (which includes the losses of the non-controlled banks) [eq.(1)].

Global losses of the financial sector

$$Loss_t^G = \sum_{bk=\{i\}} (Cash_{bk,t} + Cred_{bk,t} + Dep_{bk,t}) - \sum_{int=\{j\}} Cash_{int,t} \quad (1)$$

Losses of the controlled banks

$$Loss_t^C = \sum_{bk=\{i\}} (Cash_{bk,t} + Cred_{bk,t} + Dep_{bk,t}) - \sum_{int=\{j\}} Cash_{int,t} - \sum_{nc=\{k\}} IBMd_{nc,t} \quad (24)$$

Final losses at the end of the simulation

$$Loss_t^F = \sum_{bk=\{i\}} (Cash_{bk,t} + Cred_{bk,t} + Dep_{bk,t}) \quad (25)$$

where “i” denotes the subset of banks controlled by the Holding Company, “j” – the subset of banks at which the Central Bank intervenes, “k” – the subset of non-controlled banks, “Cash” – the liquidity extracted from the bank, “Cred” – the amount of non-performing loans given by the bank to firms affiliated with the Holding Company, “Dep” – the amount of deposits placed in foreign banks, “IBMd” – the amount of interbank deposits placed at controlled banks, “Loss^G” – the global losses of the financial sector (in case of intervention), “Loss^C” – the losses of the controlled banks (in case of intervention), “Loss^F” – the final losses (in case of no intervention), and “t” – the time period.

In these equations $\sum_{bk=\{i\}} (Cash_{bk,t} + Cred_{bk,t} + Dep_{bk,t})$ represents the losses resulting from the three main positions targeted by the fraud scheme: direct Cash extraction, issuance of Non-Performing Loans and the placement of Deposits in foreign banks. In the event of no intervention, these losses apply to all three banks. If the Central Bank decides to intervene at one of the banks, the recovered amount is $\sum_{int=\{j\}} Cash_{int,t}$ which corresponds to the direct cash theft which is prevented by the regulator. This amount is extracted from the losses incurred by the three banks until the intervention moment. $\sum_{nc=\{k\}} IBMd_{nc,t}$ represents the losses of the non-controlled banks in the economy that credited the controlled banks. This sum must be removed from the losses formula in order to obtain the losses associated only with the controlled banks.

Because, in reality, the Central Bank did not intervene to take control of any of the three financial institutions directed by the Holding Company, it is difficult to determine theoretically when the intervention moment of the regulator should have occurred. The Central Bank can formulate multiple strategies regarding the moment of intervention depending on the: regulatory framework which may (or may not) impose the regulator to act quickly, expectations of future losses and reimbursements by the fraudulent entity, the existence of an objective of finding all the institutions affected by the fraud (some of whose prudential indicators may not yet indicate problems), etc. Table 4.2 presents a number of possible Central Bank intervention strategies, their advantages and disadvantages.

Table 4.2. Central Bank Intervention Strategies

Strategy 1 – Immediate	
As soon as one prudential indicator surpasses its maximum or minimum admissible value, the Central Bank is, in principle, authorized to take action at the bank with the surpassed indicator.	Advantages: Quick intervention time, minimizes losses at the controlled banks.
	Disadvantages: Tips off the Holding Company regarding the Central Bank’s awareness of the scheme and willingness to intervene, determines the Holding Company to promptly extract maximal value from the other banks under its control.
Strategy 2 – Delayed	
As soon as at least two prudential indicators surpass the admissible norm, the Central Bank intervenes.	Advantages: More prudent approach, avoids sanctioning “healthy” banks with temporary lapses, more adapted to an environment of low voluntary capital and liquidity buffers.
	Disadvantages: Slower response time, less efficient at minimizing losses at the controlled banks.
Strategy 3 – Group intervention	
Wait for prudential indicators at multiple	Advantages: Can intervene at multiple

institutions to be surpassed before acting.	financial institutions at the same time thus minimizing Cash losses, can lead to asset recovery as it gives the fraudulent entities time to reimburse some of the received loans.
	Disadvantages: Slow response time induces higher NPL and Foreign Deposit losses which may overshadow the gains of this strategy.

Table 4.2 presents the advantages and disadvantages related to a number of interventions strategies that the Central Bank can adopt when faced with prudential indicators that deteriorate at one or multiple financial institutions.

In order to avoid limiting the analysis by making assumptions as to which strategy the Central Bank adopts, within the simulation, we calculate the “global losses” and the “losses for the controlled banks” in case of intervention at each period. In this way, we obtain two series of data that we can use to compare with the “final losses” in case of no intervention.

3.2. Discussion of the findings

The two series of data related to the global losses of the financial sector and the losses of the controlled banks give an idea of how great the damage of the financial fraud is at each period, if the Central Bank intervenes at that moment in time. Furthermore, the series are indicative of who is affected by the crisis at any given point in time – only the controlled banks, or the other banks as well. The data produced by the model also allows for a dissociation of the losses into their individual components: Cash losses, losses resulting from Non-Performing Loans, losses resulting from the placement of funds in Deposits at foreign banks, and losses from Interbank Market Operations. This component distribution can be seen in Figure 4.8 alongside the Global and Controlled Bank Loss series which are compared in Figure 4.7.

Figure 4.7. Comparison of losses

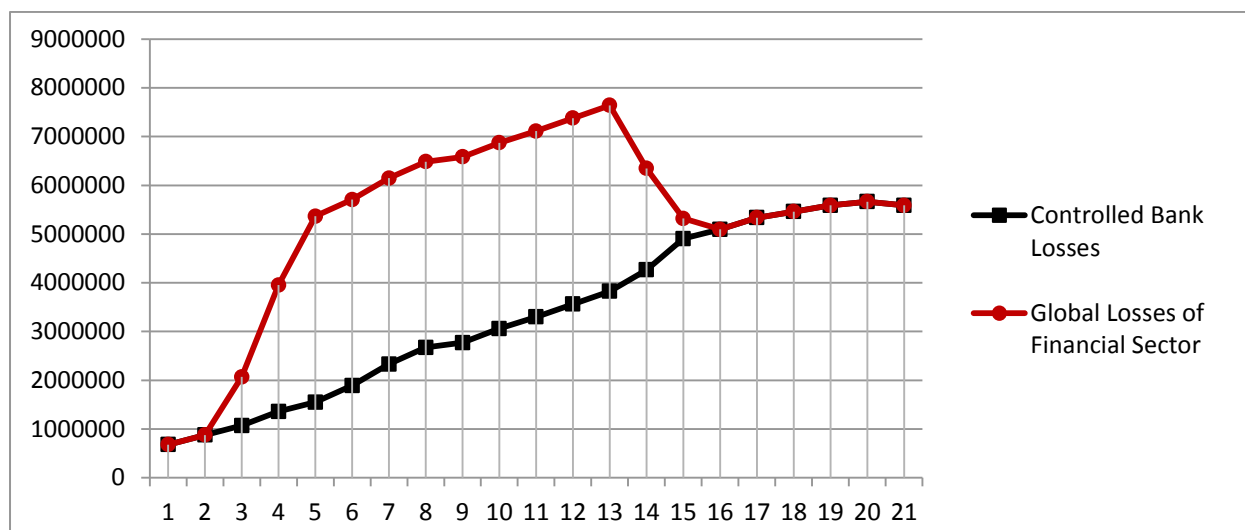


Figure 4.7 compares the losses that are incurred by the controlled banks with those of the financial sector if the Central Bank decides to intervene at any given point in time. These losses can then be compared with the final losses incurred at the end of the simulation if the Central Bank does not intervene. The x-axis shows time (in months), and the y-axis – the value of the losses.

Figure 4.8. Composition of losses

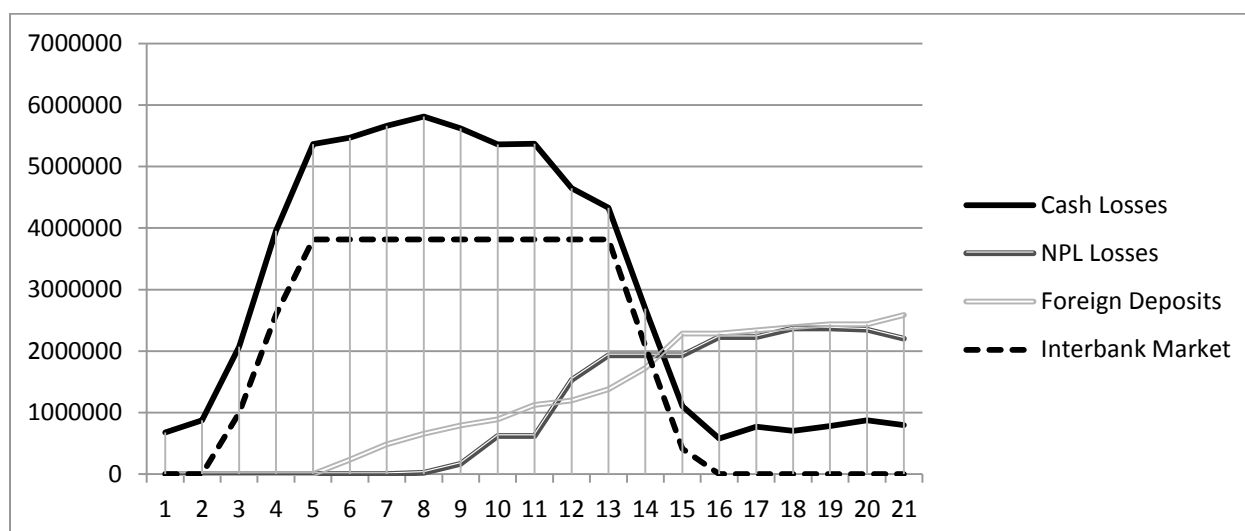


Figure 4.8 shows the components of losses: Cash Losses, Non-Performing Loans, losses arising from Deposits placed in foreign banks, and losses resulting from Interbank Market operations.

As can be seen in Figure 4.7 losses at the three controlled banks continue to amount throughout the simulation with the exception of the final period when reimbursements are higher than new credit issued to firms controlled by the Holding Company. The increase in losses is due to the growing exposure of the controlled banks to firms belonging to the Holding Company, as well as the deposits opened in foreign banks, as seen in Figure 4.8. At the same time, to improve prudential indicators and finance the issuance of NPLs, the controlled banks contract a significant amount of loans on the interbank market from the non-controlled banks. This serves to greatly bolster the available liquidity (cash) of the controlled banks. These funds are eventually reimbursed, probably in the hopes of obtaining a larger amount of loans in the future. When the controlled banks are in possession of the interbank market funds, the global amount of losses of the financial sector becomes detached from the losses of the controlled banks. The amount of global losses above the losses of the controlled banks corresponds to the non-controlled banks' losses. Once the interbank market loans are reimbursed, the global losses of the financial sector are once again determined exclusively by the losses of the three controlled banks. Towards the final phases of the simulation, despite the Holding Company's goal of maximizing the extracted value from the controlled banks, the degradation of prudential indicators made it impossible for them to continue to access the interbank market in order to extract funds from non-controlled financial institutions immediately prior to the controlled banks' defaults. This has the effect of limiting the losses associated with non-intervention at the end of the simulation.

Throughout the simulation, the prudential indicators of the three affected banks vary significantly when compared to the evolution of the indicators reported by the other banks in the economy. The variations are in line with the actual evolution of the prudential indicators in the Moldovan financial fraud.

As shown in Table 4.3, we notice a steady degradation of the prudential indicators at the three controlled banks. Bank 3 starts to display 1 surpassed prudential indicator at period 7. It is joined by the other two controlled banks at period 10 when all three institutions have at least one surpassed indicator. Since not all of the captured banking institutions utilize the same fraud schemes at the same time, the prudential indicators of the three institutions deteriorate asynchronously. To further complicate matters, since most banks do not hold safety buffers above the regulatory norms, it is possible for non-captured banks to also temporarily have "bad" prudential indicators (as is the case for banks 5, 7 and 12). This induces noise and makes it difficult for the Central Bank to distinguish between benign occasional hiccups and

the deterioration of prudential indicators related to concerted fraud operations. This uncertainty increases the difficulty of the Central Bank's intervention dilemma.

Table 4.3. Number of prudential indicators surpassing the admissible regulatory values

Time	<u>Bk 1</u>	<u>Bk 2</u>	<u>Bk 3</u>	Bk 4	Bk 5	Bk 6	Bk 7	Bk 8	Bk 9	Bk 10	Bk 11	Bk 12
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	1	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	1	0	0	0	0	0	0	0	0	2
8	0	0	1	0	0	0	0	0	0	0	0	0
9	0	0	1	0	0	0	0	0	0	0	0	0
10	2	1	1	0	0	0	0	0	0	0	0	0
11	2	2	1	0	1	0	0	0	0	0	0	0
12	3	3	2	0	1	0	1	0	0	0	0	0
13	3	3	3	0	0	0	1	0	0	0	0	1
14	3	3	3	0	0	0	0	0	0	0	0	1
15	3	3	3	0	0	0	0	0	0	0	0	0
16	4	3	3	0	0	0	0	0	0	0	0	0
17	3	3	3	0	0	0	0	0	0	0	0	0
18	4	3	3	0	0	0	0	0	0	0	0	0
19	4	3	3	0	0	0	0	0	0	0	0	0
20	4	3	3	0	0	0	0	0	0	0	0	0
21	3	3	3	0	0	0	1	0	0	0	0	0

Table 4.3 shows, for each bank included in the simulation and at every point in time, the number of prudential indicators that exceed the maximum or minimum admissible values set forth by the regulation. In the table, banks that are controlled by the Holding Company have their names underlined.

To discuss the intervention decision of the Central Bank, we must think about the contagion effects of action on behalf of the regulator. In what follows I assume that the Central Bank's objective is to minimize the global losses of the financial system, however (when generalizing) this may be different for countries other than Moldova. In the event of multiple financial institutions being taken over by the same fraudulent holding company – any regulatory intervention on only one of the captive institutions would trigger an alarm for the holding company signaling that the fraudulent scheme being perpetuated is about to be discovered and stopped. As a result, the most logical course of action for the holding would

be to withdraw a maximum of funds from the institutions remaining under its control after having liquidated existing assets (at potentially fire-sale prices) to convert them into easily extractible cash. As such, it is in the Central Bank's interest to act on all affected institutions at the same time in order to avoid the negative signaling effects of intervention. However, in the context in which the deterioration of prudential indicators at the affected financial institutions does not occur simultaneously, a strategy of immediate intervention is suboptimal.

As seen from the data, "early" intervention would lead the Central Bank to take control of controlled Bank 3 at period 7 after the beginning of the fraud scheme. This would alert the Holding Company that the Central Bank is closing in on the scheme and would cause the holding to extract all possible liquidity from the remaining banks. Coupled with the NPLs and foreign deposits, the losses at this point would be almost maximal. Intervention at any point prior to period 7 would be seen as illegitimate and could be construed as the Central Bank meddling into the private banking system. Accounting for the matter of legitimacy, in order to minimize the global losses of the financial sector, the Central Bank would have to act in period 16 when there is a complete reversal of the interbank market transactions leading to the removal of the non-controlled financial institutions' exposure towards Holding Company banks.

Still, fraud perpetrators may decide to reimburse loans just as they reversed interbank operations in order to ensure the sustainability of their fraud schemes, if they believe that greater future benefits can be extracted from the controlled banks. In this instance, the Central Bank may decide to postpone intervention in expectation of acting when the perpetrators have reimbursed a significant portion of the extracted funds. In this instance, the Central Bank gambles on whether it can minimize losses. In the event of strategic failure, the Central Bank is confronted with larger losses than in the case of early action. The gamble is only worthwhile for the institution if it does not know how many banks are being controlled by the fraudulent Holding Company.

All in all, the decision of not intervening is reflective of one, or more of the following factors – the Central Bank:

- does not dispose of adequate prudential indicators that can provide either an "early-warning" system or a comparison between financial institutions.

- cannot obtain information regarding the ownership structure of banks because of no regulatory provisions prohibiting off-shore companies from acquiring financial institutions.
- misses an opportunity to intervene when the interbank market operations are reversed or it erroneously bets on more loan reimbursements to come.
- is non-interventionist by nature and won't act no matter what (in which case its role as regulator comes into question).
- wishes to avoid losses resulting from panic and potential bank-runs on other non-controlled banks (which have not been quantified in this model).

Indeed, the performance of the Central Bank has proven to be sub-optimal in minimizing the risk. Whereas not all of the above-detailed problems that the institution faced can be resolved, some propositions can be made. With respect to the Central Bank's awareness of the final beneficiaries of financial institutions – legislative changes coupled with increased cooperation at the international level are needed in order to identify the de-facto ownership structure of Moldovan banks. As to the argument about the potential losses arising from bank runs – by not intervening, the Central Bank did not eliminate this threat, but merely postponed it until the actual default of the three financial institutions. Indeed, one could argue that less of a panic would have ensued if action had been taken prior to the banks' default. Finally, The Central Bank must also become more proactive in monitoring the financial situation of the banking sector in order to act in a timely manner, when intervention is necessary. However, to do so it needs additional tools and measures to facilitate its work. Some propositions in this regard are formulated in the following section where I discuss more complex and informative aggregate prudential indices that can be constructed from existing data.

3.3. Enhanced prudential indices

The Central Bank's decision of whether to intervene or not has proven to be a difficult choice. The mere knowledge that prudential indicators have surpassed their admissible values does not offer the regulator enough information to found its decision. At the same time, comparing the financial data of banks can be difficult because of the different sizes of banks, balance sheet compositions, etc. As such, an enhanced prudential measure is necessary that can not only alert the Central Bank about the appearance of indicators that surpass the regulatory norm, but also provide a quantitative measure of the degree to which the

admissible values have been surpassed. These enhanced prudential indices render possible a comparison of the bank's financial health and can be used as an early-warning system that alerts the regulator about the moment when the bank is about to default.

In this section, I propose the construction of three aggregate (or complex) indices that measure the financial health of banks according to their prudential indicators. The advantage of these constructed indices is that they utilize the existing data series of the prudential indicators and can be configured in accordance with the importance of each prudential measure in determining the default-risk of financial institutions. This makes the indices easy to construct for regulatory authorities and does not increase the intrusion level into banking data.

The first index that I construct is geared towards comparing the financial health of multiple institutions. Its objective is to provide a dynamic overview of the financial health of banks so as to allow the regulator to see the changes that occur in time. Each prudential indicator that is to be included in the index is assigned a "component contribution" that depends on the: 1. boundary value set by the regulatory norm, 2. whether the boundary value is a maximum or minimum admissible value, and 3. the indicator value for certain default (we expect that if the prudential indicator takes this value than the bank is guaranteed to default).

The component contribution of each prudential indicator to the Comparison Index is constructed in the following way:

$$C.PI_t = D * (PI_t - N)/(N - MV * N) \quad (26)$$

where "C.PI" is the component contribution of the prudential indicator to the comparison index, D – a discrete variable indicating whether the boundary value is a maximum or minimum admissible value, PI – the value of the prudential indicator at time "t", "N" – the normative maximum or minimum admissible value of the indicator, "MV" – the indicator value for certain default, "t" – the time period.

$$D = \begin{cases} 1, & \text{if } N \text{ is a minimum boundary value} \\ -1, & \text{if } N \text{ is a maximum admissible value} \end{cases} \quad (27)$$

The "indicator value for certain default" is expressed as a multiplier. For instance, if it takes the value 2 and the maximum admissible value of the prudential indicator is 16 → then we

expect that if the indicator reaches a value of $2 * 16 = 32$, the bank is guaranteed to instantly default.

The comparison index itself is constructed as an average of the component contributions:

$$Ind.Comp_t = \sum_{ind=1}^i C.PI_{ind,t} / i \quad (28)$$

where “Ind.Comp” is the comparison index, “ $C.PI_{ind,t}$ ” is the component contribution of prudential indicator “ind” at time “t”, “i” is the number of component contributions corresponding to prudential indicators.

After multiple simulations, I have found the comparison indicator to vary across the range [-2; 2], but it may take higher values than 2 when the bank defaults in the next period. However, for reasons of graphical representation, it helps to bind the indicator at a maximum value of 2 at which point the bank is guaranteed to default.

The resulting index is presented in Table 4.4 which summarizes the index value for each bank and at each time period of the simulation discussed in the previous sections.

Table 4.4. Comparison Index

Time	Bk 1	Bk 2	Bk 3	Bk 4	Bk 5	Bk 6	Bk 7	Bk 8	Bk 9	Bk 10	Bk 11	Bk 12
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221	-0.39221
3	-0.45111	-0.46609	-0.46609	-0.37213	-0.24558	-0.41313	-0.44287	-0.31114	-0.33986	-0.42923	-0.37973	-0.3788
4	-0.4981	-0.55898	-0.55898	-0.34689	-0.29147	-0.31423	-0.30064	-0.3817	-0.27528	-0.31782	-0.37364	-0.44324
5	-0.52232	-0.6255	-0.6255	-0.35553	-0.26261	-0.31555	-0.30665	-0.33814	-0.34269	-0.33309	-0.28144	-0.23624
6	-0.37661	-0.55883	-0.55968	-0.32702	-0.2959	-0.29793	-0.37165	-0.31339	-0.39329	-0.35734	-0.27747	-0.24013
7	-0.39804	-0.53579	-0.4248	-0.38978	-0.2814	-0.30094	-0.38636	-0.29803	-0.37327	-0.3485	-0.33109	-0.21579
8	-0.37262	-0.53355	-0.37276	-0.4163	-0.25933	-0.33533	-0.38158	-0.3086	-0.3528	-0.32363	-0.37106	-0.25473
9	-0.22847	-0.41874	-0.35635	-0.32785	-0.25369	-0.34335	-0.40737	-0.26182	-0.28725	-0.25461	-0.30521	-0.25351
10	-0.17521	-0.14111	-0.33913	-0.30899	-0.22995	-0.29769	-0.32396	-0.26109	-0.29911	-0.36645	-0.29016	-0.26668
11	0.132202	0.152455	-0.35364	-0.41156	-0.22459	-0.3047	-0.27467	-0.2674	-0.3387	-0.42215	-0.26652	-0.28074
12	0.436126	0.46149	-0.34993	-0.37444	-0.23362	-0.28399	-0.24065	-0.38844	-0.41368	-0.43992	-0.38067	-0.25459
13	0.707092	0.598641	-0.12649	-0.38339	-0.29316	-0.304	-0.25716	-0.40664	-0.38542	-0.33905	-0.46026	-0.22991
14	0.747621	0.725351	0.174574	-0.32938	-0.43936	-0.37685	-0.46112	-0.54043	-0.52081	-0.29754	-0.46696	-0.22848
15	0.980526	0.875069	0.39238	-0.57396	-0.49658	-0.56791	-0.47755	-0.47918	-0.42682	-0.4216	-0.68956	-0.39547
16	1.214974	0.859664	0.437933	-0.59011	-0.56674	-0.64854	-0.52222	-0.54799	-0.44173	-0.55139	-0.75759	-0.55591
17	1.202071	0.846624	0.441666	-0.62159	-0.6289	-0.70804	-0.60046	-0.68752	-0.4726	-0.55774	-0.80946	-0.6978
18	1.389698	0.902005	0.476896	-0.70086	-0.67994	-0.74796	-0.55642	-0.69736	-0.48075	-0.63531	-0.83265	-0.75498
19	1.488511	0.966138	0.583645	-0.65936	-0.72348	-0.7037	-0.48711	-0.61418	-0.62386	-0.60559	-0.70228	-0.73376
20	1.579326	1.021075	0.598729	-0.53416	-0.58772	-0.59238	-0.41895	-0.5498	-0.51901	-0.53902	-0.57659	-0.62856
21	2	2	0.629539	-0.53062	-0.50913	-0.55448	-0.28916	-0.51655	-0.55302	-0.4974	-0.51029	-0.57401

Table 4.4 presents the values of the comparison index for all banks at each period of the simulation. *Positive (and higher) values indicate that the bank's financial situation is unsatisfactory. Negative (and lower) values indicate that the bank's financial situation is satisfactory. A value of "2" (or above) means that the bank defaults in the next period.*

As we can see from Table 4.4, the financial health of the three controlled banks starts to be significantly worse than that of the other banks in the economy at period 10. The bank that is first to have indicators that surpass the norm is in better financial standing than the others largely because it only engages in foreign deposits and does not directly credit controlled firms. Its prudential indicators degrade early, but only slightly. This is reflected by the comparison index. The other two controlled banks have much graver and rapid degradations of the index, which is indicative of the crediting activity through which they issue NPLs. The index also allows us to see the effects of the initial liquidity hoarding that the three banks engaged in. Indeed, we notice a conspicuous improvement of the index values of the three controlled banks at the beginning of the simulation, when the other banks are in worse condition.

The advantages of this indicator are that it allows us to compare the financial standing of banks. It shows which banks are the healthiest and which ones are riskiest from the perspective of their prudential indicators. Furthermore, the index allows us to see the global health of a bank despite minor, temporary surpassings. For instance, bank 7 at period $t = 21$ has one surpassed prudential indicator, but the indicator's value only exceeds the regulatory norm by very little. As a consequence, the value of the index remains negative to indicate that, overall, the bank's financial standing is not bad.

A disadvantage of the indicator is that because of the volume of data that it presents, it does not allow the regulator to immediately spot those banks which have surpassed prudential indicators and dissociate them from those which have no issues.

To provide the regulator with a measure that offers a global view of the financial sector and immediately signals out the ailing banks, I construct the Distress Index. It is similar in nature to the comparison index, but has a few modifications. Whereas, the construction of the index itself remains unchanged, the component contributions of the prudential indicators are modified. The component contribution now takes the value:

$$C.PI_t = \begin{cases} D * \frac{PI_t - N}{N - MV * N}, & \text{if } D * \frac{PI_t - N}{N - MV * N} > 0 \\ 0 & , \text{if } D * \frac{PI_t - N}{N - MV * N} < 0 \end{cases} \quad (29)$$

where “C.PI” is the component contribution of the prudential indicator to the distress index, D – a discrete variable indicating whether the boundary value is a maximum or minimum admissible value, PI – the value of the prudential indicator at time “t”, “N” – the normative maximum or minimum admissible value of the indicator, “MV” – the indicator value for certain default, “t” – the time period.

$$Ind.Dist_t = \sum_{ind=1}^i C.PI_{ind,t} / i \quad (30)$$

where “Ind.Dist” is the distress index, “C.PI_{ind,t}” is the component contribution of prudential indicator “ind” at time “t”, “i” is the number of component contributions corresponding to prudential indicators.

Table 4.5. Distress Index

time	Bk 1	Bk 2	Bk 3	Bk 4	Bk 5	Bk 6	Bk 7	Bk 8	Bk 9	Bk 10	Bk 11	Bk 12
1	-	-	-	-	-	-	-	-	-	-	-	-
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0.018636	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0.005295	0	0	0	0	0	0	0	0	0.002563
8	0	0	0.026435	0	0	0	0	0	0	0	0	0
9	0	0	0.037596	0	0	0	0	0	0	0	0	0
10	0.019076	0.0129	0.048055	0	0	0	0	0	0	0	0	0
11	0.318785	0.250602	0.051688	0	0.00314	0	0	0	0	0	0	0
12	0.531076	0.490813	0.062971	0	0.006042	0	0.001038	0	0	0	0	0
13	0.770839	0.633737	0.191561	0	0	0	0.001884	0	0	0	0	0.003096
14	0.795672	0.765681	0.427793	0	0	0	0	0	0	0	0	0.003903
15	1.010309	0.920771	0.640574	0	0	0	0	0	0	0	0	0
16	1.214974	0.911044	0.660258	0	0	0	0	0	0	0	0	0
17	1.206255	0.903554	0.686929	0	0	0	0	0	0	0	0	0
18	1.389698	0.961101	0.743316	0	0	0	0	0	0	0	0	0
19	1.488511	1.02735	0.820324	0	0	0	0	0	0	0	0	0
20	1.579326	1.085315	0.859655	0	0	0	0	0	0	0	0	0
21	2	2	0.913916	0	0	0	0.019002	0	0	0	0	0

Table 4.5 presents the values of the distress index for all banks at each period of the simulation. Higher values indicate that the bank’s financial situation is worse. Lower values

indicate a better financial standing. A value of “0” indicates that the bank has no indicators that exceed the prudential norm. A value of “2” (or above) means that the bank defaults in the next period.

By assigning a null value when the component contribution is negative, we obtain a dataset in which only the positive component contributions (or surpassed prudential indicators) are visible in the index. The advantages of this approach are that: 1. the index shows non-null values only for those banks that have indicators above or below the allowed limits, thereby reducing the amount of noise and facilitating the Central Bank’s task of detecting ailing institutions; 2. it shows whether the indicators have moved very far away from the maximum or minimum allowed levels or whether they have barely surpassed the limits. For instance, in Table 4.5 that presents the calculated values of the index, Bank 12 has two surpassed indicators, but they have surpassed the allowed level by very little. As a result, the distress index is very small.

The disadvantage of this method is that it is now only possible to compare the situation of banks with surpassed indicators. The index no longer provides information about how healthy a bank is, if it has no surpassed indicators.

The final index that I construct is a simple weighted average of the indicator-to-norm ratios of the prudential indicators. The goal is to show that even a very simple construct can provide meaningful information about the financial landscape and can help the Central Bank to make more informed decisions. Within this index, I also show how it is possible to prioritize prudential indicators by assigning higher weights to those that are more indicative of the risk being studied (i.e. the risk of default). Similarly to the other indices, the Simple Index is constructed from the component contributions of each prudential indicator, and, in the case of this index, each contribution is weighted according to its importance.

$$C.PI_t = \frac{W}{\sum_{ind=1}^i W_{ind}} * \left(\frac{PI_t}{N} \right)^{-D} \quad (31)$$

where “C.PI” is the component contribution of the prudential indicator to the simple index, D – a discrete variable indicating whether the boundary value is a maximum or minimum admissible value, PI – the value of the prudential indicator at time “t”, “N” – the normative maximum or minimum admissible value of the indicator, “W” – the weight of the indicator, “i” – the number of indicators, “t” – the time period.

$$Ind.Smpl_t = \sum_{ind=1}^i C.PI_{ind,t} \quad (32)$$

where “Ind.Smpl” is the simple index, “ $C.PI_{ind,t}$ ” is the component contribution of prudential indicator “ind” at time “t”, “i” is the number of component contributions corresponding to prudential indicators.

The value of this index is not capped, but in practice, any value that grows disproportionately larger from one time period to another indicates that the bank is bound to default.

Table 4.6. Simple Index

time	Bk 1	Bk 2	Bk 3	Bk 4	Bk 5	Bk 6	Bk 7	Bk 8	Bk 9	Bk 10	Bk 11	Bk 12
1	-	-	-	-	-	-	-	-	-	-	-	-
2	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745	0.618745
3	0.56986	0.566602	0.566602	0.634871	0.757875	0.602614	0.585631	0.695798	0.673107	0.591073	0.628543	0.629308
4	0.529917	0.515952	0.515952	0.668319	0.712253	0.695017	0.708124	0.649441	0.728783	0.693081	0.636073	0.58257
5	0.508754	0.485245	0.485245	0.67218	0.739279	0.69836	0.705406	0.688308	0.678131	0.686653	0.722534	0.764254
6	0.641536	0.574512	0.557877	0.692296	0.711785	0.712289	0.662412	0.705964	0.647021	0.671641	0.726302	0.760545
7	0.627257	0.572191	0.697457	0.65369	0.724179	0.711024	0.654897	0.717919	0.660654	0.678697	0.68593	0.784223
8	0.655038	0.58577	0.771947	0.638647	0.742887	0.686764	0.657934	0.710597	0.673863	0.695538	0.659286	0.747891
9	0.78493	0.666774	0.815217	0.693229	0.747941	0.681545	0.642702	0.745341	0.720773	0.74861	0.705146	0.74902
10	0.836913	0.874413	0.860163	0.70655	0.77008	0.713671	0.69649	0.746003	0.711518	0.667103	0.716949	0.737918
11	1.155156	1.158152	0.874406	0.640453	0.775473	0.709717	0.73302	0.740779	0.683728	0.634834	0.736545	0.726531
12	1.478988	1.535613	0.906605	0.663839	0.767215	0.725457	0.761411	0.659926	0.638459	0.627032	0.652257	0.747905
13	1.817354	1.67856	1.087632	0.65838	0.715866	0.709545	0.748155	0.651462	0.657028	0.687217	0.606937	0.770784
14	1.863699	1.81198	1.384802	0.694374	0.591248	0.662077	0.578246	0.53134	0.543829	0.716453	0.605222	0.772211
15	2.149314	1.976708	1.668753	0.512149	0.553882	0.517309	0.570507	0.564632	0.600317	0.601111	0.459643	0.643921
16	2.752934	1.939525	1.713825	0.505681	0.516309	0.479351	0.541625	0.528042	0.586832	0.523977	0.43246	0.520319
17	2.556924	1.913191	1.745009	0.490911	0.486468	0.454529	0.501814	0.462515	0.568975	0.521156	0.413784	0.455046
18	3.007287	1.979899	1.824258	0.456585	0.465445	0.438956	0.526992	0.458545	0.564644	0.485143	0.406126	0.433217
19	3.051114	2.059121	1.961112	0.476988	0.447173	0.45752	0.564949	0.495267	0.489004	0.499415	0.456841	0.441579
20	3.090327	2.128846	2.018535	0.539724	0.509034	0.510555	0.609774	0.530038	0.543996	0.535848	0.515038	0.487235
21	41.57908	3.612889	2.101036	0.541947	0.551903	0.532559	0.712713	0.548874	0.526002	0.559761	0.551788	0.514446

Table 4.6 presents the values of the simple index for all banks at each period of the simulation. Values greater than “1” indicate that the bank’s financial situation is bad. Values lower than “1” indicate a good financial standing. More generally, the higher the value of the index, the worse is the bank’s compliance with the prudential norm. All prudential indicators are equally weighted.

Table 4.6 provides an alternative construction that allows the regulator to compare the financial health of institutions, determine the extent of the non-conformity of prudential

indicators (or by how much they have surpassed the regulatory norm) and allows the resulting index to be weighted according to the importance given to individual prudential indicators. In absence of any information regarding the comparative pertinence of each indicator in the Moldovan Central Bank's decision criteria, the weights have been left equal for the purposes of this simulation. Since the indicator has not been capped, we can see the comparative situation of the three banks, one of which is in the worst shape because of the volume of NPLs issued by the bank.

The indices that I have constructed are simple examples of how the Central Bank can aggregate information to compare the individual state of each bank and make more informed decisions regarding intervention. Even if the Central Bank wishes to be very cautious, the aggregate prudential indices that have been constructed clearly indicate that after period 11 something is amiss with 2 banks. After period 13, the third bank can be safely considered to be part of the scheme. None of the other financial institutions that showed signs of temporary degradation of their prudential indicators ever came close to the values reported by the controlled banks. As such, usage of the aggregate indices can be beneficial in providing a comparative overview of the financial system and in ensuring informed and timely regulatory decision-making.

4. Concluding Remarks

The Moldovan banking sector fraud that led to the collapse of three of the country's banks highlighted the inadequacy of the Central Bank's response to the crisis. The regulatory institution was accused of having a policy of non-interventionism that led to significant losses and a perpetration of the fraud schemes for a long period of time. Within an agent based simulation, this paper reconstructed the environment and conditions in which the events took place, as well as the specific fraud schemes that were used. The results show that whereas early intervention by the Central Bank would have been suboptimal and may have led to higher losses for the financial sector, the regulatory institution did have an opportunity to intervene when the exposure of non-controlled financial institutions towards controlled banks was reduced. The Central Bank, however, failed to seize this opportunity. This may have occurred for a number of different reasons, one of which is the lack of adequate measures that both provide an overview of the financial sector and allow the regulator to compare the financial state of banks both dynamically (by looking at the bank's performance in time) and across the financial sector (by comparing each bank to the rest of the sector). The paper

proposes three composite indices that better reflect the general “health” of the financial institution, or, in other words, the conformity of the bank to the prudential norms set forth by the regulator. By using these indices, the Central Bank can obtain a clearer view of the evolutions within the financial sector and can base its decisions on whether or not to intervene on the index values. Usage of the indices helps to alleviate the institution’s uncertainty with regard to action, and may in the future provide the foundation for automatic intervention rules at distressed financial institutions.

CONCLUSION GENERALE

Dans le cadre de cette thèse, j'ai étudié l'impact de la supervision prudentielle sur la stabilité du système bancaire, les indicateurs financiers des banques, mais aussi son impact sur l'économie, plus globalement, à travers une étude des effets macroéconomiques de la supervision sur le crédit domestique. La thèse a été structurée en trois chapitres.

Dans le premier chapitre, qui étudie empiriquement l'impact de la supervision prudentielle sur le crédit domestique, je trouve que la supervision prudentielle peut avoir un impact positif en termes de croissance du crédit. Cette relation positive est importante car elle s'inscrit dans une littérature très récente qui vise à prouver que les outils prudentiels dont l'objectif est de limiter le risque encouru par les institutions financières ne doivent pas forcément passer par un canal de restriction du crédit pour produire l'effet attendu. Dans le cas de la supervision prudentielle, l'effet positif sur le crédit passe par un mécanisme de signalisation. Une réglementation prudentielle plus complète prenant la forme d'une rigueur accrue de la supervision du système bancaire constitue un signal qui indique aux créiteurs et aux déposants que l'environnement des affaires est plus sûr et, donc, propice à générer un crédit et une croissance plus élevés. Cependant, comme le souligne la littérature, cet effet est seulement applicable aux économies avancées avec des marchés compétitifs et des institutions financières développées. Effectivement, on voit que dans les pays avec des fondements de marché plus faibles, ou qui passent par une transition d'un système réglementaire avec un seul superviseur vers un modèle de supervision unifié, il y a seulement un effet faible, ou bien un effet restrictif, d'une hausse de la rigueur de la supervision sur le crédit. Toutefois, la transition vers des formes plus courantes de réglementation prudentielle dans lesquelles soit la Banque Centrale est activement impliquée dans les activités prudentielles, ou bien il y a une consolidation des objectifs prudentiels dans une seule institution superviseuse, indique qu'une hausse de la rigueur de la supervision prudentielle est attendue, ce qui à travers un effet de signalement de la sûreté et solidité du système bancaire du pays, entraînera des effets positifs sur le crédit.

Suite à cette analyse, je trouve que la volonté de mettre en œuvre un Système de Supervision Unifié au niveau européen, suivant le modèle réglementaire unifié qui consiste à avoir une Banque Centrale qui exerce une influence significative sur la supervision prudentielle, semblerait être une décision correcte car c'est notamment ce type de système réglementaire qui est le plus performant en termes d'effets de la supervision sur le crédit. De plus, à long

terme, les pays de l'Union Européenne qui n'ont pas encore évolué vers un tel système pourraient être encouragés à le faire par la perspective de gains en termes de croissance du crédit issus de la consolidation et du renfort des pratiques prudentielles.

Dans le deuxième chapitre, j'étudie théoriquement dans quelle mesure la stabilité et la rentabilité des banques dans des conditions de crise de long terme peut être assurée à travers la réglementation prudentielle sous forme de supervision couplée avec trois outils réglementaires « traditionnels » : une norme, un marché d'assurances et un mécanisme de type « bail-in » prenant la forme d'une taxe sur les clients de la banque en cas de détresse de l'institution financière. En prenant comme donnée l'hypothèse du contrôle coûteux²⁸ (hypothèse qui a été à la fois stipulée théoriquement et vérifiée empiriquement), j'ai placé la banque dans un environnement d'asymétrie informationnelle élevée où ses capacités à contrôler ses clients étaient limitées par la difficulté d'obtenir l'information les concernant. Ensuite, cette contrainte a été relâchée afin de créer un environnement avec plus de transparence de marché. Dans ces nouvelles circonstances, la situation financière de la banque s'est améliorée grâce à un accès plus large de la banque à l'information concernant ces clients, ce qui lui a permis d'entreprendre des stratégies plus efficaces de contrôle. Malgré cette amélioration, en absence d'intervention réglementaire, la banque tombe toujours dans une situation de faillite au bout d'un nombre de périodes après le déclenchement de la crise. Ainsi, afin d'assurer la solvabilité de la banque, il faut utiliser un instrument prudentiel couplé avec la supervision. Le premier instrument est une norme qui oblige la banque à contrôler une proportion fixe de ces clients. Dans les premières périodes suivant le déclenchement de la crise il semblerait que la situation financière de la banque se stabilise, mais cet effet positif s'accompagne d'un rationnement de crédit croissant observé tout au long de la phase de stabilité. Effectivement, lorsque le rationnement de crédit atteint un niveau critique, la banque ne peut plus tenir et fait faillite. Ainsi ses réserves de liquidités deviennent négatives (ce qui correspond à un emprunt de dernier ressort sur le marché interbancaire ou à une injection de liquidités de la part de la Banque Centrale) et se situent sur une trajectoire qui tend vers l'infini négatif (ce qui indique que la banque ne peut plus

²⁸ hypothèse qui suppose qu'en présence d'asymétries informationnelles concernant la qualité d'un projet d'investissement présenté à la banque dans le but d'obtenir un financement, la banque peut se protéger contre le risque de faillite en contrôlant le client. Pourtant, le contrôle est une opération qui nécessite un effort significatif de la part de la banque et s'avère, ainsi, coûteux. A cause des coûts de contrôle élevés que les banques doivent souvent supporter, des travaux comme Williamson (1986) stipulent qu'il est optimal pour la banque de contrôler uniquement lorsque la probabilité de défaut du client est suffisamment grande.

opérer de manière autonome sans un soutien financier constant du régulateur). Cet état des choses rend impossible le sauvetage de la banque. La variation du degré d'asymétries informationnelles sert uniquement à modifier la durée de survie de la banque, mais pas la finalité. Ainsi, un environnement d'asymétries plus faibles réussit seulement à repousser, mais pas à éviter la faillite de la banque. Le deuxième outil étudié est un marché d'assurances qui permet à la banque d'acheter des unités d'assurance afin de se protéger contre le risque de faillite de ses clients, auprès d'un assureur indépendant. Introduit sans supervision, le marché s'effondre laissant derrière soi non seulement une banque en faillite, mais aussi un assureur en banqueroute qui doit lui-aussi être sauvé. Lorsque le marché est introduit en présence de supervision du régulateur, et que le régulateur est activement engagé dans l'optimisation des actions des intervenants sur le marché des assurances, il y a une stabilisation sur le marché. Lorsque les asymétries informationnelles sont significatives, l'assureur n'arrive pas à compenser les pertes générées par les inefficiences du contrôle bancaire – ce qui conduit systématiquement à la survie seulement de l'assureur. Lorsque l'accès à l'information est amélioré, la banque arrive à faire bon usage de l'instrument supplémentaire dont elle dispose afin de gérer de manière efficace le risque encouru. Effectivement, dans un environnement de transparence, le marché d'assurances produit un résultat meilleur que la norme. Le dernier instrument étudié est un instrument fondé sur le principe de la taxation et suivant le principe du « bail-in ». Dans ce cadre, le régulateur introduit une taxe sur le profit des clients de la banque, lorsque leur créancier rencontre des difficultés financières. Ici, la puissance de la taxe est clairement visible. L'instrument produit des résultats exceptionnels en présence d'asymétries informationnelles faibles et se montre efficace même dans des environnements d'asymétrie accrue. Dans le cas des asymétries faibles, l'instrument de taxation réussit à protéger la banque pendant un temps suffisamment long, ce qui permet à la banque de s'adapter à l'environnement de crise de long terme et de continuer à dérouler une activité profitable sans avoir besoin d'interventions du régulateur. Pour résumer, cette étude a montré que les instruments comme les normes réglementaires peuvent produire des résultats stabilisateurs de court terme, mais avec des conséquences négatives en termes de rationnement du crédit. En même temps, les instruments de marché sont très dépendants des conditions de marché, des cadres réglementaires et de la présence de la supervision. Ainsi, le plus puissant instrument présent dans l'arsenal du régulateur est la taxe qui arrive à produire une amélioration dans des conditions de faibles, comme de fortes asymétries informationnelles. Elle a aussi ses faiblesses spécifiques car elle induit des fluctuations plus fréquentes de l'instrument réglementaire lorsque le régulateur ajuste l'outil à l'environnement

financier qui se trouve en constante évolution. En même temps, l'aspect « bail-in » de l'instrument pose la question de la légitimité de la décision du régulateur de sacrifier la profitabilité du secteur productif dans le but de sauver les institutions financières, en particulier, lorsque ce sont les entreprises du secteur productif qui bénéficient de l'activité bancaire.

Dans le troisième chapitre, j'effectue une analyse des schémas de fraude utilisés pour commettre un détournement massif de fonds dans le secteur bancaire Moldave qui s'est déroulé en 2011. L'inaction de la Banque Centrale fut présentée par les médias comme l'un des principaux facteurs qui ont rendu possible le déroulement des opérations financières frauduleuses qui, à leur tour, ont entraîné la faillite de trois banques majeures et ont plongé le pays dans la crise. Je propose une analyse détaillée du système de fraude qui a été utilisé pour détourner les fonds des trois banques. Ensuite, je crée une simulation multi-agent du système bancaire qui reproduit l'environnement pré-crise et les schémas de fraude afin de déterminer si l'intervention de la Banque Centrale aurait pu limiter les dégâts et ainsi prévenir la crise. Les résultats montrent que l'intervention précoce aurait été sous-optimale et aurait pu conduire à des pertes plus importantes pour le secteur financier. Une intervention dans les premiers mois suivant la détection de la fraude par la Banque Centrale aurait minimisé les pertes pour les trois banques impliquées dans la fraude, mais pas pour l'ensemble du secteur financier car au cours du temps, le montant des fonds détournés ne cesse pas d'augmenter, alors que l'exposition sur le marché interbancaire des banques non impliquées dans les schémas vis-à-vis des institutions bancaires participant dans la fraude varie. En même temps, la non-intervention, ou bien, une intervention tardive, auraient conduit aux pertes moins grandes pour l'ensemble des banques, mais néanmoins graves (comme ce fut le cas en réalité, la Banque Centrale ayant choisi de ne pas intervenir). En effet, le régulateur a eu l'opportunité d'intervenir au moment où l'exposition des institutions financières non-impliquées dans le contournement des fonds vis-à-vis des institutions participantes dans les schémas de fraude était minimum. Une intervention à cette étape aurait minimisé les pertes du secteur financier (mais pas celles des banques impliquées dans les schémas). Cependant, la Banque Centrale a raté cette opportunité. Les raisons de cette défaillance de la Banque Centrale peuvent être diverses, l'un des principaux étant l'absence de mesures adéquates qui pourraient fournir au régulateur un panorama du secteur financier, et, en même temps, lui permettre de comparer l'état financier des institutions bancaires à la fois en dynamique (en comparant les performances des banques à travers le temps), ainsi qu'à travers le secteur

financier (en comparant l'état de chaque banque au reste du secteur). Afin de remplir cette lacune, je propose trois indices synthétiques qui permettent de mieux refléter la « santé » générale des institutions financières, et notamment, leur conformité aux normes prudentielles établies par le régulateur. En utilisant ces indices, la Banque Centrale peut obtenir un meilleur aperçu des évolutions dans le cadre du secteur financier et, ainsi, peut, sur la base des valeurs prises par les indices synthétiques, mieux justifier ces décisions d'intervention (ou de non-intervention). L'utilisation de ces indices permet de diminuer l'incertitude à laquelle se confronte l'institution réglementaire dans son processus de prise de décision et pourrait constituer, dans l'avenir, une composante-clé dans la construction des règles d'intervention automatique pour sauver les banques en détresse.

Dans le cadre de cette thèse, j'ai intégré l'hétérogénéité des systèmes et des agents dans l'analyse de la supervision prudentielle à travers l'utilisation des régressions économétriques bayésiennes et de la modélisation multi-agent. L'utilisation de ces méthodes m'a permis d'investiguer des problématiques macro-économiques partant du niveau micro de l'agent, de ses objectifs et de ses comportements. Ainsi, j'ai pu voir émerger des caractéristiques systémiques et des évolutions de la supervision prudentielle issues de la diversité des agents et de leurs actions. Ceci a enrichi le cadre d'analyse et a permis de créer des modèles dont le fonctionnement et les caractéristiques sont plus proches de celles de la réalité.

La recherche dans le domaine de la supervision prudentielle restera un domaine prioritaire dans les prochaines années qui verront la mise en œuvre intégrale de la réglementation prudentielle du cadre Bale III. En 2016, quand cette thèse a été écrite, aux Etats-Unis le domaine de la réglementation du secteur bancaire constitue un sujet électoral controversé où les deux candidats ont des visions très différentes sur l'avenir de la réglementation et de la supervision prudentielle – l'un étant en faveur d'un élargissement significatif de leur portée et dureté, alors que l'autre, au contraire promet de les réduire et de les rendre plus laxistes. Ainsi, une extension de la recherche effectuée dans le cadre de cette thèse pourrait se faire dans le domaine de l'impact de la supervision sur les notations des banques. Il est important de savoir si une réglementation plus dure (ou plus complète), peut produire des résultats positifs en terme de notations. Si c'est effectivement le cas, alors l'argument en faveur de la déréglementation perdrait du terrain dans le débat. En même temps, en Europe, l'année 2016 s'est avérée également tumultueuse, avec le vote historique des britanniques en faveur de la sortie du Royaume Uni de l'Union Européenne. L'un des arguments majeurs des adeptes de la sortie était la compétitivité du pays dans un cadre concurrentiel de plus en plus acerbé et en

présence d'une unification supranationale de la supervision et de la réglementation prudentielle. Ainsi, une piste de recherche qui pourrait être développée serait d'investiguer les effets des changements de la dureté de la supervision prudentielle dans un pays sur sa compétitivité et sur celle de ses voisins régionaux et de ses partenaires commerciaux internationaux. Des variables explicatives d'intérêt seraient : le montant d'investissements (IDEs et investissements de portefeuille), les flux de capitaux (entrants et sortants), la mobilité des entreprises (délocalisations, changements de siège social, fusions et acquisitions, etc.), mais aussi le volume du commerce et les rémittences. L'idée derrière la sortie du Royaume Uni de l'Union Européenne est qu'en présence d'un accord commercial permettant au pays de jouir des mêmes facilités en termes de commerce et mobilité des capitaux, couplée avec une réglementation prudentielle moins dure et détachée de celle européenne, le pays pourrait aboutir à une hausse de sa compétitivité. Ainsi, une confirmation des potentiels coûts de la réglementation en termes de compétitivité régionale ou internationale pourrait conduire à un ralentissement des efforts d'élargissement du cadre réglementaire qui sont aujourd'hui en cours en Europe. On remarque, donc, que le débat sur la réglementation et la supervision prudentielle est loin d'être fini, une recherche plus profonde de leurs impacts et des effets secondaires potentiels étant nécessaires pour assurer l'évolution future optimale de la régulation du système bancaire.

BIBLIOGRAPHIE

Acharya, V. and Merrouche, O. (2012). Precautionary Hoarding of Liquidity and Interbank Markets: Evidence from the Subprime Crisis, *Review of Finance* (2013) 17 (1): 107-160.

Agénor, P.R. and da Silva, L.A.P. (2014). Macroprudential regulation and the monetary transmission mechanism. *Journal of Financial Stability*, 13, pp.44-63.

Allen, F., Carletti, E. and Gale, D. (2009). Interbank market liquidity and central bank intervention. *Journal of Monetary Economics*, 56(5), pp.639-652.

Angelini, P., Neri, S. and Panetta, F. (2011). Monetary and macroprudential policies. Bank of Italy Temi di Discussione (Working Paper) No, 801.

Angkinand, A. and Wihlborg, C. (2005). Deposit insurance coverage, credibility of non-insurance and banking crisis. Center for Law, Economics and Financial Institutions at CBS (LEFIC), Copenhagen Business School, Working Paper, (2005-010).

Baltagi, B. H. and Kao, C. (2000). Nonstationary panels, cointegration in panels and dynamic panels: a survey. *Advances in Econometrics* 15, 7–51.

Baltagi, B. H., Bresson, G. and Pirotte, A. (2008). To pool or not to pool? in *The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*, in: L. Mátyás and P. Sevestre (eds.), Series: Advanced Studies in Theoretical and Applied Econometrics 33. Springer-Verlag, New York.

Baltagi, B. H., Bresson, G., Griffin, J. M. and Pirotte, A. (2003). Homogeneous, heterogeneous or shrinkage estimators? Some empirical evidence from French regional gasoline consumption, *Empirical Economics*, 28, pages 795-811.

Bank of Greece. (2014). Banking Supervision and Supervision of Private Insurance.

Barnett, K. and Harder, S. (2014). Remedies in Australian Private Law. Cambridge University Press. pp.99-127.

Barth, J., Caprio, G. and Levine, R. (2013). Bank regulation and supervision in 180 countries from 1999 to 2011, *Journal of Financial Economic Policy*, Emerald Group Publishing, vol. 5(2), pages 111-219, April.

Bassett, W. F., Lee, S. J. and Spiller, T. W. (2012). Estimating changes in supervisory standards and their economic effects. Federal Reserve Board, Finance and Economics Discussion Series (FEDS).

Baxter, N. D. (1967). Leverage, risk of ruin and the cost of capital. *The Journal of Finance*, 22(3), September, pp.395-403.

Bekaert, G., Ehrmann, M., Fratzscher, M. and Mehl, A.J. (2011). Global crises and equity market contagion, ECB Working Paper No. 1381. Macprudential Research Network, European Central Bank.

Benigno, G., Chen, H., Otrok, C., Rebucci, A. and Young, E. (2012). Financial crises and macro-prudential policies, *Journal of International Economics*, 89 (2), pp. 453-470.

Bernanke, B., Gertler, M. and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework, in: J. B. Taylor & M. Woodford (ed.), *Handbook of Macroeconomics*, edition 1, volume 1, chapter 21, pp. 1341-1393, Elsevier.

Black, F. and Scholes, M. (1973). The pricing of options and corporate liabilities, *Journal of Political Economy* Vol. 81, No. 3 (May - Jun., 1973), pp.637-654.

Bolton, R.J. and Hand, D.J. (2002). Statistical fraud detection: A review. *Statistical science*, pp.235-249.

Booth, J. R. (1992). Contract costs, bank loans, and the cross-monitoring hypothesis. *Journal of Financial Economics*, 31(1), pp.25-41.

CA Technologies (2014). Project Risk Score Calculation. CA Clarity PPM Cookbook.

Cashin, P. A. and Duttagupta, R. (2008). The anatomy of banking crises. IMF Working Papers, pp.1-37.

Chortareas, G. E., Girardone, C. and Ventouri, A. (2012). Bank supervision, regulation, and efficiency: Evidence from the European Union, *Journal of Financial Stability*, Volume 8, Issue 4, pages 292-302, December.

Čihák, M. and Podpiera, R. (2008). Integrated financial supervision: Which model?. *The North American Journal of Economics and Finance*, 19(2), pp.135-152.

Coase, R. H. (1960). The problem of social cost. *Journal of Law and Economics* 3, pp.1-43.

Dalla Pellegrina, L., Masciandaro, D. and Pansini, R.V. (2013). The central banker as prudential supervisor: Does independence matter?. *Journal of Financial Stability*, 9(3), pp.415-427.

Delis, M. D. and Staikouras, P. K. (2011). Supervisory Effectiveness and Bank Risk, *Review of Finance* (2011), vol. 15(3), pp.511-543.

Deloitte (2014). 2014 global survey on reputation risk. Deloitte Touche Tohmatsu, United Kingdom. October.

DeWalque, G., Pierrard, O. and Rouabah, A. (2010). Financial (In)Stability, Supervision and Liquidity Injections: A Dynamic General Equilibrium Approach, *Economic Journal*, Royal Economic Society, vol. 120(549), pages 1234-1261, December.

Di Giorgio, G., Di Noia, C. and Piatti, L. (2000). Financial market regulation: the case of Italy and a proposal for the euro area.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The Review of Economic Studies*, 51(3), pp.393-414.

Diamond, D.W. and Rajan, R.G. (2002). Bank bailouts and aggregate liquidity. *The American Economic Review*, 92(2), pp.38-41.

Dickson, J. and Einstein, A. (2010). On measures for illustrating credit risk assessments: the case of heat maps, risk matrices and cubes. *IFC Bulletin*, 25, 365.

EBA. (2014). Supervisory Convergence (<http://www.eba.europa.eu/supervisory-convergence>). Last accessed: 07.11.2014.

ECB. (2014). List of Supervised Entities Notified of the ECB's Intention to Consider them Significant (<http://www.ecb.europa.eu/ssm/pdf/SSM-listofdirectlysupervisedinstitutions.en.pdf>). Last accessed: 05.07.2014.

ECB. (2014). Survey on the access to finance of small and medium-sized enterprises in the Euro Area, ISSN 831-9998.

ECB. (2014). The Single Supervisory Mechanism (<http://www.ecb.europa.eu/ssm/html/index.en.html>). Last accessed: 07.11.2014.

Engle, R. F., Jondeau, E. and Rockinger, M. (2014). Systemic Risk in Europe, Review of Finance (forthcoming) (First published online: March 31, 2014).

Ericsson, J., Jacobs, K. and Oviedo, R. (2009). The determinants of credit default swap premia. Journal of Financial and Quantitative Analysis, 44(01), pp.109-132.

Ewing, J. (2015). A Fragile Recovery. As Cyprus Recovers From Banking Crisis, Deep Scars Remain. New York Times, Vol. CLXIV, No. 56,808, pp.B2,B7, March.

Experian. (2014). Credit Risk Management For Small Businesses. Business Credit Risk. Small Business Section. USA.

FDF. (2012). Report on macroprudential oversight in Switzerland; BIS, 2009. Issues in the Governance of Central Banks, FINMA, 2011. Addressing Too Big To Fail.

Federal Reserve System. (2014). Enhanced Prudential Standards for Bank Holding Companies and Foreign Banking Organizations, Federal Register, Vol. 79, No. 59, Thursday, March 27, 2014, Rules and Regulations, pages 17240-17338.

Fonseca, A. R. and Gonzalez, F. (2010). How bank capital buffers vary across countries: The influence of cost of deposits, market power and bank regulation, Journal of Banking & Finance, Volume 34, Issue 4, pages 892-902, April.

Freixas, X. (1999). Optimal bail out policy, conditionality and creative ambiguity (No. dp 327). Financial Markets Group.

Freixas, X., Martin, A. and Skeie, D. (2011). Bank liquidity, interbank markets, and monetary policy. Review of Financial Studies, 24(8), pp.2656-2692.

Fry, M. (1988). Money, interest, and banking in economic development, Johns Hopkins University Press, Baltimore.

Furstenberg, G. and Kalckreuth, U. (2006). Dependence on External Finance: An Inherent Industry Characteristic?, Open Economies Review, Springer, vol. 17(4), pages 541-559, December.

Gaganis, C. and Pasiouras, F. (2013). Financial supervision regimes and bank efficiency: International evidence, Journal of Banking & Finance, Volume 37, Issue 12, pages 5463-5475, December.

Gertler, M. and Kiyotaki, N. (2010). *Financial Crises, Bank Risk Exposure and Government Financial Policy*, Princeton University Press.

Gillespie, B., Hackwood, J. and Mihos, C. (2010). *Managing credit risk for global commodity producers*. PricewaterhouseCoopers.

Goodhart, C., Schoenmaker, D. and Dasgupta, P. (2001). The Skill Profile of Central Bankers and Supervisors, *European Finance Review* (2002) 6 (3): 397-427.

Gopalan, R., Nanda, V. and Yerramilli, V. (2011). Does poor performance damage the reputation of financial intermediaries? Evidence from the loan syndication market. *The Journal of Finance*, 66(6), pp.2083-2120.

Gumbel, P. (2013). Cyprus Rescue: The Destruction of a Tax Haven. *Time*. March 25, 2013 ed.

Hakenes, H. and Schnabel, I. (2010). Banks without parachutes: Competitive effects of government bail-out policies. *Journal of Financial Stability*, 6(3), pp.156-168.

Hand, D.J. and Weston, D.J. (2008). Statistical techniques for fraud detection, prevention, and assessment. *Mining massive data sets for security*, pp.257-270.

Hansen, H. (1996). The Impact of Interest Rates on Private Consumption in Germany, Discussion paper 3/96, Volume 19, Economic Research Group of the Deutsche Bundesbank.

Hardy, D. C. and Nieto, M. J. (2008). Cross-Border Coordination of Prudential Supervision and Deposit Guarantees, IMF Working Paper WP/08/283, December.

Hernandez, L., Mellado, P. and Valdes, R. (2001). Determinants of Private Capital Flows in the 1970s and 1990s: Is There Evidence of Contagion?, IMF Working Paper, WP/01/64, May.

Hsiao, C. (2003). *Analysis of panel data*. Cambridge University Press, Cambridge.

Hsiao, C., Pesaran, M.H. and Tahmiscioglu, A.K. (1999). Bayes estimation of short-run coefficients in dynamic panel data models. In: Hsiao C., Lahiri K., Lee L.-F. and Pesaran M.H. (Eds.), *Analysis of Panels and Limited Dependent Variables : A Volume in Honour of G.S. Maddala*. Cambridge University Press, Cambridge, pp. 268–296.

Hsieh, W. J. and Hong, M. C. (2004). The Determinants of Foreign Direct Investment in Southeast Asian Transition Economies, International Symposium on Foreign Trade, FDI, and Industrial Development, National Chung Cheng University, Chia-Yi, Taiwan.

Infosys (2012). Needed, A Holistic Approach to Reputation Risk Management in Banks. Building Tomorrow's Enterprise.

Inklaar, R. and Koetter, M. (2008). Financial dependence and industry growth in Europe: Better banks and higher productivity, GGDC Research Memorandum GD-100, Groningen Growth and Development Centre, University of Groningen.

Kovach, S. and Ruggiero, W.V. (2011). Online banking fraud detection based on local and global behavior. In Proc. of the Fifth International Conference on Digital Society, Guadeloupe, France (pp. 166-171).

Lee, G.H. (2008). Rule-based and case-based reasoning approach for internal audit of bank. Knowledge-Based Systems, 21(2), pp.140-147.

Levi, M. (2014). Regulating fraud revisited. In Invisible Crimes and Social Harms (pp. 221-243). Palgrave Macmillan UK.

Levine, R. (2004). Finance and Growth: Theory and Evidence, NBER Working Paper No. 10766.

Lin, H. and Paravisini, D. (2011). What's bank reputation worth? The effect of fraud on financial contracts and investment. The Effect of Fraud on Financial Contracts and Investment (June 1, 2011).

Lipman, I.A., Warren, Gorham and Lamont, Inc and United States of America (1977). Combatting Internal Bank Fraud. Bankers Magazine, 160, pp.71-74.

Maddala, G. S, Trost, R. P., Li, H. and Joutz, F. (1997). Estimation of short-run and long-run elasticities of energy demand from panel data using shrinkage estimators. Journal of Business and Economic Statistics 15, 90–100.

Maddala, G. S. and Hu, W. (1996). The Pooling Problem. In: Matyas, L., Sevestre, P. (Eds.), The Econometrics of Panel Data: a Handbook of Theory with Applications, Kluwer Academic Publishers, 2nd Ed., Boston, pp. 307-322.

- Maddaloni, A. and Peydro, J. (2013). Monetary Policy, Macroprudential Policy and Banking Stability: Evidence from the Euro Area, ECB Working Paper Series No. 1560, ISSN 1725-2806.
- Mahdi, M.D.H., Rezaul, K.M. and Rahman, M.A. (2010). Credit fraud detection in the banking sector in UK: a focus on e-business. In Digital Society, 2010. ICDS'10. Fourth International Conference on (pp. 232-237). IEEE.
- Martinez-Miera, D. and Suarez, J. (2011). A Macroeconomic Model of Endogenous Systemic Risk Taking, CEPR Working Paper.
- Masciandaro, D. (2004). Unification in financial sector supervision: The trade-off between central bank and single authority. *Journal of Financial Regulation and Compliance*, 12(2), pp. 151-169.
- Masciandaro, D. (2006). E Pluribus Unum? Authorities' design in financial supervision: trends and determinants. *Open Economies Review*, 17(1), pp. 73-102.
- Maudos, J. and Guevara, F. (2006). Banking competition, financial dependence and economic growth, MPRA Paper 15254, University Library of Munich, Germany.
- McKinnon, R. (1973). *Money and Capital in Economic Development*, Brookings Institution, Washington D.C.
- Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance* 29(2), pp.449-470.
- Moldovan National Bank (2016). *Economic and Financial Activity of Moldovan Banks Report 2013 - 2015*.
- Northcott, C. A. (2004). Competition in banking: A review of the literature. Working Paper. Bank of Canada. pp.2004-24.
- Ozkan, F.G. and Unsal, D.F. (2012). Global financial crisis, financial contagion, and emerging markets. Working Paper WP/12/293, International Monetary Fund.
- Petroff, A. (2013). Europe bank rescue plan would hit investors. CNNMoney. London, June 27, 2013.

Prabodhachandran, N. (2004). Determinants of Fixed Investment Behavior A Study of Indian Private Corporate Sector With Emphasis on Financial Liberalisation, 6th Annual Conference on Money and Finance in the Indian Economy.

Raj, S.B.E. and Portia, A.A. (2011). Analysis on credit card fraud detection methods. In Computer, Communication and Electrical Technology (ICCCET), 2011 International Conference on (pp. 152-156). IEEE.

Rajan, G. and Zingales, L. (1998). Financial Dependence and Growth, American Economic Review, 88(3), pp. 559-586.

Ratnovski, L. (2013). Liquidity and transparency in bank risk management, Journal of Financial Intermediation, Volume 22, Issue 3, pp.422-439, ISSN 1042-9573, July.

Schoenmaker, D. (2011). Financial Supervision in the EU. Forthcoming in: Caprio, G. (ed.), "Encyclopedia of Financial Globalization", Elsevier Amsterdam.

Serres, A., Kobayakawa, S., Slok, T. and Vartia, L. (2006). Regulation of Financial Systems and Economic Growth in OECD Countries: An Empirical Analysis, OECD Economic Studies No. 43, 2006/2.

Shaw, E. (1973). Financial Deepening in Economic Development, Oxford University Press, New York.

Smith, A. F. (1973). A general Bayesian linear model. Journal of the Royal Statistical Society, Series B35, pp. 67-75.

Snyder, M. (2013). Cyprus-Style Wealth Confiscation Is Now Starting To Happen All Over The Globe. Global Research, September.

Soral, H.B., İşcan, T.B. and Hebb, G. (2006). Fraud, banking crisis, and regulatory enforcement: Evidence from micro-level transactions data. European Journal of Law and Economics, 21(2), pp.179-197.

Stanley, D. T. and Girth, M. (1971). Bankruptcy: Problem, process, reform. Brookings Institution Press.

Trapani, L. and Urga, G. (2009). Optimal forecasting with heterogeneous panels: A Monte Carlo study. International Journal of Forecasting 25, pp. 567-586.

Ueda, K. and Valencia, F. (2012). Central Bank Independence and Macroprudential Regulation, IMF Working Paper WP/12/101.

Van Horne, J. (1974). Fundamentals of Financial Management, Prentice Hall, New Jersey.

Vanston, N. (2012). Trust and reputation in financial services. Driver Review DR30. Foresight. Government Office for Science, United Kingdom.

Walsh, C. (1998). Monetary theory and policy, MIT Press, Cambridge.

Wei, W., Li, J., Cao, L., Ou, Y. and Chen, J. (2013). Effective detection of sophisticated online banking fraud on extremely imbalanced data. World Wide Web, 16(4), pp.449-475.

Williamson, S.D. (1986). Costly monitoring, financial intermediation, and equilibrium credit rationing. Journal of Monetary Economics, 18(2), pp.159-179.

Wiszniowski, E. (2011). Internal Bank Fraud as a Category of Operational Risk. A Argument, p.137.

World Bank. (2014). World Development Indicator Database.

Zey, M. (1993). Banking on fraud: Drexel, junk bonds, and buyouts. Transaction Publishers.

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