Aalto University
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# Systemic Banking Crises and Bank Capitalization - Evidence from the UK

Economics

Master's thesis

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2012

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Master's Thesis Abstract

Paavo Vuorilehto 30.10.2012

SYSTEMIC BANKING CRISES AND BANK CAPITALIZATION – EVIDENCE FROM THE UK

OBJECTIVE OF THE STUDY:

After the triggering of the financial crisis in 2008, discussion has questioned financial regulation's attempt to maintain the financial system's solvency by making individual financial institutions secure, and asked, if a more systemic perspective should be applied. In the study I attempt to answer this question by looking at the approaches and results of recent topic literature focused on the UK banking system, and estimating if additional capitalization of banks is sound given that it is a trade-off between financial system's resiliency and cost of funding of non-financial organizations.

METHODOLOGY AND DATA:

The study is performed by a literature review focusing on the UK financial system and by a cross-industrial empirical study on industry total capital costs with altered ratios of leverage. The empirical data consists of weekly stock prices and reported financial statements of 16 British corporations and weekly values of the FTSE 100 –stock exchange between May, 2012 and April, 2002 and is obtained from Thomson ONE –database. The empirical research is performed using the OLS –method for regressing company leverage with company stock market sensitivity for company equity rate of return and aggregating for weighted industry average cost of equity capital. The total costs of capital of industries are estimated at realized and halved leverage ratios in periods 2002 H2-2008 H1 and 2009 H1-2011 H2.

RESULTS:

Research on UK banking system solvency has proved that costs of a single bank's insolvency to the aggregate financial system's solvency are amplified significantly when banks hold common assets on their balance sheets, and drastically when they get excessively interconnected through the interbank market funding together with common asset holdings. This calls for a top-bottom regulation approach where the banking system is first capitalized, and then individual institutions would be allocated with respective apportions of the total systemic capital. This noticed, bank capital regulation would optimally be dynamic and would have required banks to carry one through six percentage point higher equity capital to total asset ratios during the recent crisis years in the UK. Capitalizing banks, at least in the UK, is sound as capitalization would not increase non-financial industries' total capital costs excessively.

KEYWORDS: systemic insolvency, shock, insolvency tolerance level, financial system, banks, non-financial companies, total cost of capital, asset value correlation, networking

**Aalto-yliopiston kauppakorkeakoulu**

Pro Gradu -tutkielma Johdanto

Paavo Vuorilehto 30.10.2012

# SYSTEEMISET PANKKIKRIISIT JA PANKKIEN PÄÄOMITTAMINEN – EVIDENSSI ISO-BRITANNIASTA

## TUTKIELMAN TAVOITTEET:

Vuonna 2008 puhjenneen rahoitusmarkkinakriisin jälkeen empiirinen kirjallisuus on kyseenalaistanut rahoitusmarkkinasääntelyn pyrkimyksen taata rahoitusjärjestelmän maksukyky sääntelemällä yksittäisten rahoituslaitosten maksukykyä ja kysynyt, pitäisikö sääntelyssä ottaa systeemisempi lähestymistapa käyttöön. Tutkielmassa pyrin vastaamaan tähän kysymykseen erittelemällä Iso-Britannian pankkijärjestelmään fokusoituneessa kirjallisuudessa käytettyjä lähestymistapoja ja tuloksia, sekä tutkimalla onko pankkien lisäpääomittaminen kyseisessä järjestelmässä empiirisesti perusteltua pääomituksen ollessa valinta rahoitusjärjestelmän vakavaraisuuden ja ei-rahoituksellisten yritysten rahoituksen hinnan välillä.

## MENETELMÄ JA DATA:

Tutkielman pääasiallinen metodi on kirjallisuuserittely. Empiirisessä osassa teen vertailun viiden teollisuusalan keskimääräisistä kokonaispääoman hinnoista todennetuilla ja puolitetuilla velkavipuasteilla. Empiirinen data koostuu 16 isobritannialaisen yrityksen viikoittaisista markkinaosakehinnoista ja julkaistuista tilinpäätösluvuista, sekä FTSE 100 – osakemarkkinaindeksin viikoittaisista arvoista aikana toukokuu 2012 – huhtikuu 2002. Data on kerätty Thomson ONE –tietokannasta. Empiirisen tutkielman suoritan regressoimalla yritysten velkavipuasteen yrityksen osakepääomakannan markkinasensitiivisyyden suhteen osaketuottovaatimusta varten ja muodostamalla saaduista luvuista painotetut keskimääräiset teollisuusalakohtaiset osaketuottovaatimukset. Alakohtaiset kokonaispääoman hinnat arvioidaan todennetuilla ja puolitetuilla velkavipuasteilla periodeina 2002 H2 – 2008 H1 ja 2009 H1 – 2011 H2.

## TULOKSET:

Kirjallisuus Iso-Britanniasta on osoittanut yhden pankin maksukyvyttömyydestä seuraavien kustannusten rahoitusjärjestelmän vakavaraisuudelle kasvavan merkittävästi kun pankit jakavat taseissaan samoja pääomia ja runsaasti kun pankit tulevat kohtuuttomasti toisistaan riippuvaisiksi pankkien välisten lainamarkkinoiden kautta jakaessaan samanaikaisesti taseissaan yhteisiä pääomia. Pankkipääomasääntelyn tulisi tätä myöten edetä siten että ensimmäisessä vaiheessa koko pankkijärjestelmä pääomitetaan ja tämän jälkeen yksittäisille instituutioille osoitetaan suhteelliset osuudet koko järjestelmän pääomakannasta. Edelleen pankkipääomasääntelyn tulisi olla dynaamista ja Iso-Britanniassa pankkien osakepääomakannan suhteessa kokonaispääomakantaan olisi pitänyt olla yhdestä kuuteen prosenttiyksikköä suuremmat viimeisten kriisivuosien aikana. Pankeilta vaadittava lisäpääomittaminen Iso-Britanniassa on perusteltua, sillä pääomittaminen ei lisäisi suhteettomasti ei-rahoituksellisten teollisuusalojen kokonaispääomakustannuksia.

AVAINSANAT: systeeminen maksukyvyttömyys, shokki, maksukyvyttömyyden toleranssitaso, pankit, ei-rahoitukselliset yritykset, kokonaispääomakustannus, tasearvojen korrelaatio, verkottuminen

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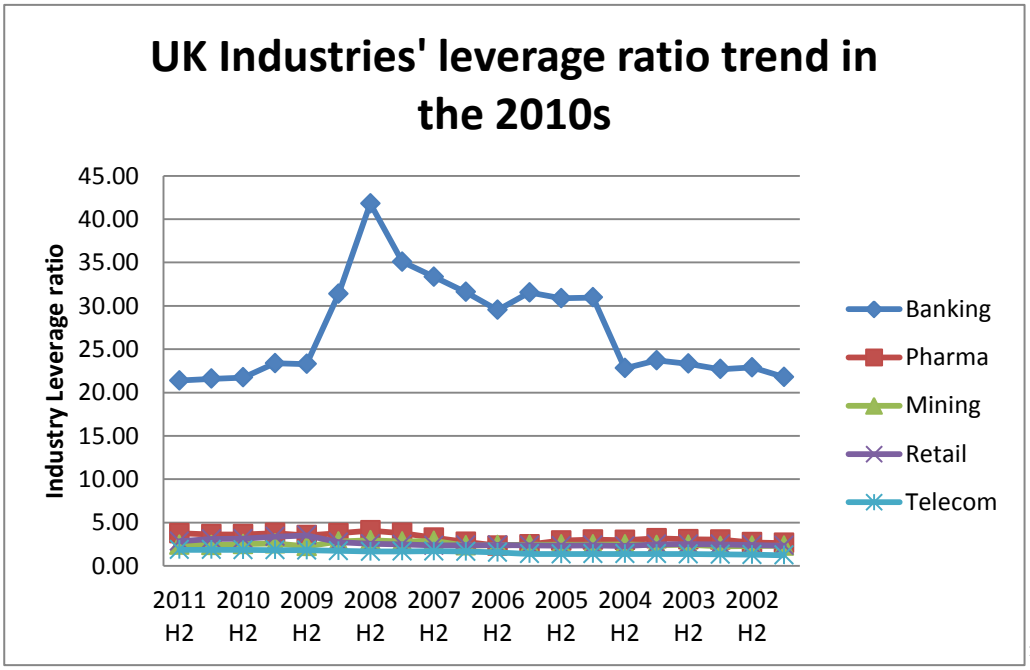
# 1 Introduction

This study is an attempt to find out if bank capital regulation should be approached from a systemic perspective in the post 2008 –era, given that bank equity capital increase may increase financing costs of non-financial companies and that higher proportion of equity capital funding at banks is likely to provide better bolsters against financial system insolvency. The study focuses on developments and findings on the UK financial system and attempts to find insights to generalize.

I treat financial system's systemic insolvency as a situation where system's aggregate liabilities are superior in value to system's aggregate assets. In this situation, funding intermediation through the system seizes. A financial system is composed of fund intermediating institutions that I simplify here to be banks. Thus, financial system's insolvency means insolvency of several banks in the extent that in the insolvent or defaulting banks, asset value losses exceed the total value of system's aggregate equity capital. Should there be sufficient equity capital in place at such banks, system's asset value after a loss perhaps would still be higher than the value of liabilities.

In the run-up to the triggering of the financial system crisis in 2008, the banking industry in the UK levered itself virtually by default, carrying a leverage ratio of 41.80 at the time when the crises initiated meaning that only 2.40% of its funding consisted of equity capital. In theory, a shock causing asset values in the UK to drop by the same percentage, would have caused the financial system in the UK – a major financial center in the world – to go bankrupt. The latest reported figures indicate the UK banking system to carry a leverage ratio of 21.40 and the corresponding proportional equity capital funding of 4.70%.




[1]

[1] Source: Thomson ONE banker –database; May, 2012

Recent literature on the subject ties banking crises to financial crises. Carmen Reinhart and Kenneth Rogoff (2009) define financial crisis as a serial default on debt. They further introduce that a banking crisis is one of five varieties of economic crises. The others are external and domestic sovereign debt defaults, currency crashes and inflation outburst. (Reinhart and Rogoff, 2009) Guerrieri and Shimer (2011) imply that a financial crisis is a financial market breakdown, and that in nature it is a process: In the early stages, investors start to expect that all securities they hold might not pay all due coupons and principal. Sellers start thinking that they later might have to sell the assets. At this moment, it is beneficial for the sellers to find out which ones may not pay in full, that is, the quality of their securities. Buyers do not have incentive to find out the quality of all securities because they don't know which securities may later be available for sale. This setting where sellers find out and then know the quality of all their securities, but buyers do not, creates the adverse selection problem. Emergence of adverse selection causes a fire sale, leading the price and liquidity of a security – an asset of the financial system – to fall. If there however is a third-party market agent who can buy and then destroy all low-quality assets, the liquidity and price-dividend ratio of the initial high-quality securities will rise. (Guerrieri and Shimer, 2011)

Financial regulation has also been touched in research literature from the perspective of macroeconomic policy. Blanchard et al. (2010) find that the crisis of 2008 was given room to arise, as financial intermediation as a whole was neglected as a feature of macroeconomics. Consequently, the financial regulation focused on the soundness of individual institutions, leaving the systemic nature of the markets unaddressed. (Blanchard et al., 2010)

Households ran on institutions in the 2008 crisis before authorities were able to inject cash into the financial system and guarantee a big fraction of the financial system. Runs on banks caused these institutions and other industrial organizations to acquire liquidity by massive asset sales at fire sales prices causing their prices to drop. (Tirole, 2011)

## 1.1 Market Breakdowns and Financial Crises

Reinhart and Rogoff (2009) define a financial crisis as a serial default on sovereign debt, whether external or domestic. The financial crises defined like this refers specifically to sovereign debt default. In this sense, a corporate debt or a residential mortgage default doesn't count as a financial crisis. The authors write a banking crisis to be an accompanying phenomenon of default on sovereign debt. (Reinhart and Rogoff, 2009).

Reinhart and Rogoff write that problems in banking rise often from protracted deterioration in bank's asset quality, not from their liabilities or bank funding. (Reinhart and Rogoff, 2009) According to the authors, banking crises are defined in events and in two ways:

1) In case of bank runs; closure, merger or a public sector takeover of one or more financial institutions

2) Closure, merger, takeover or a large-scale government assistance of an important financial institution that marks a start of a string of similar events for other financial institutions in case without runs.

The latter is to say, an operation that leads to contagious events at other institutions. Reinhart and Rogoff conclude (2009) that banking crises accompany sovereign debt defaults, the causality direction being that defaults precede banking crises.

According to Reinhart and Rogoff (2009) defaults on debt are in turn a universal phenomenon in perennial economic development. Furthermore, banking crises are correlated with boosted cross-currency border movement of capital. Capital inflows are also associated with higher risk of debt default in destination country. (Reinhart and Rogoff, 2009)

Enrica Detragiache depicts a model for studying how banking sector integration and capital mobility relate to one another. Her setting is that banking sector in a country of origin or domestic country is fragile and international capital mobility is imperfect. Increased financial integration for bank deposit markets increases the risk for bank runs in the country of origin, that in turn, result in a welfare loss for country's businesses. (Detragiache, 2001)

In the case of a bank run, depositors can either win or lose in relative to their initial deposit. When depositors win, whether their gain outweighs the losses from the run to businesses, depends on the ratio between depositors' foreign currency denominated asset holdings and the absolute size of the domestic bank run. A positive ratio yields aggregate net benefit from the run. (Detragiache, 2001)

In the literature review, I analyze two papers written on asset value shocks and bank funding by Bank of England's researchers, and on that basis attempt to find insights and approaches that would be useful in determining guidelines for improved bank capital regulation. Optimal bank capital by David Miles, Jing Yang and Gilberto Marcheggiano (April, 2011) studies long run UK optimal equity capital in bank funding with respect to debt financing. Systemic capital requirements by Lewis Webber and Matthew Willison (October, 2011), looks at how aggregate bank capital increase in UK financial system should be approached given that it is a trade-off between system's stability and efficiency, and that there are varying features in individual banking institutions and financial regulation. At the end, I perform a cross-industrial comparison on total capital costs on five UK industries to assess the size of the trade-off in bank capitalization.

I begin with literature and theory review on corporate capital structure and the financial system features.

# 2 Capital Structure Theory

Here I present the basic corporate capital structure theory. The purpose is to illustrate how changing banks' capital structures would affect the lending rates of interest they offer to non-financial companies in economies. The theory introduction is based on Brealey, Myers and Allen (2006).

## 2.1 Capital Structure, Opportunity Cost of Capital and Net Present Value

Brealey, Myers and Allen (2006) explain capital structure to relate to the company cost of capital, that is, the expected return on a portfolio of company's all outstanding securities and that usually, such a portfolio includes debt, as well as equity. Thus, the cost of capital is a blend of the cost of debt (corporate specific interest rate) and the cost of equity (expected required rate of return on firm's equity). This blended cost of capital is usually called the weighted average cost of capital (WACC).

$WACC = \frac{debt}{debt+equity} * R_{debt} + \frac{equity}{debt+equity} * R_{equity}$, where

$R_{debt}$ = required rate of return on company debt

$R_{equity}$ = required rate of return on company equity

WACC is the opportunity cost of capital for investing in a firm's assets and therefore the appropriate discount rate for a firm's average-risk projects. The role of the cost of capital is that it works as a benchmark for evaluating the net-present values of prospective projects that a company undertakes and that any project with a positive net present value is expected to create wealth for the company. (Brealey et al., 2006)

The cost of capital calculations are modified when taxes and capital structure changes are incorporated into the formula; interest payments on debt are tax deductible and capital maturities and issues change capital structures. (Brealey et al., 2006) The opportunity cost is also affected by risks of individual projects. The opportunity cost of capital for a project is determined by taking the highest expected return available for all equally risky projects available. (Brealey et al., 2006)

The Modigliani-Miller proposition states that the capital structure has no effect on the market value and further the total cost of capital of any firm. (Brealey et al., 2006) In the case where the total amount and value of assets remains unchanged all the time, it is simply looked what happens to returns on equity and debt, when the capital structure between debt and equity is changed. The financial structure does not affect the cash flows on the entire package of debt and equity. Therefore, if investor requires a particular rate of return on the whole package of securities, he will require that same return on whole package afterwards.

But since the capital structure changes, investors may well require different rates of return on individual securities in the package. When for instance the debt capital is increased and consequently equity capital decreased, the rates of return on both debt and equity capital increase, because they both become more risky. In the empirical research of the thesis, corporate debt rate of interest is assumed to be insensitive to market movements and therefore carries a fixed rate of interest.

## 2.2 Estimating the Cost of Equity

The general method for estimating the cost of equity is the capital asset pricing model (CAPM). (Brealey et al., 2006) The model says that required rate of equity capital is a sum of risk-free rate of return and corporate equity returns' market sensitivity weighted by required equity market risk premium:

$R_{equity} = R_f + \beta(R_m - R_f)$, where

$R_m - R_f$ = equity market risk premium on equity over risk free rate of interest

$R_f$ = Risk free rate of interest

$\beta$ = Beta of company's stock, a measure of sensitivity of equity returns to changes in general equity market returns

The average market risk premium on stock market portfolio has been 7,6% since the 1900, and the risk-free rate of interest ($R_f$) is widely regarded as a return on US Treasury bill. (Brealey et al., 2006) In the empirical estimations of the study, the risk-free rate of interest and the equity market risk premium are assumed to be 5,0%.

The concern in the context of the thesis is how does equity capital's sensitivity to the general corporate equity market, equity capital cost and further the total corporate capital cost change when the capital structure is changed.

The equity market index used in the empirical study of the thesis is FTSE 100. Theoretical hypothesis on bank lending is that a bank extends loans for as long as its company cost of capital produces a positive net present value from the lending projects. (Brealey et al., 2006) Chapter 7.2 introduces bank off-balance sheet activities, of which one operation is to create a loan and then sell it at a premium to another financial institution. This refutes assumption that banking is merely loan extension and further, that the cost of capital would reflect exactly the true discount rate for evaluating bank operations. I retain the assumption however for practical reasons.

## 2.3 Factors of Distress and Their Occurrence

There are direct and indirect costs to financial distress, a situation when debt obligations are not met or are met with difficulty, that is, insolvency. (Brealey et al., 2006) The direct one is bankruptcy. Here, stockholders of a levered firm exercise their right to default: limited liability lets stockholders walk away, leaving all unpaid liabilities to creditors. Bankruptcy is a legal mechanism and its exercise depends on firm's next accounting period's total assets values and payable debt. If payable debt exceeds in value the total asset values, a company is declared bankrupt. (Brealey et al., 2006) This definition of insolvency is also used by Miles et al. (April, 2011) and Webber and Willison (October, 2011).

Indirect costs are near impossible to measure and Brealey et al. (2006) write that only circumstantial evidence is available for indicating their size. According to the authors, the best indication of indirect bankruptcy costs is the reluctance of creditors to enforce liquidation of a bankrupt company.

Having looked at the capital structure theory, I introduce next the principles of financial systems and theory on their functioning, banking, crises in the system and regulation.

# 3 Financial System and Its Tasks

In this section I present theory on financial markets and fund intermediation. The fundamental task of the financial system is to intermediate funds from savings creating households to public and private sector institutions that have productive investment opportunities. (Howells and Bain, 2008) (Mishkin, 2010) These end-users of the financial system have three alternatives for organizing the exchange of funds: direct lending, organized markets and organized markets with intermediaries. (Howells and Bain, 2008) For thesis's purposes, I focus only on the last form, the intermediated markets. The reason intermediaries[2] exist is that they are able to bring lenders and borrowers together more quickly, efficiently and cheaply and to reduce risk of a transaction through diversified asset and liability portfolios, thanks to their economies of scale and expertise, in relation to if the end users of the financial system found each other out on their own. (Howells, Bain, 2008)

There has to be thus a benefit for both end parties to be gained that an intermediary offers that makes the two parties to exchange funding through it. Howells and Bain (2008) explain the two benefits created to be financial asset and liability creation and liquidity in the financial market. The two benefits are discussed next. First, the motives of lenders and borrowers are explained.

## 3.1 Motives of Lenders

In developed economies households tend to have periodical incomes from work that exceed their corresponding periodical consumption. In other words, they have savings. According to Howells and Bain (2008), these savings can be used in two ways: they can used to acquire real investments, like a house, or in a case where there are savings left after these investments, to acquire financial assets. The financial assets are then, on behalf of households, potential lending[3]. This is what makes households a surplus unit. Howells and Bain (2008) say that in order to induce households to lend their financial assets, their demands concerning return, risk and liquidity must be met. Surplus unit wants a maximum return, with minimum risk and has a positive attitude toward liquidity. (Howells and Bain, 2008)

## 3.2 Motives of Borrowers

Deficit units have insufficient periodical incomes to their corresponding consumption plans or real investment plans. According to Howells and Bain (2008), they therefore must either shed their previously accumulated real investments or financial assets, or incur financial liabilities. Borrowers look for two things according to Howells and Bain (2008): they want to minimize risk and maximize maturity. With long

[2] The intermediaries include: banks, insurance companies, mutual funds, and stock-, bond-, and other financial instrument markets, and they are all regulated by public authorities. (Mishkin, 2010)

[3] Previously, when wages were paid in cash, there was a possibility for households to keep cash reserves, or hoards, but as wages are paid electronically these days, I neglect hoards from the financial assets.

maturity, borrowers look forward to minimizing chances that a loan has to be serviced at an inconvenient time or that the loan would have to be replaced when interest rates are high.

## 3.3 Liquidity Creation

Reconciling differing and conflicting interests of lenders and borrowers is why there are financial intermediaries. Howells and Bain (2008) explain intermediaries to do this reconciling by creating assets and liabilities for the two parties that through direct interaction between each other would not be possible. However, from economic perspective creation of financial assets and liabilities does not matter, since they always demolish one another. There is no net creation of wealth, unless economic behavior of consumers is affected by the amount of total assets and liabilities. (Howells and Bain, 2008) The second element that financial intermediaries create is liquidity[4]. (Howells and Bain, 2008) The authors define financial system liquidity as:

Extent *to which an asset can be converted to money, quickly, cheaply and for a known capital sum*

Liquidity has therefore three dimensions: time – speed at which an assets can be turned to money, risk – a chance that the realized value of the asset when converted is different from what expected, and cost – what has to be given up to make the transaction. (Howells and Bain, 2008) How liquidity shows is that lenders are willing to lend more and hold less liquid financial assets than would be the case if lenders and borrowers interacted without an intermediary. The outcome is increased amount of funding and lower rates of interest. (Howells and Bain, 2008) According to Howells and Bain (2008), economists say that when having an opportunity to hold liquid assets, a consumer spends a higher proportion of his income either in consumption or in real investment, as he or she knows, she can quickly get money if faced with a sudden need for cash. Another way how advantages of liquidity show is that lenders have more options for holding savings. They can make many low risk loans to intermediaries that can pool them, and then extend as a single loan to a borrower for a real investment project (Howells and Bain, 2008). Financial system liquidity therefore shows as a number of cheap, accessible and value predictable loans with different mixes of maturities and interest rates available to lenders and borrowers.

According to Mishkin (2010) the greatest problem relating to exchange of funds between surplus and deficit units in the financial system is intermediation inefficiency that is caused by transaction costs and information asymmetry. Inefficiency means reduction in the amount of savings at disposal of the investment sector from that supplied by the surplus sector. The most important function of the financial system is the reduction of transaction and information costs, and thus promotion of intermediation efficiency. The transaction costs are mitigated through economies of scale and financial intermediation

[4] Liquidity creation happens through four processes by intermediaries: maturity transformation of supplied and demanded loans, risk reduction, search and transaction cost reduction and loan monitoring (Howells and Bain, 2008).

expertise of financial institutions, problems with information relate to information asymmetry and therein to adverse selection and moral hazard. (Mihskin, 2010)

Mishkin (2010) defines asymmetric information as a situation where one party's insufficient knowledge about the other party involved in exchange of funds makes it impossible to make accurate decisions when conducting the transaction. An example is a corporation manager who knows whether he is honest or has better information about investment projects than the stockholders of the company. The existence of asymmetric information leads to adverse selection and moral hazard. (Mishkin, 2010)

## 3.4 Adverse Selection

Adverse selection occurs before the exchange of funds. Mishkin (2010) defines it as a phenomenon where borrowers who are the most likely to produce a negative outcome – a bad credit risk – are the ones who most actively seek loans and therefore are most likely to be handed the financing. The single motivation of adverse selection borrowers is the size of the gain from their eventual investment, no matter how unlikely. Since adverse selection makes it likely for the bad projects to get financing, lenders may decide not to extend loans, even when there would be good investment projects seeking funding. (Mishkin, 2010)

## 3.5 Moral Hazard

Mishkin (2010) explains the moral hazard to occur after the exchange of funds, in contrast to adverse selection. He defines it as follows: it is a risk (hazard) in the financial markets that the borrower might engage in activities after having received the funds that are not desirable (immoral) from lender's point of view, because these activities reduce the probability that a loan will be paid back. As with adverse selection, the moral hazard lowers the probability that the loan is paid back, which may lead lenders to decide again, that they do not extend any loans all together. With adverse selection and moral hazard, the monetary loss from bad projects accrues entirely to the lenders, as the borrower nevertheless gets his utility from engaging in the bad projects. (Mishkin, 2010)

Mishkin (2010) explains that in an economy with financial intermediaries, small savers or households can lend to a trustworthy intermediary, like a bank or an insurance company that in turn lends the pooled funds out, or buys corporate bonds or stocks. Successful intermediaries get higher returns than households because they are better able to screen out bad credit worth projects, thereby reducing losses due to adverse selection and to monitor the ultimate borrowers and their actions, thereby reducing chances of moral hazard. The result is that intermediaries earn a higher return than lender-savers and therefore are able to pay their depositors a profit, or to provide substantial services and yet make a profit.

# 4 Banking and Management of Financial Institutions

This section presents how banks and other financial institutions in an economy work. The vast majority of financial intermediaries are private business such as banks, so I take the theoretic functioning of all financial intermediaries to be that of banks. According to Mishkin (2010), financial intermediaries are businesses in process of making as much profit as possible: they acquire funds, make loans and manage their assets and liabilities. I look here two parts of banking: banks' balance sheet, and off-balance-sheet activities. Information presented is based on Mishkin's work (2010).

## 4.1 Bank Balance Sheet

Balance sheet lists any organization's assets (revenue generating items), liabilities (sources of external funds) and capital (organization's own funds) such that,

***Total Assets = Total Liabilities + Capital***

Banks obtain liabilities by borrowing and by issuing liabilities such as deposits. They then use these funds to obtain assets, that is, securities and loans. Banks make a profit by charging a higher interest rate on their extended loans on assets than on interest that they pay for their liabilities and borrowings. The second element on the liability side, capital, is the combined stock of bank's issued equity capital and retained earnings. It is a cushion against a drop in the value of bank's assets that could force the bank into bankruptcy. Bank capital is therefore the net worth of a bank. (Mishkin, 2010)

The liabilities of banks are of three kinds: first, there are the ordinary bank accounts or checkable accounts from which the account owner can make withdrawals to pay for merchandizes. Second, there are non-transaction deposits from which the account holder cannot withdraw funds, but where the bank pays a higher rate of interest. Borrowings are the third form of bank liabilities and include bank funds obtained from central banks – discount loans or advances – interbank market loans and corporate loans. Borrowings also include liabilities raised in non-domestic currencies. (Mishkin, 2010)

The assets of banks are in four kinds (Mishkin, 2010): firstly reserves. All banks must hold some proportion of their assets as a reserve at their local central bank as specified by the central bank. The reserves are of two forms: mandatory reserves, known as reserve requirement that is defined as a portion of deposits that banks must deposit to their central bank, and excess reserves that are voluntary funding kept at the central bank for additional liquidity reserve. Together with deposits at other banks and cash items in process of collection, reserves represent approximately 10% of total assets of a bank and are referred to as cash items.

Secondly there are securities, debt instruments extended to other banks[5]. The securities consist of government, state and local securities and other securities. Securities are the second-from-top liquidity class assets that banks hold.

The third class of bank assets are loans, and it is these assets where banks revenues primarily come from. In a hypothetical description by Mishkin (2010), 61% of banks' assets are loans, and according to the author, it has in recent years generated more than 50% of bank revenues. Loans are in nature non-cashable securities until their maturity. They are primarily extended to business and real estate sector. For these two reasons, they are more risky and less liquid assets than cash items and securities, and earn a higher interest for banks, so generating the high revenues.

The forth group of assets includes any physical capital, such as bank buildings, office supplies and other equipment owned by a bank. These assets are relatively illiquid, yet something that is owned by the bank and can be sold in secondary markets. (Mishkin, 2010)

## 4.2 Shadow Banking System and Off-Balance-Sheet Activities

Shadow banking system means an unregulated fund intermediation market, and has proved in academic literature to have been the epicenter of the 2008-crisis. Gary Gorton (2008) writes that the prior to the triggering of the current financial crisis, a shadow banking system, or sector, had emerged and evolved within the entire banking or financial system. This shadow system was vulnerable to the possible panics in the financial system. As the crisis and panic emerged, the shadow system failed. Ignorance about location and sizes of losses of products created within the shadow banking system, such as subprime mortgage related securities, was the shock that initiated the crisis, according to Gordon. (Gorton, 2008)

Shadow banking according to Gorton (2009) was, and probably still is today, a new and real form of banking where big organizations with financial arrangement capabilities exchange funds between each other. A particular market in the shadow banking system was the repo-markets where industrial organizations can "make deposits" and where the counterparty in the deal, "a bank", provided collateral for the loan. The price of the deal was the repo-rate. When depositing organizations began to fear the value and liquidity of the collateral provided by the banks in the repo-deals, they required higher margins, or haircuts, or refused to renew their loans to each other. This sparked the crises that spread to the interbank markets and further to the real economy. (Gordon, 2009)

According to Mishkin (2010), banks have engaged into off-balance sheet activities as banking industry has become more competitive and profits from traditional banking have deteriorated. The off-balance-sheet

[5] According to Mishkin (2010), banks are not allowed to hold stocks as assets in the US. This may not apply to non-US banks.

activities are operations at banks that create revenue for a bank, but do not show on bank's balance sheets. Shareholders, stakeholders or any potential investor in bank's equity cannot know whether or not a bank is engaged in these activities and if yes, in what extent. Information asymmetry is created by banks as a side effect of their actions and the outcome is increase in adverse selection and moral hazard threats. Off balance sheet activities exist for banks' profitmaking and include following activities: financial instrument trading and risk management techniques; income generation from fees and loan sales. (Mishkin, 2010)

# 5 Financial Crisis Theory and Features

I describe here theory on financial crisis. According to Mishkin (2010) a crisis develops in sequences: there's first initiation, followed by a banking crisis and finally a debt deflation. Necessary tools used to understand financial crises are agency theory and effects of asymmetric information on financial markets, and further on economic activity. (Mishkin, 2010) I first look at the trigging factors behind crises and then crises' dynamics.

## 5.1 Initiating Factors

Financial systems intermediate funds efficiently when there is minimal information asymmetry and transaction costs. A financial crisis begins to emerge when disruptions to this funding intermediation efficiency begin. These disturbances or shocks cause information asymmetry between lenders and borrowers, that is, between financial system end users to increase. Information asymmetry and thereafter adverse selection and moral hazard cause the efficiency of the financial system to decrease that eventually causes economic activity to decline. (Mishkin, 2010)

According to Mishkin (2010) there are three forms of shock that affect borrowing deficit unit's asset values: stock market declines, domestic currency crashes, and asset write downs. Each of them relates to borrowing firms' net worth[6] and the resulting decline in intermediaries' willingness to extend it credit. When asset values decline, the net worth of a borrowing company decreases and this raises the threat of moral hazard in the company, since company owners have less to lose if their hazardous investments prove unable to serve raised loans. The three other possible trigging factors of crises are problems in financial intermediary's balance sheet, interest rate hikes and government fiscal imbalances. (Mihskin, 2010)

## 5.2 Banking Crises

As asset value declines in borrowing deficit units begin to pile up in larger extent in the economy, banks' asset values may start also to decline thus diminishing banks' net worth. If or when banks' depositors become aware of bank net worth decline, they may start to raise their deposits, and as a consequence raise a banking crisis. Mishkin (2010) writes that in banking crises, depositors start to withdraw their savings from financial intermediaries, thus causing banks to quickly sell their assets and probably go bankrupt. The resulting decline in the number of intermediaries in the financial system causes information production in the system to decline, thus increasing information asymmetry problem, causing credit crunches and higher rates of interest, and eventually decline in economic activity. (Mishkin, 2010)

Mihskin (2010) writes that in the US, good credit worth businesses are sorted out from bad ones in bankruptcy proceedings. The same is often done in case of banks with help of private and public authorities.

[6] Net worth means difference between values of assets and liabilities. Essentially therefore, equity value of a corporation.

Once this sorting out has been done, uncertainty in the financial system diminishes and interest rates drop. Information asymmetry and the financial crises subside. With financial markets cleared, economic recovery begins. (Mishkin, 2010)

## 5.3 Debt Deflation

Mishkin (2010) argues that if an economic downturn as a result of lending crunches at financial intermediaries leads to sharp declines in prices, i.e., deflation, the recovery from insolvencies can be cut short. This is because when prices decline the revenues of companies plummet, causing them to become increasingly dependent on external credit, thereby increasing their indebtedness. This added to asymmetric information problems may curb economic recovery for a long time. (Mishkin, 2010)

# 6 Financial Regulation Framework

In this section I present background and theory of financial and bank capital regulation. All the time I look at how regulation affects banking crises and economic development.

Howells and Bain (2008) write the basic concern for banking and insurance regulation is the industry's reliance on public confidence.

The public confidence concern relates to fact that banks hold a fractional portion of their assets in liquid reserves that are fractional in relation to the amount of their extended deposits. The deposits are very liquid form of securities, whereas bank assets – the loans, representing the majority of bank assets – are not. This creates a risk of solvent bank with sound, but illiquid assets facing a liquidity problem, like Northern Rock in the UK in 2007. Furthermore, bank assets in liquidation are likely to have significantly lower values than if a bank would be a going concern. (Howells and Bain, 2008)

The two key points in bank collapses from economic perspective are contagion and consumer protection. With contagion, the primary concern is that a failure of one bank causes a loss of confidence in banking in general. A run on a bank may appear either because a bank has made dubious loans, has ended up in difficult financial position, and its depositors and creditors become more discriminating in their depositing decisions and run the bank, without endangering any other bank in the system with sound assets. Or, as in the case where collapse of one bank leads confidence in banking to vanish in general, many depositors in various banks may get concerned and withdraw their funds from various banks causing problems to the whole industry and system. (Howells and Bain, 2008)

The possible second source of contagion is a very high level of interbank dealings that is a common feature of modern finance[7]. A collapse may create a significant quantity of bad debts for other banks. (Howells and Bain, 2008)

The second concern of bank collapses, the consumer protection, comes from desire to enhance efficiency of the financial system by involving in its funding intermediation as many households as possible, but since they are likely to be unaware of the workings of the system, they need to be protected from illegal and harmful practices. (Howells and Bain, 2008) As there are many participants in the system, prices of financial assets are driven a lot by expectations and the majority of the participants are likely to be unaware of the products and processes of the financial system. When future expectations heavily influence financial asset price fluctuation, quick profits and losses are available to those familiar with the financial products and processes and are therefore incentivized to possibly destructive activities that may harm average households. (Howells and Bain, 2008) Taken together, the possibility of contagious bank insolvencies and

[7] Excessive interbank market funding is studied in detail by Webber and Willison (October, 2011)

desire to involve as many households as possible in the financial system give reasons for financial system regulation. (Howells and Bain, 2008)

According to Mishkin (2010), financial regulation has been designed over time to tackle the information asymmetry problem, and the resulting adverse selection and moral hazard problems. These three concepts are essential for understanding the current form of regulation.

There are nine different forms of regulation: government safety net, restrictions on asset holdings, capital requirements, prompt corrective actions, chartering and examination, assessment of risk management, disclosure requirements, consumer protection and restrictions on competition. (Mishkin, 2010) The two most essential of these, government safety net and government-imposed capital requirements are studied closer next.

## 6.1 Government Safety Net

Government safety net in its various forms exists to prevent a system-wide depositors' or creditors' runs on banks. Runs tend to happen in case of an unexpected large-scale shock that severely deteriorates banks' asset values resulting to banks' loss of net worth and bankruptcy. (Mishkin, 2010) I introduce five issues that government safety net deals with: bank panics or the aforementioned system-wide runs, moral hazard, adverse selection, the "too-big-to-fail"-problem and financial institutions consolidations.

### 6.1.1 Bank Runs and Deposit Insurance

Mishkin (2010) defines bank failure as an event, where bank cannot meet its obligations to its depositors and creditors is thus forced to bankruptcy. A bank run develops as follows: before the run, depositors or creditors know that if the bank with their deposits or credit goes bankrupt, they first will have to wait a long time, even years, to get their money back, and second, that at the time of bankruptcy they will only get a fraction of their savings back. In addition to these, they are aware that they cannot know, if the bank has been honest with their savings. Information asymmetry about bank's intentions prevails. If a shock hits the economy and drives a small fraction, say five per cent of banks to insolvency, and there is no deposit insurance, depositors or creditors are unable to tell which banks are insolvent and they run all banks in the economy, both insolvent and solvent ones. The run extends to all banks, becoming a system-wide bank run, since banks serve depositors on first-come, first-served-basis, so depositors have an incentive to be the first to withdraw their deposits. (Mishkin, 2010)

Before 1934 when the FDIC[8] was created in the US to guarantee depositors' savings in banks, the US experienced major banking panics in the 19$^{th}$ and the early 20$^{th}$ century approximately every 20 years. In the 1930-1933 crises, bank failures averaged more than 2000 per year in the US, according to Mishkin

[8] Federal Deposit Insurance Corporation

(2010). Between 1934-1981, after the establishment of the FDIC, bank failures in the US dropped to 15 per year. (Mishkin, 2010)

A deposit insurance, like one offered by the FDIC, guarantees depositors a certain nominal amount[9] of deposit pay-backs if a bank goes bankrupt. With fully or partially insured deposits, depositors have less need to withdraw their deposits, so endangering bank's solvency, when their savings are guaranteed no matter what happens. (Mishkin, 2010)

According to Mishkin (2010), the FDIC uses two ways to handle failed banks: payoff method, and purchase and assumption method. With the former, FDIC allows bank to fail and pays the deposit insurances from its own funds acquired from insurance payments by banks. It then liquidates the failed bank's assets, and lines up with other deposit and credit holders to be paid back the proceeds from liquidated assets. Those with deposits over the insurance limit have got on average 90% of their savings back, although with some years queuing. With the purchase and assumption method, the FDIC reorganizes the bank, by finding a merger partner that assumes all of a failed bank's liabilities. It may offer cheap loans or buy out some of the weakest assets to induce the take-over. With this method, FDIC guarantees all of failed bank's liabilities and deposits and it is indeed the costlier method for it to act[10]. (Mishkin, 2010)

Other methods by public authorities to handle bank failures and deposit insurances are government loans from central bank to troubled intermediaries, the operation called the lending of last resorts, direct funding of institutions and government take-overs, nationalizations, whereby the government assumes all liabilities and guarantees full pay-backs to creditors. (Mishkin, 2010)

### 6.1.2 Moral Hazard, Adverse Selection and Government Safety Net

As the deposit insurance and other equivalent arrangements exist to prevent depositors' and creditors' runs on banks, there exist incentives for detrimental activities at banks. (Mishkin, 2010) Mishkin writes that moral hazard shows in financial system with banks having incentives to take excessive risks since they get to keep profits if they prove successful and public authorities incur costs if they go bankrupt. Depositors and creditors have in turn less incentive to monitor banks' activities, since they are protected up to the insurance limit if the bank goes bankrupt. They also accept more risky activities by banks.

A particular research performed in the deposit insurance implications on bank and depositor behavior is one by Cooper and Ross (2002). What they found was that complete deposit insurance does not produce

[9] In the US, the insurance is $100,000. It was temporarily increased to $250,000 in October 2008 during the subprime financial crises. (Mishkin, 2010)

[10] The purchase and assumption method was used by the Federal Reserve in the US in March 2008, when Bear Stearns drifted to bankruptcy and was acquired by JP Morgan.

the ideal outcome in terms of depositors' bank monitoring and bank risk taking. They find that with proper bank capitalization fused with the deposit insurance program, the ideal outcome can be achieved.

### 6.1.3 "Too Big to Fail"

The too-big-to-fail problem relates to the government safety net to be extended from depositor and small creditors to large bondholders of big banks or very interconnected banks in the financial system that if collapsing would have the potential to paralyze an entire financial system[11]. (Mishkin, 2010) Mishkin (2010) explains that in the too-big-to-fail arrangements, the local deposit insurance authority uses the previously mentioned purchase and assumption method to merge the collapsing institution with a willing partner and give the insolvent entity a capital infusion to pay its obligations. Mishkin (2010) highlights however, that in the too-big-to-fail operations, the collapsing banks managers are fired and the banks shareholders lose their investment.

The problem with the too-big-to-fail arrangements is that it increases moral hazard activities by bank creditors and managers, thereby inducing even more risk taking, and making bank failures ever more likely. (Mishkin, 2010). He adds that the too-big-to-fail problem extends also to non-banking financial intermediaries like insurance companies.

### 6.1.4 Financial Consolidation and Government Safety Net

Financial consolidation of big financial institutions is one of the key issues concerning financial system regulators after the subprime crises era. (Mishkin, 2010) According to the author, consolidations of financial institutions in the US began from legislative establishments in the 1990s. Big institutions started to emerge.

The formation of consolidated institutions poses two threats to financial systems stability and the financial system safety net provided by public authorities. The first is that such formation increases the too-big-to-fail-threat. The second is that due to mergers, the government safety net arrangements may become extended to bail depositors and creditors from insolvencies raising from banks' off-balance-sheet activities that the safety nets are not meant to do. Both threats increase the moral hazard and adverse selection threats, and consequently, they hamper real investment and future economic growth. (Mihskin, 2010)

The government safety net is indeed a two-bladed-sword. It gives financial system surplus units confidence to give money to financial system and lending and not to immediately pull it out should an adverse shock emerge. However at the same time, it gives incentives for detrimental activities in banks and among

[11] A bank getting disproportionately large in balance sheet size relative to other banks in a banking system and then collapsing is studied by Webber and Willson (October, 2011) They find that such a scenario causes massive economic damage and leads to substantial additional equity capital barriers.

investors. The challenge is in defining the appropriate limit of nominal deposit insurance and extent of legislative actions, regulation and bank capital as implied by Cooper and Ross (2002).

### 6.1.5 Restrictions on Asset Holdings

Mishkin (2010) writes that even without government safety net arrangements, banks would still be eager to take excessive risks because in case of bankruptcies, depositors and creditors bear the losses, but they retain possible profits. This keeps surplus units alert in extending loans to financial intermediaries. To prevent bank runs, banks have been regulated in terms of their asset holdings. According to Mishkin (2010), banks are not allowed to own risky assets like corporate common stock. Regulators also demand diversification of asset holdings by banks in order to keep them from lending excessively to a singly risky debtor.

## 6.2 Capital Requirements

Equity capital requirements in banks' balance sheets come for two reasons: one, that the more banks carry own capital in business activities, the more they have to lose if things turn bad and are therefore inclined to take less risk in their activities, and two, that equity capital works as a cushion against insolvency if bank's asset values severely decline. (Mishkin, 2010)

Bank capital requirements are in two forms. One is based on the leverage ratio. In one example, a bank is well capitalized, if the equity capital ratio to total assets is bigger than five per cent, that meaning a leverage ratio below 20, and poorly capitalized if the equity capital to total asset ratio is less than three per cent, that meaning a leverage ratio of over 33[12]. Surpassing this so called minimum leverage ratio, results to increased regulatory restriction on bank's activities. (Mishkin, 2009)

The other form of capital requirement is the risk-based capital requirement such as one set up by the Basel Committee on Banking Supervision in the Basel Accord. The Basel Accord did require banks to hold capital at least 8% of their risk-weighted assets, and has been adopted by over 100 countries, including the US. (Mishkin, 2010) Risk weighted asset are bank assets whose values are affected by shocks. This accord has been developed by regulators, as they have become increasingly worried about the off-balance-sheet-activities of banks. In the accord, banks' assets and off-balance-sheet-activities are allocated to four categories and each category is assigned a different weight to indicate the risk-level of assets and activities in that category. The four categories are: OECD countries' government securities, banks in OECD countries, municipal bonds and residential mortgages and consumer and corporate loans. The off-balance-sheet-activities are assigned with a corresponding risk-level weight to match them with on-balance-sheet assets. The original Basel Accord has had the regulatory arbitrage-problem in which in each category, banks hold the most risky assets possible, giving thereby a less risky picture to regulators and outsiders (Mishkin, 2010).

[12] According to this definition, the UK banking industry was on average poorly capitalized in periods 2007,H2 - 2008,H2.

In essence, bank capital requirements strive for keeping banks solvent and to give regulators and outside investors tools to evaluate the soundness of banks' activities. Mishkin (2010) adds however, that banks strive to avoid legislation in search for profits, so the regulation also must change as bank activities change. It is indeed a never-ending cat-and-mouse game.

## 6.3 International Regulation

Information asymmetry problems are of the same kind everywhere in the world, so financial regulatory frameworks are rather similar everywhere as well. (Mishkin, 2010) Mishkin (2010) explains that regulatory features are being standardized on global basis, the Basel Accord being an example of this. The particular reason for international regulation comes from financial intermediaries having operations in multiple countries. The problems here are which country's regulatory authorities are responsible for monitoring the institution and imposing regulatory actions upon it, and that regulators in respective countries lack the knowledge or the ability to monitor a multinational entity's actions. (Mihskin, 2010)

Having introduced the theoretical framework of the study, I next turn to analyze the literature approaches and results on optimal bank capitalization. The literature focuses on the UK financial system.

# 7 Long Run Optimal Bank Capital – Miles et al. model

The underlying idea of Miles, Yang and Marcheggiano (April, 2011) in increasing the equity proportion in banks' funding is equity capital's loss-absorbing feature. This means that funding itself by equity, a bank can sustain losses in its business and thereby incur reductions in its cash item assets while still maintaining superior total asset values to its total liability values that if breached, would cause the bank to be declared bankrupt.

The authors explain that the essential feature in the financial crises that began in 2007 was that highly-leveraged banks found themselves unable to raise new credit from lenders when fears of the size of their losses in relation to their capital spread among investors. Furthermore, the resulting debate about bank and financial system regulation has on broad scale focused on financial intermediates capital structure. (Miles et al.; April, 2011)

The focus on Miles et al.'s (2010) paper is on estimating the long-run costs and benefits of having banks use more equity capital in their funding and estimate an optimal bank capital structure. The benefits come from larger bolsters in the capital structure that reduce the possibilities of a banking crisis, or insolvency. The offsets come in form of potentially higher costs of intermediation in the financial system and thereby lost output through reduced amount of investments undertaken: the higher equity capital proportion would increase the average cost of bank funding that would in turn show in the higher rates of interest offered those who borrow from banks. Looking at the costs, Miles et al. (2011) take into account in bank lending cost determination how shifts in funding affect banks' required rates of return, the tax treatment of debt and equity, and the state insurance or deposit insurance, and how resulting costs in lending are divided between public costs and private costs.

When looking at corporate capital structure, Brealey, Myers and Allen (2006) explained a corporation to undertake any project that produces a net present value for it when cash flows from the project are discounted at corporation's opportunity cost of capital, or whose opportunity cost is less than its own weighted average cost of capital. The subsequent raise in rates of interest could so reduce the amount of investments undertaken, having probably long lasting effects on the total economic activity.

Hence, Miles et al.'s (April, 2011) optimal bank equity-to-total-asset-ratio can be formulated as follows:

$U\left(\frac{E_q}{A}\right) = (1 - P\{Crisis\}) * E(C\{Crisis\}) - Y\left(L\left\{After - tax\ WACC\left[\frac{E_q}{A}\right]\right\}\right)$, where

$E_q$ = bank equity

$A$ = total bank assets, bank equity + bank liability

$P\{Crisis\}$ = probability of banking crisis

$C\{Crisis\}$ = economic costs of banking crisis

$Y(L)$ = total output as a function of bank lending

## 7.1 Method

Miles et al. (April, 2011) use data on UK banks to assess costs from funding structure changes and data on shocks to incomes in several countries over a period of nearly 200 years to assess risks to banks and how equity protects against those risks.

### 7.1.1 Cost of Increased Equity capital

Miles et al. (April, 2011) assume the Modigliani-Miller hypothesis to hold, meaning that the weighted average cost of capital of a bank does not change when the capital structure is altered. They point two reasons why this would not hold: the tax treatment of debt and equity capital and the existence of state insurances of debt, both deposit and non-deposit debt. In other words, Miles et al. (April, 2011) assume corporate debt to be insensitive to general market movements[13], therefore having fixed required rate of return, and the cost of equity to change only in relation to corporate leverage in a manner that the total cost of capital remains all the time intact, whatever shifts in capital structure take place. They then look in what extent does the Modigliani-Miller -theory hold in practice.

Holding true to the fixed total capital cost and assuming corporate debt is systematically risk free, the total risk of corporate assets falls entirely to the equity. I.e., the sensitivity of banks' assets is equal to its equity's sensitivity to the total market risk, that is, the general economy. Where this leads to is the conclusion, that the bank equity risk and thereby the bank equity cost is linearly, by the factor of bank leverage, linked to the total asset market risk of the bank. In formula form:

[13] Here Miles et al. (April, 2011) assume corporate debt value fluctuations not to depend on general market movements, i.e. $\beta_{debt} = 0$. They do not imply that corporate debt's default probability would be zero.

$$\beta_{asset} = \beta_{equity} * \frac{E}{D+E} + \beta_{debt} * \frac{D}{D+E}$$

$$\Rightarrow \beta_{bank\ equity} = \frac{D+E}{E} * \beta_{bank\ assets}, where$$

$$Leverage = \frac{D+E}{E}, D = Debt, E = Equity$$

(Miles et al., April, 2011)

As asset beta and total cost of capital is assumed by the Modigliani-Miller proposition to be fixed, halving leverage should halve bank equity risk and the bank equity market premium cost. It is this hypothesis that Miles et al. (April, 2011) test.

Miles et al. (April, 2011) estimate bank equity return sensitivities, the betas, for Lloyds TSB, RBS, Barclays, HSBC, Bank of Scotland and Halifax by regressing their equity returns with FTSE 100 stock index returns over discreet six-month periods between 1992-2010. From 1997 until 2008 they end up with betas ranging between 1,5 and 0,5. However in year 2009 their regression estimated bank beta to be almost 2,5 and in 2010 over 1,5. They then regress these betas with the banks' time-period corresponding leverage ratios[14].

The regression function authors use for banks' beta and leverage is:

$\widehat{\beta_{l,t}} = \alpha_i + X'_{i,t-1} b + \epsilon_{i,t}$, where

$i$ = 1… J; banks

$t$ = 1,2,…T; time periods

$X$ = matrix of regressors with lagged leverage and year dummies

$b$ = vector of parameters

$\alpha_i$ = bank specific influence on beta

(Miles et al., April, 2011)

Miles et al. (April, 2011) present three estimates for the model: a pooled OLS estimate, a fixed bank specific effect (FE) on beta and a random bank specific effect on beta (RE).

[14] Miles et al. (April, 2011) use Basel II Tier 1 loss absorbing capital that comprises equity and some hybrid instruments that have lesser ability in loss absorption as the denominator in the leverage regression. The Basel III uses Common Equity Tier 1 capital (CET1) as loss absorbing capital that essentially is only equity, making the denominator 40 percentage points less than Basel II Tier 1 capital. The authors point out however, that leverage estimates with Tier 1 capital are informative, since Tier 1 and CET1 capitals can be expected to move closely together. (Miles et al., 2011)

### 7.1.2 Results

Miles et al. (April, 2011) estimate leverage coefficents around 0.025 with OLS estimation and RE-model and approximately 0.031 for the FE-model, meaning that with fixed bank specific effects on bank leverage, the impact of leverage changes to changes in bank equity beta are somewhat bigger than with an OLS-estimate and random effects. All the estimates of leverage impact on beta are highly significant and explain around 66% of the variability in betas. (Miles et al., April, 2011) The authors (April, 2011) find the constant in the regression to be positive and significant, and thus conclude the results not to conform to equity beta being fully explained by total bank asset beta weighted by leverage. The joint conditions of Modigliani-Miller and capital asset pricing model do not hold. (Miles et al., April, 2011)

Miles et al. (April, 2011) use the Hausman test to compare FE and RE estimators, and make null hypothesis that the differences in coefficients are not systemic. At standard levels they don't reject the null hypothesis; Chi-square (12) = 2.84 with P-value = 0.99. They therefore use the FE-estimator as their central estimates.

Miles et al. (April, 2011) use the weighted average cost of capital -approach for estimating leverage and equity beta implications on banks cost of capital. They do assume bank debt to be free of systematic risk, $\beta_{debt} = 0$, and thereby conclude it to be similar to the risk free rate of interest ($R_f$). They point out this assumption to be conservative and to understate the increase in the cost of total corporate funding that lower leverage theoretically implicates. The authors acknowledge that by so assuming they eliminate one channel through which the Modigliani-Miller theory would work. Miles et al. (April, 2011) thus introduce WACC as:

$$WACC = R_{equity} * \frac{E}{D+E} + R_f * (1 - \frac{E}{D+E})$$

Miles et al. (April, 2011) assume the CAPM for equity capital cost estimation and define it as:

$R_{equity} = R_f + \beta_{equity} * R_p$ , where

$R_{equity}$ = required rate of return on equity, equity capital cost

$\beta_{equity}$ = corporate equity capital beta

$R_p$ = equity market risk premium, 5,0%.

Using coefficient estimates from regression between bank beta and leverage, CAPM for equity is formulated as:

$R_{equity} = R_f + (\hat{a} + \hat{b} * leverage) * R_p$, where

$\hat{a}$ = the coefficient for constant

$\hat{b}$ = the leverage coefficient for beta from the beta-leverage regression.

(Miles et al., April, 2011)

In the sample of banks, collected by Miles et al. (April, 2011) the average leverage measured with the Tier 1 capital in 2006-2009 was 30. If the measure is taken in CET 1 capital, the figure would be 50. Using the Tier 1 -capital and the estimated regression coefficients in the beta-leverage regression, Miles et al. (April, 2011) count the required return on UK bank equity to be 14.85%, and the weighted average cost of bank capital to be 5.33%. The equity capital cost with leverage ratio of 15, that is, with halved leverage ratio, would be 12.6%, and WACC would rise to 5.51%.

To test if the implications of Modigliani-Miller hypothesis holds, Miles et al. (April, 2011) compare beta-leverage regression results to the estimates of WACC in the case that the Modigliani-Miller hypothesis would not hold, that is, that leverage changes would have no effect on the required rate of equity capital. In this case, the authors' estimate of the cost of equity is 5.33%, and WACC is 5.66%.

The authors (April, 2011) conclude that if Modigliani-Miller would not hold at all, meaning that decreased leverage would not make equity returns safer and decrease its required rate of return, bank WACC would be 5.66% with halved leverage. With halved leverage and decreased required rate of return of equity, bank weighted average cost of capital would be 5.51%. Bank weighted average cost of capital with actual values taken at the time of estimation and initial leverage is 5.33%. The rise in WACC would be 5.66%-5.33%= 33bps if the Modigliani-Miller would not hold at all. With Modigliani-Miller hypothesis, the rise is 5.51%-5.33% = 18bps. Therefore, the Modigliani-Miller hypothesis assumed, explains only (33bps-18bps)/33bps = 45% of cost of capital changes in Miles et al.'s (April, 2011) estimations of what it should explain if the hypothesis held exactly.

Miles et al. (April, 2011) also note, that when Modigliani-Miller hypothesis and CAPM assumptions are calculated in log form, the hypothesis explain 75% of the bank weighted total capital cost changes that it would if it held exactly. The authors point out however, that leverage change implications on required rate of return on debt is not factored in. They do however assume such changes to be marginal. Also, they point out they have not account for the tax treatment of debt and equity. (Miles et al., April, 2011)

Miles et al. (April, 2011) finally compare leverage to post-notice required equity rates of return of their sample banks. Here they use realized actual earnings over share price as a proxy for required rates of equity returns and regress it on leverage. Their obtained results by this method imply that the required rate of return on bank equity exactly halves as bank leverage is halved[15]. In this case the Modigliani-Miller

[15] Standard errors of the test were however robust, with $R^2$ –measures being 0.0801 for OLS-, FE-, and RE-estimates. (Miles et al., April, 2011)

proposition holds exactly. However, since they used realized earnings as opposed to expected or required earnings, and that in their calculations they assume risk-free rate of equity market returns to be 5,0%, this method with its results is questionable. Miles et al. conclude to take the Modigliani-Miller effect on bank WACC to be 45% of its potential full effect.

Finally, Miles et al. (April, 2011) neglect the effect of taxation on bank WACC estimations on the basis that what banks pay in taxes, the global authorities gain. However, this approach does not account for the deadweight losses resulting from taxation. They later account for this problem by treating taxes as a true cost of business.

## 7.2 Effect of higher cost of capital to output

Miles et al. (April, 2011) estimate setbacks of higher cost of total bank capital by studying how increased cost of bank capital reduces total output, GDP. They use a standard production function, in which output is produced from labour and capital: Y = f(K,L). Shifts in the total bank cost of capital change total capital stock in the economy. Capital stock change affects steady-state output and this permanent shift defines the long-run total cost of higher bank equity capital requirement. The authors also assume that any rise in cost of capital is transferred on one-for-one from banks to customers. (Miles et al., April, 2011)

Miles et al. (April, 2011) use a constant elasticity of substitution production function:

$$Y = f(K, L)$$

Using chain rule, the authors formulate output responsiveness to higher capital cost as:

$$\frac{dY}{dP_k} * \frac{P_k}{Y} = \left[\frac{dY}{dK} * \frac{K}{Y}\right] * \left[\frac{dK}{dP} * \frac{P}{K}\right] * \left[\frac{dP}{dP_k} * \frac{P_k}{P}\right]$$

$= \alpha * \sigma * \frac{1}{1-\alpha}$, where

$\left[\frac{dY}{dK} * \frac{K}{Y}\right] = \alpha =$ output elasticity of substitution with respect to cost of capital

$\left[\frac{dK}{dP} * \frac{P}{K}\right] = \sigma =$ capital elasticity of substitution with respect to relative production factor price

$\left[\frac{dP}{dP_k} * \frac{P_k}{P}\right] = \frac{1}{1-a} =$ relative production factor price elasticity to the cost of capital[16].

$P_k$ = marginal product and cost of capital

$\alpha$ = income share of capital

$1 - \alpha$ = income share of labour

(Miles et al., April, 2011)

According to the authors (April, 2011), the equation says that given the constant output elasticity of substitution with respect to capital, if the cost of capital increases by 1%, output decreases by factor $\sigma * \frac{\alpha}{1-\alpha}$. With income share of labor ($\alpha$) assumed to be 1/3, and capital stock elasticity of substitution with respect to relative factor price ($\sigma$) to be 0.5, the authors estimate a 1% cost of capital increase to decrease output by 0.25%. (Miles et al., 2011)

[16] For deduction of relative factor price elasticity to cost of capital, refer to Optimal bank capital; Miles, Yang and Marcheggiano, April, 2011, p.22

With previous section estimation about bank total cost of capital, if leverage would halve from 30 to 15, with Tier 1-capital – or with CET 1, from 50 to 25 – the total capital cost of UK banks would increase by 18bps, and this would be transferred one-on-one to bank customers (With 5% rates of risk free return and equity market risk premium and tax effect exclusion). Miles et al. (April, 2011) write bank lending to represent typically less than 1/3 of firms' total financing and therefore an 18 bps increase in firms' total cost of capital means 1/3*18bps = 6bps increase in the total cost of financing. They assume (April, 2011) that corporate debt is risk-free, and carries a risk-free rate of interest of 5,0%. Corporate cost of equity is 10% (risk free rate of 5%, plus risk premium of 5% with a unit beta – the overall beta of the stock market is one, and is therefore the beta of an average company), so the overall cost of financing increases by 0,6% ($\frac{(10{,}06\%-10{,}0\%)}{10{,}0\%}$), when the total cost of bank capital increases 18bps. According to Miles et al. (April, 2011) this means a 0,6*0,25% = 0,15% decrease in annual aggregate output. Miles et al. (April, 2011) assume the real social discount rate of 2,5%, so the decrease in output in permanent terms is 0,15%/0,025 = 6,0%.

Halving bank leverage would therefore turn into 6,0% decrease in all future output in present value. This is Miles et al.'s (April, 2011) estimate of the cost of halving bank leverage against which they compare benefits of less likely banking crises from lower bank leverage.

## 7.3 Alternative scenarios in taxation, rates of interest, Modigliani-Miller-effect

Miles et al. (April, 2011) look six different scenarios for changes in bank weighted average cost of capital and lost output: 1) Cost of bank equity capital does not change when leverage is halved and taxes are a true economic cost. 2) They allow a 45% Modigliani-Miller hypothesis to banks' cost of equity with the tax effect. 3) They allow the Modigliani-Miller offset to be 75%. 4) Real discount rate of interest is assumed to be 5,0%. 5) Bank share of funding in non-financial companies is set in 16%. 6) Equity market risk premium is assumed to be 7,5%.

In all cases they simulate results for halved bank leverage. Miles et al.'s (April, 2011) results are reported in the following two tables that are both direct depictions from their paper Optimal bank capital (April, 2011). In the following result tables, the bolded figures stand for the base case results introduced in sections 7.1. and 7.2.

Economic impact of halving bank leverage, basis points. (Miles et al., April 2011)

| | Tax effect, 0% Modigliani-Miller offset | Tax effect, 45 % Modigliani-Miller offset | No tax effect, 75% Modigliani-Miller offset | **No tax effect, 45% Modigliani-Miller offset** |
|---|---|---|---|---|
| Change in bank WACC | 38,0 | 22,5 | 7,7 | **17,9** |
| Change in PNFC[17] WACC | 12,7 | 7,5 | 2,6 | **6,0** |
| Fall in long run annual GDP | 31,7 | 18,8 | 6,4 | **14,9** |
| Fall in GDP in present value | 1268 | 751 | 256 | **596** |

[17] Private Non-Financial Companies

**Economic impact of halving bank leverage, basis points (Miles et al., April 2011)**

| | **No tax effect, 45% Modigliani-Miller offset** | Higher discount rate, 5,0% | Lower share of banks in PNFC finance, 16,0% | Higher equity market risk premium, 7,5% |
|---|---|---|---|---|
| **Change in bank WACC** | **17,9** | 17,9 | 17,9 | 26,8 |
| **Change in PNFC[18] WACC** | **6,0** | 6,0 | 2,9 | 8,9 |
| **Fall in long run annual GDP** | **14,9** | 14,9 | 7,1 | 22,3 |
| **Fall in GDP in present value** | **596** | 298 | 286 | 894 |

The two tables indicate Miles et al's (April, 2011) estimates on bank and non-financial firm WACC, and GDP losses if assumptions concerning taxation, Modigliani-Miller offset impact on bank equity, real societal discount rate, external debt's share of firms' source of funding, and equity market risk premium are changed. Required rate of return on bank debt has been kept fixed in all estimations. Within these assumptions bank total cost of capital increases with doubled equity capital between 7,7bps and 38,0bps, or 0,077% and 0,38%, and GDP losses in annual basis vary between 6,4bps and 31,7bps, or 0,064% and 0,317%. If required returns on bank debt were allowed to drop as equity capital is increased, as the Modigliani-Miller theorem implies, increases in bank total cost of capital and GDP losses would drop from the above estimates. This would still give support for increasing banks' equity capital share of funding[19]. Miles et al. (April, 2011) keep the assumption that there are no deadweight costs associated with banks' profit of investors capital or dividend taxation. In reality this assumption is false, but for sake of simplifying the analysis, the assumption is kept.

## 7.4 Benefits of higher bank equity capital

According to Miles et al. (April, 2011), benefits from higher equity capital in banks' funding come in the present value of expected future costs of avoided bank insolvencies. The outcome should be more robust

[18] Private Non-Financial Companies

[19] Miles et al. (April, 2011) point out that required rates of return on bank debt capital might not change after heavier capital regulation measures because of public implicit bank debt insurance programs.

banking sector and lower frequency of crises. The authors (April, 2011) define a banking crisis as a situation where many banks come close to, or end up into insolvency, and insolvency as a situation where asset values have fallen below the value of liabilities. (Miles et al., April, 2011) Put another way, they say insolvency appears when bank asset value fall exceeds the value of bank's loss-absorbing equity capital. Furthermore, Miles et al (April, 2011) say asset value falls are system-wide, meaning they are not isolated to any particular bank.

### 7.4.1 Probability Calibration of banking crises

Miles et al. (April, 2011) use as starting point facts that bank asset values fluctuate over time, that banking crises result from extreme negative fluctuation, and that these extreme fluctuations appear with higher frequency than predicted by normal distribution. They therefore reject the normal distribution for a model for banking crises distributions.

Miles et al. (April, 2011) assume bank assets to be debt contracts of varying risk-weights[20], and that ability of borrowers to service their debts depends on their income and savings that in turn, depend on permanent fluctuations in GDP. Further, they assume each bank asset's value declines to be linked to permanent falls in GDP[21]. They specifically assume that percentage changes in risk-weighted assets to move in line with any permanent change in GDP. On asset value loss calibration from a permanent GDP drop, asset risk-weights work in Miles et al.'s (April, 2011) model as a multiplier of GDP fall to losses. Following Basel III-accord definitions for UK bank asset risk weighing, Miles et al. (April, 2011) aggregate individual risk-weights to an average risk-weight for total bank assets: if bank has risk weighted assets in relation of 1/2,25 on average to its total assets, the average risk weight of bank's total assets is $\frac{1}{2{,}25} \approx 0{,}45 = 45\%$. Then, if GDP falls in permanent basis by 10%, bank asset value drops by $10\% * 0{,}45 = 4{,}5\%$. Bank assets initially worth £1,0 would be worth 95,50p. The required leverage to sustain such loss would have to be lower than $\frac{1}{0{,}045} = 22{,}22$.

When looking at past recessions, that is GDP declines, with actual historical values together with bank asset value declines, Miles et al. (April, 2011) note that the two go often hand in hand. They assume risk-weighted assets to be more exposed to GDP declines, and as Basel III measures for risk-weighted assets set them to be 45% of total bank assets, this would suggest risk-weighted asset value falls to be over twice as great as those of other assets. This refutes the assumption that risk-weighted assets and GDP falls move in

[20] Miles et al. (April, 2011) classify each bank asset using risk weights ranging from 0 to infinity, $RWA \in [0, \infty]$. RWA (0) means the asset, a debt contract, is always repaid. RWA (>0) means that for every permanent percentage point drop in GDP, GDP(%), risk weighted asset's value permanently declines by the factor of GDP(%).

[21] Miles et al. (April, 2011) use a model for GDP fluctuations that is a random walk with drift and a stochastic term that has a mixed distribution. The model implies GDP changes to be permanent – the GDP has a unit root in the model. For further information, see Miles et al (April, 2011; p. 27)

equal portions. However, since bank assets are treated in average risk-weights, the authors retain their assumption of equal percentage falls in annual GDP and bank asset values.

Miles et al. (April, 2011) use an assumed probability distribution on annual GDP fluctuations to calibrate the probability of banking crisis in any given year for different levels of bank capital. For data, they use annual per capita income fluctuations from a group of 31 countries over a period from 1821 through 2008. The authors' results (April, 2011) on GDP fluctuations give two significant insights: first, changes in GDP fluctuations do not follow the normal distribution, the frequency of large shocks to incomes are "very much greater" than implied by the normal distribution. Second, big negative fluctuations appear more frequently than big rises. (Miles et al., April, 2011) Otherwise, the normal distribution matches their GDP fluctuation findings well. The graphical depiction of Miles et al.'s (April, 2011) results on annual GDP fluctuations is given below.

**Frequency distribution of annual falls in per capita GDP; Miles et al, April, 2011**

| **Annual per capita GDP fall** | >20% | >15% | >10% | >5% | >2% | >0% |
|---|---|---|---|---|---|---|
| **Observed frequency (%)** | 0,40 | 1,21 | 2,48 | 6,95 | 13,8 | 27,10 |
| **Frequency implied by normal distribution (%)** | 0,006 | 0,16 | 1,90 | 11,58 | 25,17 | 37,50 |

The essential thing to keep in mind when looking at the above results is that Miles et al. (April, 2011) find some evidence that annual per capita GDP falls are equal to bank asset value declines weighted by the average risk of total bank assets. The results are therefore that banks are to face annual total asset value declines of higher than 5% once every 14 years, higher than 10% once every 40 years and higher than 15% once every 80 years. In practice this says that once every few decades a shock comes that is very large and that does not follow the prediction by the normal distribution. So, if one assumes that average risk

weighted bank assets fluctuate in line with GDP, then banks need loss-absorbing equity capital in equal proportions to their liabilities, i.e. 5%, 10% and 15%, to sustain such declines[22].

### 7.4.2 Cost Calibration of banking crises

Miles et al. (April, 2011) use the approach by the Bank of England to calibrate the cost of a systemic banking crisis. Initially, following the crises, GDP drops by a particular amount. For the following five years, the drop in annual GDP due to the crisis is 75% of the initial loss, and a quarter of the size of the initial loss is permanently lost. Using a real discount rate ($\delta$) of 2,5%, and the assumption that the initial drop is 10%, Miles et al. (April, 2011) estimate the present value gain in permanently decreasing the likelihood of a systemic banking crisis in any given year by one percentage point to be 55% of current annual GDP.

The equation used by Miles et al. (April, 2011) to calculate accumulated total present value of one banking crises (LPC) is:

$$LPC = \left(\frac{3}{4} * \frac{1-\delta^5}{1-\delta} + \frac{1}{4} * \frac{1}{1-\delta}\right) * 10\%,$$

$$LPC \approx 140\% \; of \; GDP, when \; \delta = 2{,}5\% \; .$$

Therefore, for every percentage point by which the likelihood of a particular banking crises is reduced, the present value cost of that banking crises is reduced by 140% / 100 = 1,4%. (Miles et al., April 2011)

As higher capital requirements reduce also the probability of all future banking crises, the present value of the expected benefit for reducing the probability of all future banking crises by one percentage point is 1,4% / 0,025 ≈ 55% of GDP. (Miles et al., April, 2011)

The result is sensitive to assumption of a banking crisis having permanent effects on income – assumed equal to gross domestic product – and persistence of crisis. (Miles et al., April, 2011) If effects were temporary, the expected gain for higher bank capital requirements reducing the chance of banking crisis drops to 20% of annual GDP for one percentage point decrease in the likelihood of crises occurrence. (Miles et al., April, 2011)

Miles et al. (April, 2011) conclude estimations of expected costs of systemic banking crises as follows: if very rare and negative shocks to household incomes and GDP are allowed that follow historic evidence in their occurrence, there are large benefits to be expected for having banks use higher proportion of loss-absorbing equity capital in their funding. (Miles et al., April, 2011)

[22] These figures are in Basel II Tier-1 capital. In Basel III risk weights, the equity capital requirements, the CET1, would be about 60% of the Tier 1 measures, since CET 1 is essentially pure equity, and Tier 1 a combination of equity and hybrid instruments.

## 7.5 Calibrating Optimal Capital Ratios

Given the estimates of social costs and benefits for higher proportional equity funding of banks, Miles et al. (April, 2011) optimize a socially-optimal level of capital for the banking sector, that is the capital ratio at which the marginal benefit for decreased expected costs of future systemic banking crises just outweighs the extra cost for decreased total output of non-financial firms for having higher total capital costs. Miles et al. (April, 2011) measure costs and benefits in expected present value of changes to the future levels of GDP.

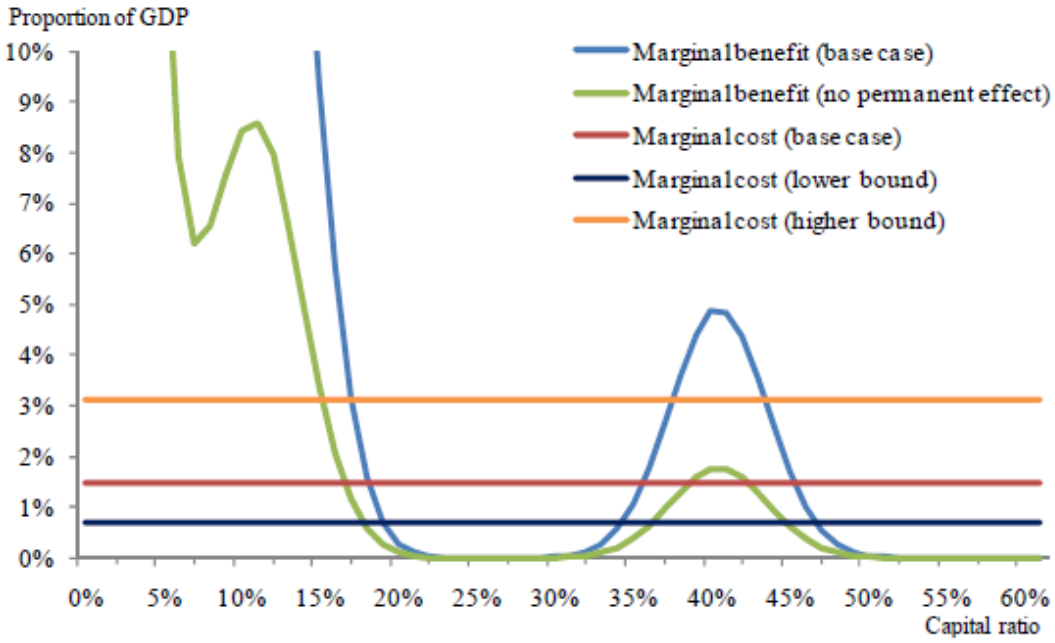
Miles et al. (April, 2011) use two estimates of the marginal benefits of higher bank capital for capital level calibration: one, the base case, in which a banking crises is assumed to have a permanent negative effect of one quarter of the initial fall after the crisis on GDP, and another where after five years of the crisis the GDP is expected return to the initial level. In both cases, the marginal benefits decline rapidly as the bank capital ratio to risk weighted bank assets increases, but once reached, the level-state does not decline. In chart 5 below by Miles et al. (April, 2011) the capital ratio axis refers to pure capital in relation to the risk weighted assets[23].

In measuring costs for having banks use more equity in relation to risk weighted assets, Miles et al. (April, 2011) translate the change in the aforementioned capital ratio to change in the banks weighted average cost of funds. When bank leverage is halved, the estimate of the permanent loss in annual GDP due to increased total capital costs of non-financial companies by Miles et al. (April, 2011) was 596 basis points in present value. Miles et al.'s (April, 2011) estimate the increase in the ratio of pure bank equity capital to risk weighted bank asset to be 4,064 percentage points when UK bank leverage is halved in Basel III - definitions for loss-absorbing bank capital and risk weighted assets. So, the cost of one additional percentage point of pure bank equity capital in relation to risk weighted bank assets in lost GDP in present value is $\frac{596bp}{4{,}064} = 149bp$. The authors (April, 2011) use this estimate of marginal cost of bank equity capital as their base case[24].

[23] E.g. For total bank assets being 2,5 times the risk weighted bank assets, or risk weighted assets being 1/2,5 = 0,4 times total bank assets, 20% Capital ratio in the chart 5 means the total bank asset equity capital ratio, or leverage, is 1/(0,4 * 0,20) = 12,5. This means 0,4*0,20 = 0,08 or 8% ratio of equity capital to total assets.

[24] Miles et al. (April, 2011) estimate two other figures for marginal cost of bank equity capital: the *higher bound*, where the cost of bank equity capital does not change with halved leverage and bank taxes are a loss to society (>300bp per percentage increase of pure equity capital to risk weighted assets), and a *lower bound* where banks provide 16% of non-financial firms' funding (<100bp per percentage increase in pure capital to risk weighted assets). Please refer to Chart 5 and the tables Economic impact of halving bank leverage above.

**Chart 5. Expected marginal costs and benefits of more capital**




[25]

Chart 5 is a direct depiction of Miles et al.'s (April, 2011) results on marginal benefits and costs of higher bank capital. The increased benefits at 40% capital ratio level corresponds to very rare, hyper negative shocks to incomes where bank asset values drop in order of 35%. This particular result is however neglected, because the true probability and effects of such events are difficult to estimate accurately. (Miles et al.; April, 2011) While such restrictions on results are imposed by the authors (April, 2011), they conclude the results validly point the optimal ratio of loss-absorbing pure bank equity capital to risk weighted bank assets to lie between a range of 15 and 20 per cent depending on assumptions concerning crises cost permanency and total bank capital cost formation. In Basel III -measures and 0,4 risk weight of total assets of UK banks, this turns to 0,4*0,15=0,06 = 6,0%, and 0,4*0,20=0,08=8,0% of equity capital to total asset ratios, and the corresponding leverage ratios of 100%/6,0% = 16,7 and 100%/8,0% = 12,5. When compared to the realized UK banking industry's average capital ratio in the second half of 2011, Miles et al.'s (April, 2011) recommendation on capital to total asset ratio would mean additional bank capital ratios of 8,0%-4,7%=3,3%, and 6,0%-4,7%=1,3% in the UK.

The two tables on optimal capital ratios below are directly depicted from Miles et al.'s paper (April, 2011) and illustrate the optimal capital to risk weighted assets ratios in different scenarios of cost and benefit formation.

[25] Source: Miles et al., April, 2011

**Optimal capital to risk weighted assets ratios, full distribution of bad events, Miles et al (April, 2011)**

| | Banking crises have permanent effects on GDP growth | Banking crises have no permanent effects on GDP growth |
|---|---|---|
| **45% Modigliani-Miller offset, no tax effects** | 19% | 17% |
| **45% Modigliani-Miller offset, no tax effects, lower share of banks in PNFC finance, 16,0%** | 47% | 18% |
| **0% Modigliani-Miller offset, tax effect** | 18% | 16% |

**Optimal capital to risk weighted assets ratios, exclusion of worst events, Miles et al (April, 2011)**

| | Banking crises have permanent effects on GDP growth | Banking crises have no permanent effects on GDP growth |
|---|---|---|
| **45% Modigliani-Miller offset, no tax effects** | 19% | 17% |
| **45% Modigliani-Miller offset, no tax effects, lower share of banks in PNFC finance, 16,0%** | 20% | 18% |
| **0% Modigliani-Miller offset, tax effect** | 18% | 16% |

The only peculiar result depicted above is the 47% equity capital to risk weighted bank asset -ratio in the scenario where there is an unlikely possibility of a super negative shock on incomes and non-financial companies take only 16% of their funding from bank loans. As the worst income shock scenarios are excluded for the uncertainty of their actual effects, the optimal bank capital ratio range is between 16 and

20 per cent of risk weighted bank assets. Chart 5 by Miles et al (April, 2011) also illustrates that capital ratios below 5% of risk weighted assets (0,05*0,4=0,02=2% of total assets) would not provide maximal net utility from increased bank equity capital funding, and ratios above 20% of risk weighted assets (0,2*0,4 = 0,08=8% of total assets) are not to be expected to either increase or decrease such utility.

According to Miles et al (April, 2011) the Basel III -accord on bank capital sets the minimum target for common equity capital at 7% of risk-weighted assets – meaning leverage ratio of 1/(0,4*0,07) = 35,7 and pure capital to total asset ratio of 0,4*0,07 = 2,8% - and redefines capital to be loss-absorbing capital, essentially, pure equity. On this basis, the UK banking industry was inferior in equity funding to Basel III – accord's minimum target for common equity capital with equity to total asset ratio of 2,4%.

# 8 Systemic Bank Capital Allocation – Webber and Willison model

Lewis Webber and Matthew Willison (Systemic capital requirements; October, 2011) approach bank capital requirement question from an individual bank's credit risk to the whole financial system. Their analysis slightly differs in assumptions from that of Miles et al. Webber and Willison (October, 2011) assume banks within the financial system to share same assets and thus, to be positively correlated in asset value fluctuations, and the aggregate bank financial distress costs to spread and increase within the financial system through the interbank markets. Miles et al. (April, 2011) share the asset value fluctuations to be positively correlated between the banks, but omit the costs of insolvencies to spread and amplify through the interbank markets. Consequently, should some banks collapse, the impacts on solvency of other banks in the system vary between the two papers.

Webber and Willison (October, 2011) calibrate equity capital requirements for banks using a "system-wide risk management approach" that takes into account varying features in balance sheet size, types of exposures to real economy, that is the assets, and obligations to other institutions between banks. They optimize minimum bank equity capital for the financial system in aggregate and how it should be distributed between individual banks for gaining the optimal systemic bank credit risk.

## 8.1 Introduction

Webber and Willison argue the traditional banking regulation to be flawed on the basis that it assumes that every bank can be made safe by focusing on its individual risks affecting its solvency[26]. (Webber et Willison; October, 2011) There are two reasons: one is that some banks' assets may be similar, so their values fluctuate simultaneously in same direction in all banks' balance sheets concerned. The other is that if an individual bank would default on its debt obligations, it may trigger contagious failures of other banks in the banking system through interbank lending. (Webber and Willison; October, 2011). The authors argue such system-wide losses could far exceed the size of the initial shock.

On these two bases, Webber and Willison say a change in assessing risks of the banking system and in setting capital requirements for banks accordingly could be beneficial. Bank capital requirement should reflect the extent that an individual bank's failure would have on the wider system and the likelihood of following contagious losses. (Webber and Willison; October, 2011).

As a starting point for their analysis Webber and Willison use a banking system insolvency risk level that a policy setting authority is willing to accept. This means a probability of a system-wide insolvency appearing in a period of time that the authority is willing to accept. A systemic bank capital requirement is then set and distributed over individual banks in the system, such that it satisfies the risk tolerance level, while at

[26] Webber and Willison sight the Basel II –accord as an example of such regulative approach. (Webber et Willison; October 2011, p. 5)

same time minimizes increase in the cost of capital of non-banking firms due to expected higher lending rates offered by banks. Such a risk tolerance level is a constrained problem where the policy maker has to decide between stability of the banking system, meaning banks carrying larger equity capital proportions on their funding, and the efficiency of the banking system, meaning how much borrowing costs of non-banking firms increase when banks are required to use more equity capital in their funding. (Webber and Willison; October, 2011)

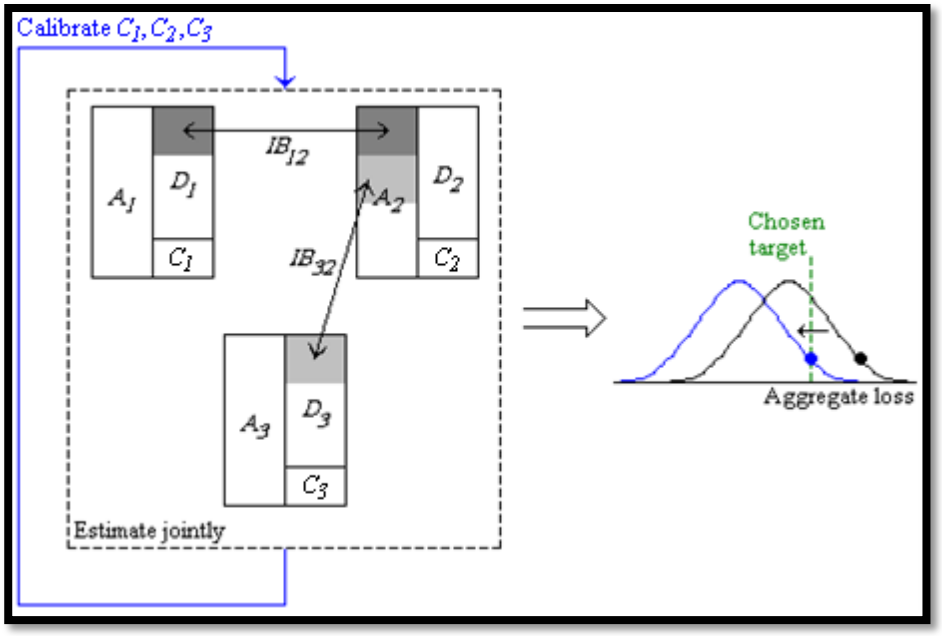
According to Webber and Willison, shocks to banks' non-bank assets are drivers of their insolvency. The systemic risk drivers of the shocks are previously mentioned share assets on bank balance sheets and the interbank markets that amplify and spread an initial shock and the following credit loss through the rest of the financial system. (Webber et Willison; October, 2011)

## 8.2 Model

I present here the model used by Webber and Willison (October, 2011). The model is presented in two parts: first, the general model, or a benchmark model, is presented to illustrate the occurrence of systemic risk of insolvency and its evolvement in the financial system. Then comparative static exercises by Webber and Willison (October, 2011) and their results are introduced. Based on these, the optimal aggregate systemic capital in the financial system and its distribution between individual banks in the system are presented.

### 8.2.1 Benchmark model of an interconnected financial system

The schema below (Kuva 1) is a direct copy of Webber and Willison's model (October, 2011) for illustrating a financial system where banks are interlinked with one another through interbank markets, and depicting how an accepted risk level of systemic insolvency in a banking system is to be reached. In Webber and Willison's model (October, 2011) there is a number of banks $\{i\}, i = [1, n]$ in the system. In the picture below (Kuva 1) there are three banks: 1, 2 and 3. Each bank has got assets, $A_1$, $A_2$ and $A_3$, and funding consisting of debt, $D_1$, $D_2$ and $D_3$; and equity, $C_1$, $C_2$ and $C_3$. The banks are connected with each other through the interbank markets. In the picture below there are two interbank loans outstanding: $IB_{12}$ and $IB_{32}$ where in both cases banks 1 and 3 are indebted to bank 2. By calibrating equity capital ($C_1$, $C_2$ and $C_3$) as a proportion of total funding at every bank and in aggregate in the financial system, a financial system can be reached that in aggregate returns a socially acceptable aggregate loss, a decline in bank asset values, due to a shock marked as the chosen target –line in the picture, with a given frequency and probability.



[27]

**Kuva 1**

In the model by Webber and Willison (October, 2011), every bank holds two kinds of asset and debt securities: those issued outside and inside the banking system. Symbol ($A_i^O$) stands for assets that have been issued by firms outside of the banking system and bring revenue for bank $i$ and ($D_i^O$) for the face value of a zero-coupon debt issued by the bank $i$ to a non-bank firm outside the banking system. Symbol ($A_i^I$) stands for an interbank asset of bank $i$ and ($D_i^I$) for an interbank liability of bank $i$. Both forms of debt have maturity at $t(i) = t$. The solvency positions of banks $\{i\}, i = [1, n]$ are checked at the maturity. The authors (October, 2011) illustrate the interbank obligations in the financial system by an $n$ X $n$ matrix M:

$$M = \begin{bmatrix} 0 & \cdots & D_{1,n}^I \\ \vdots & \ddots & \vdots \\ D_{n,1}^I & \cdots & 0 \end{bmatrix}, \text{ where}$$

$D_i^I = \sum_{j \neq i} D_{ij}^I$ and $A_i^I = \sum_{j \neq i} D_{ij}^I$ . (Webber and Willison; October, 2011)

Total systemic assets are $A \equiv \sum_i A_i = \sum_i (A_i^O + A_i^I)$, and face value of debt liabilities

$D \equiv \sum_i D_i = \sum_i (D_i^O + D_i^I)$. (Webber, Willison; October, 2011)

In Webber and Willison's model, banks are also financed by equity. Every bank $i$ has an equity to total asset ratio of $c_i \equiv C_i / A_i$, where $C_i$ is the nominal value of bank $i$'s outstanding capital. The capital is assumed to be pure common equity. (Webber and Willison; October, 2011)

[27] Source: Webber and Willison; October, 2011

In Webber and Willison's model (October, 2011) bank asset values $(A_i)$ fluctuate randomly following geometric Brownian motion with fixed ex ante expected value parameter $\mu_i$ and volatility $\sigma_i$ ,

$\frac{dA_i}{A_i} = \mu_i\, dt + \sigma_i dW_i^p$ **(1)**.

Asset value shifts are also correlated, $dW_i^p dW_j^p = \rho_{ij} dt \neq 0$.

### 8.2.2 Systemic bank default formation

Bank insolvencies occur through two channels in Webber and Willison's (October, 2011) model. If any bank's assets, say those of bank Y, are less in value than its debt liabilities at a given maturity point $t(x) = t$ the bank is declared fundamentally insolvent. The losses at this point amount to the difference between bank's debt liabilities and assets. Any bank that has extended interbank loans to the now-insolvent bank also incurs losses. As the interbank loan network[28] clears, such a bank, say bank X, may also default in which case default is contagious. Webber and Willison (October, 2011) assume the cost of contagious default is a fixed 10% of defaulting bank's assets. The interbank positions are then again evaluated. The repetition continues until there are no more contagious defaults in the financial system. Denoting all bank's total asset values after the interbank network clearings by $(\tilde{A}_i)$, the total loss $(L)$ at maturity point $t(x) = t$ in the financial system according to Webber and Willison (October, 2011) is:

$L = \sum_i (D_i - \tilde{A}_i t)$, where

$D_i$ = Aggregate outstanding value of debts of bank $i$.

Due to simplifications[29] of the model, Webber and Willison (October, 2011) do not present exact numbers for optimal aggregate systemic bank capital and its distribution, but rather insights that policymakers can follow to reach for their ideal combination of stability and efficiency in their respective financial systems.

[28] The interbank obligations are configured by the matrix M.

[29] Webber and Willison (October, 2011) acknowledge fixing banks' balance sheets to be a simplifications for practicality of their model. In practice, they say, balance sheets are dynamic and banks could seek long-run target leverage –ratios. Another simplification is to fix policymakers target for systemic solvency risk that in reality is an endogenous variable in the model.

## 8.3 Risk Quantification of systemic insolvency

Webber and Willison (October, 2011) quantify parameters for systemic insolvency risk simulation as presented below. The authors use observed bank equity prices in this determination.

Following the function of evolution of bank asset returns **(1)**, they conclude asset returns to be lognormally distributed and estimate an expected change for bank asset returns ($\mu_i$) as:

$\mu_i = \frac{E[lnA_{i,t+\Delta t}] - E[lnA_{i,t}]}{\Delta t} + \frac{1}{2}\sigma_i^2$, where

$\sigma_i$ = bank $i$'s unknown asset return volatility

Using the Normal distribution as model for bank asset return distribution, Webber and Willison (October, 2011) derive a log-likelihood function for these asset returns, $l(\sigma_i)$, that is ultimately determined by the unknown bank asset return volatility ($\sigma_i$).

$l(\sigma_i) = -\frac{1}{2\sigma_i^2 \Delta t}\sum_{t=1}^{T}\left(x_{i,t} - \left(\mu_i - \frac{1}{2}\sigma_i^2\right)\Delta t\right)^2 - \frac{T}{2}\ln(\sigma_i^2 \Delta t) - \frac{T}{2}\ln(2\pi)$ **(2),** where

$x_{i,t} \equiv ln\left(\frac{A_{i,t+\Delta t}}{A_{i,t}}\right)$ = natural logarithm of bank asset return over time interval Δt

$T$ = length of time interval over which bank asset returns ( $\sum x_{i,t}$ ) are calculated in the bank asset return likelihood function

Webber and Willison argue (October, 2011) that the likelihood function **(2)** can be used to estimate each banks' expected change of bank asset returns $(\mu_i) i$=1,2,…,$n$ and correlation structures between banks' asset returns $(\sum ij)$ $i, j$=1,2,…,n. The results of the two previous parameters can then be used to simulate systemic distribution of bank losses when some bank falls to insolvency[30]. (Webber and Willison; October, 2011) One thus obtains estimates for bank insolvency and following systemic insolvencies as follows:

$\mu_i$ = estimate of bank asset return variance, $i$=1,2,…,$n$

$\sum ij$ = matrix of expected asset return correlation between each and every bank, $i, j$=1,2,…,n

Based on the asset return correlation matrix ($\sum ij$), simulations of asset value distribution and asset shortfall distribution for the banking system can be done. (Webber and Willison; October 2011, p.12) Once performed, a percentile ($z$) on the systemic asset value loss distribution can be chosen that produces the

[30] For the exact instruction for calibrating the asset return and correlation parameters, please refer to Webber Willison's paper (October, 2011, p. 11,12)

desired outcome for systemic insolvency, the chosen likelihood of it given. (Webber and Willison; October 2011)

## 8.4 Optimization of systemic aggregate capital for chosen systemic risk target

Webber and Willison (October, 2011) assume higher equity capital in banks to increase lending rates offered to non-financial companies, but to provide stronger barriers against insolvency of the banking system and banks within it. Therefore, a policymaker deciding on the tolerable chance of systemic insolvency of the banking system faces a trade-off and attempts to set minimum systemic capital that is compatible with his chosen insolvency risk-target. (Webber and Willison; October 2011) The policymaker thus has a non-linear optimization problem:

$min_{\{C_i\}_{i=1,2,\dots,n}} \ (\sum_i C_i) \ \ s.t. systemic\ risk\ objective$, where

$C_i$ = the nominal value of bank $i$'s outstanding equity capital (Webber and Willison; October, 2011)

The systemic risk objective is defined by Webber and Willison (October, 2011) as a target for the location of the $z$th percentile on the systemic bank asset value loss distribution given the debt liabilities of banks. The optimization problem form therefore is:

$$min_{\{C_i\}_{i=1,2,\dots,n}} \ (\sum_i C_i) \ \ s.t. \ VaR_z^{system}\left(\{C_i\}_{i=1,2,\dots,n}\right) = 0 \quad \textbf{(3)}$$ (Webber and Willison; October 2011)

Webber and Willison (October, 2011) present the constrain in optimization equation **(3)**, $VaR_z^{system}\left(\{C_i\}_{i=1,2,\dots,n}\right) = 0$, also in an equivalent form, $\Pr(\sum_i A_i(C_i) < \sum_i D_i) = 1 - z$, meaning that the probability of aggregate bank asset values given the bank equity capital being less than the aggregate value of bank debt is $1 - z$ on the normally distributed model of bank asset value declines. The parameter $z$ depicts a tradeoff between additional bank equity capital increasing debt capital interest rates offered to non-financial firms[31]. (Webber and Willison; October 2011)

Webber and Willison (October, 2011) optimize the aggregate equity capital for a banking system in four steps:

1. Optimize the total level of equity capital in the banking system such that the systemic risk target - $VaR_z^{system}\left(\{C_i\}_{i=1,2,\dots,n}\right) = 0 \equiv \Pr(\sum_i A_i(C_i) < \sum_i D_i) = 1 - z$ – is satisfied. This is done first by

[31] In cases where equity capital would not significantly increase the total capital cost of banks, i.e. where there would be small trade-off between systemic risk and economic efficiency, a high value of $z$ would be suitable. (Webber and Willison; October 2011) Miles et al (April, 2011) estimated total bank cost of capital to be rather insensitive to capital structure changes. In empirical study of the thesis, I study this question by a cross-industrial comparison of weighted total cost of capital.

holding relative capital shares between all banks fixed and then by increasing (decreasing) the aggregate capital amount if $VaR_z^{system}\left(\{C_i\}_{i=1,2,\dots,n}\right) > (<)\ 0$.

2. If possible, the shares of aggregate equity capital at each bank, $\{C_i\}_{i=1,2,\dots,n} \rightarrow \left\{\tilde{C}_i\right\}_{i=1,2,\dots,n}$, are adjusted so that the chosen measure for tolerance level is reduced, $VaR_z^{system}\left(\left\{\tilde{C}_i\right\}_{i=1,2,\dots,n}\right) < 0$. If this can be done, the new allocation of equity capital between banks in the system is superior to the initial capital allocation, because the risk for systemic insolvency has been reduced by the initial amount of aggregate capital and efficiency of the system.
3. The aggregate bank capital is then marginally reduced in identical proportions at each bank, and the allocation of capital between all banks is ran again so that the measure for risk tolerance is again reduced.
4. Procedures in decreasing the aggregate systemic capital amount, increasing the efficiency of the system, and reallocating the shares of capital for reduced risk tolerance level, reducing the chance of systemic insolvency, in parts 2. and 3. are repeated until it is no longer possible to decrease capital and increase efficiency of the system on the bases of higher buffers brought upon by capital allocations without the initial tolerance level being reduced. At this point the minimum level of bank capital in the system is reached that ensures the socially desired risk-level for systemic banking crises.

(Webber and Willison; October, 2011)

In relation to regulating bank capital on microprudential basis, Webber and Willison (October, 2011) argue that the policymakers' objective function **(3)** could modified so that it depicts a minimum level of capital that banks would have to carry, or that it would include a factor that represents banks supplying a particular minimum amount of credit to the economy in downturns. The authors point out that these modifications would not however yield plausible results when bank capital ratios would be view in systemic perspective as described above.

## 8.5 Details of calibration

Webber and Willison (October, 2011) use UK banks' published records from the first half of year 2004 to the first half of year 2009 as data to calibrate their simulation. The authors define bank debt as total liabilities excluded from large interbank exposures[32], minus shareholder funds excluding minority interests. The large exposures are used to construct the matrix $M$ on the interbank obligations between banks. In case of contagious bank default resulting from interbank exposure, the defaulting bank's assets are marked

[32] Large interbank exposures mean exposures that exceed 10% of the sum of bank's Tier 1 and Tier 2 capital (Webber and Willison; October, 2011)

down by 10% from the level reached from all previous fundamental defaults.[33] (Webber and Willison; October, 2011)

Webber and Willison (October, 2011) also calibrate their model so that banks' debts have maturity of one year. The policymaker is assumed to want to reach the 95th percentile of the loss distribution for the system, meaning the $z$-value of 0,05. Webber and Willison (October, 2011) construct the estimate of distribution of asset value changes from 50000 simulations of bank asset return drifts within the study period. (Webber and Willison; October, 2011)

## 8.6 Benchmark results

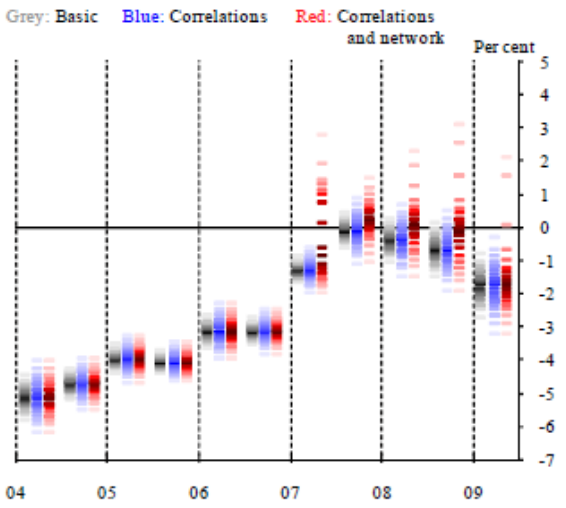
Webber and Willison (October, 2011) estimate the correlations between banks' asset returns to have been positive, and spread between values $[0.29,0.80]$ within the study period, the first half of year 2004 and first half of year 2009, $[H1{,}2004; H1{,}2009]$. The depiction (Kuva 2)[34] with Charts 1 and 2 on the next page introduces Webber and Willison's findings (October, 2011) for system-wide aggregate bank asset value losses with different assumptions concerning asset value drift correlations between banks and contagious default formation in the financial system. The results are that if the banking system becomes under stress, as of the first half of year 2007, and losses from one bank spread through the interbank markets with bank asset value correlations allowed, the probability of systemic insolvency in the banking system and frequencies of higher systemic total losses increase dramatically. (Webber and Willison; October, 2011) Authors' results on bank asset value losses therefore support Gorton's (Gorton; May,9) and Krugman's (Krugman; April 1, 2010) findings that the recent banking crisis's formation was significantly affected by what happened in the interbank markets.

Webber and Willson (October, 2011) conclude that estimating the health of the banking system simply by estimating banks' balance sheets as if they were isolated from each other and aggregating across all banks to be faulty. Also, already when banks' asset value drift correlations are allowed, but interbank market interconnectedness is not, aggregate losses in the system increase when the system comes under pressure. (Webber and Willison; October, 2011)

[33] Diffusion of asset value declines follows the asset value changes depicted in equation (1).
[34] A direct depiction from Webber and Willison (October, 2011; p.16)

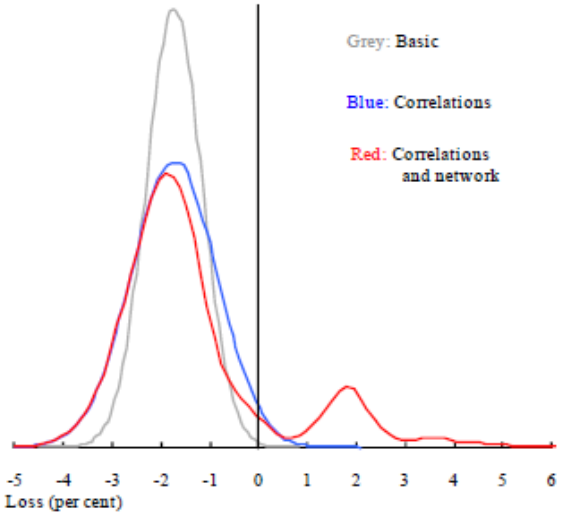
35

**Chart 1: Evolution of aggregate losses in the banking system over time**[(a)(b)]




(a) Percentiles of aggregate loss distribution across a panel of UK banks: based on stand-alone balance sheets (grey); accounting for correlation between asset returns across banks (blue); and accounting for asset return correlation and explicit interbank exposures between firms, assuming contagious default carries a deadweight cost of 10% of assets (red).
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Chart 2: Distribution of aggregate losses in the banking system (2009 H1)**[(a)(b)]




(a) Aggregate loss distribution across a panel of major UK banks: based on stand-alone balance sheets (grey); accounting for correlation between asset returns across banks (blue); and accounting for asset return correlation and explicit interbank exposures between firms, assuming contagious default carries a deadweight cost of 10% of assets (red).
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Kuva 2**

[35] In chart 1, biannual results on loss distribution are in groups of three bars. In the groups, left bar is what the chart refers to as basic, the middle bar is with correlations, and the right one is correlations and network.
In chart 2, the most centered distribution curve is basic; of the two lower curves, the one more biased toward positive aggregate losses without the hump is with correlations; and the curve less biased for positive losses with the hump is correlations and network.

Source: Webber and Willison; October, 2011

## 8.7 Simulation of changes in banking system features

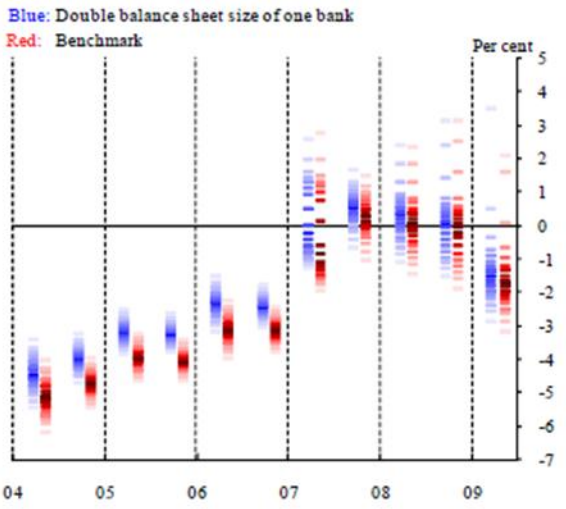
This part describes Webber and Willison's findings (October, 2011) on the aggregate systemic risk of the banking system when characteristics of the system are changed in: the size of one bank in the system; the degree of interconnectedness of banks; the deadweight cost of contagious default; and holding fixed all asset value diffusion parameters. The results are estimated in comparison to the benchmark simulation of asset value loss distribution when asset value change correlations between banks and asset value loss diffusion through interbank markets are allowed.

### 8.7.1 Doubling the balance sheet size of one bank

Webber and Willison (October, 2011) find that as a consequence of insolvency of a bank whose balance sheet size has been doubled, all else equal, the expected value of aggregate losses, their frequency, and the frequency of abnormally high positive aggregate losses over the system increase, thus having a greater impact on the solvency of the banking system. The cost of the fundamental insolvency of the balance sheet size doubled bank increases the size of interbank loan losses of other banks in the system that have extended loans to the defaulting bank. These higher losses from interbank obligations tend to trigger more contagious defaults in the banking system in response to the same hypothetical asset value shock. As the contagious defaults would spread from one bank to another, the aggregate losses over all the banking system would increase. (Webber and Willison; October 2011). The charts below (Kuva 3) graphically depict the results.

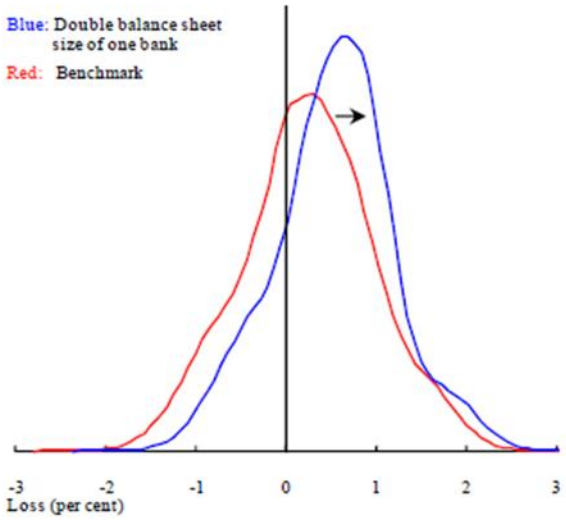
36

**Chart 3: Evolution of aggregate losses in the banking system over time when one bank doubles in size**[(a)(b)]




(a) Percentiles of aggregate loss distribution across a panel of UK banks.
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Chart 4: Distribution of aggregate losses in the banking system when one bank doubles in size (2007 H2)**[(a)]




(a) Loss expressed as a fraction of system-wide debt liabilities.

**Kuva 3**

### 8.7.2 Increasing interconnectedness of the banking system

Simulating the effect of increased interconnectedness of banks in the interbank markets by doubling all outstanding interbank obligations between banks, Webber and Willison make two findings. (October, 2011) First, that in times, when the banking system is sufficiently capitalized in aggregate in relation to the riskiness of assets within it, the risk profile of banking system's solvency does not change. The other finding is that once the relation between aggregate capitalization and asset riskiness deteriorates sufficiently, the expected value of asset value losses increase and frequency of abnormally high positive aggregate asset value losses increase. The authors claim the mechanisms for this are contagious insolvencies. (Webber and Willison; October 2011) Charts 5 and 6 constructed by Webber and Willison (October, 2011) and illustrated in Kuva 4 below, depict the results graphically. Webber and Willison (October, 2011) argue that the initial capitalization state of the banking system dictates the scale by which the aggregate loss distribution in the

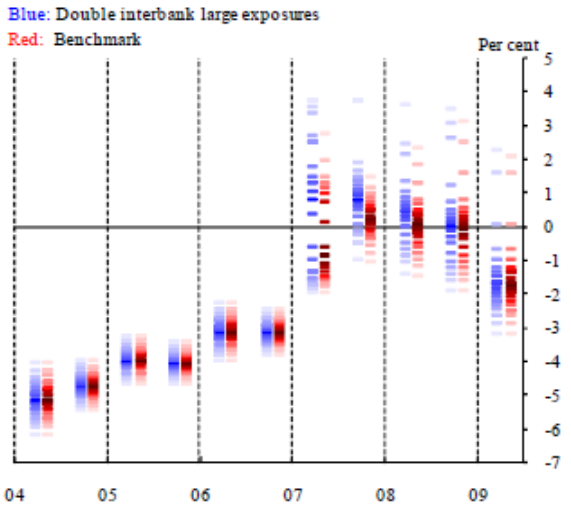
[36] In chart 3, biannual results on loss distribution are in groups of two. In the groups, left bar is systemic loss distribution with one bank balance sheet doubled, the right one is the benchmark with correlation and contagious losses allowed.
In chart 4, the left curve is the benchmark case distribution; the right curve is loss distribution with doubled balance sheet size.

Source: Webber and Willison; October, 2011

system changes when the interbank obligations are changed. Therefore, the changes depicted in charts 5 and 6 on doubling the obligations are illustrative on the UK banking system between 2004-2009, and not globally applicable to every banking system.

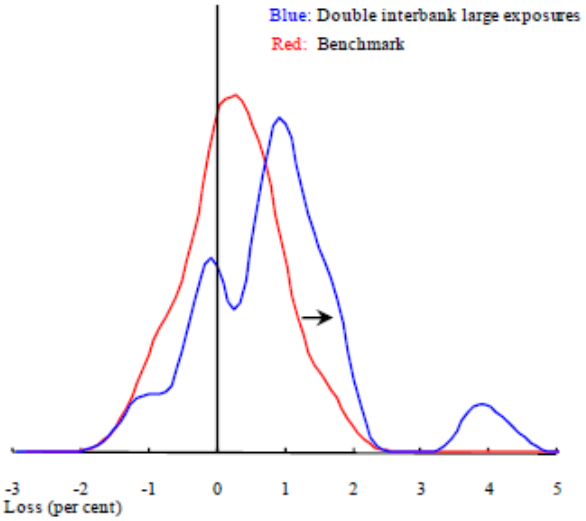
[37]

**Chart 5: Evolution of aggregate losses in the banking system over time when interbank exposures double in size**[(a)(b)]




(a) Percentiles of aggregate loss distribution across a panel of UK banks.
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Chart 6: Distribution of aggregate losses in the banking system when interbank exposures double in size (2007 H2)**[(a)]




(a) Loss expressed as a fraction of system-wide debt liabilities.

**Kuva 4**

### 8.7.3 Increasing deadweight costs of contagious default

Deadweight costs are in practice bankruptcy costs that are mostly legislative costs resulting from asset liquidation of a defaulting corporation. As with increased interconnectedness, increased contagious asset value losses in banks become significant when banks start to incur losses from investments in such extent that insolvencies begin to emerge. (Webber and Willison; October 2011) The mechanism is that when insolvency costs due to contagion increase, other banks in the banking system get more prone to have their asset values decreased. The contagion tends to spread further in the banking system causing higher aggregate losses with higher costs of contagion before the default swirl is contained. (Webber and Willison;

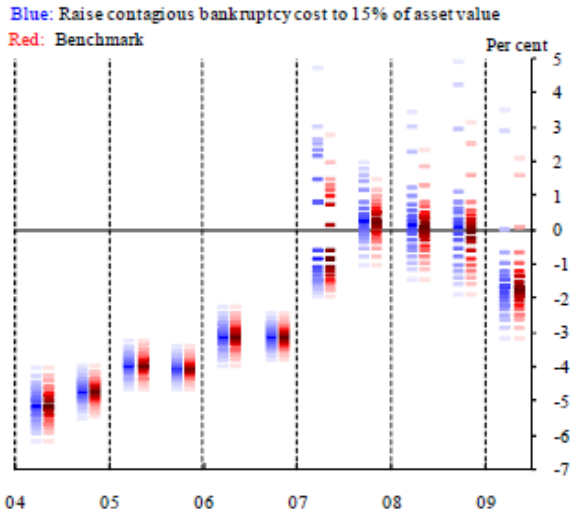
[37] In chart 5, biannual results on loss distribution are in groups of two. In the groups, left bar is systemic loss distribution with interbank obligations doubled; the right one is the benchmark case with initial obligations, asset value correlation and contagious losses.
In chart 6, the left curve is the benchmark case distribution; the right curve with loss accumulation of 4% is loss distribution with doubled interbank obligations.

Source: Webber and Willison; October, 2011

October 2011) Charts 7 and 8 depict the results by Webber and Willison (October, 2011) below (Kuva 5). The essential result is increased frequency of abnormally high aggregate asset value losses within the entire banking system.

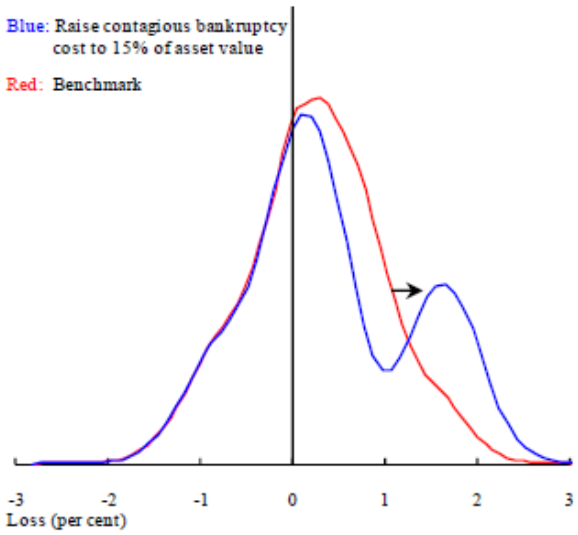
[38]

**Chart 7: Evolution of aggregate losses in the banking system over time when raising the cost of contagious default**[(a)(b)]




(a) Percentiles of aggregate loss distribution across a panel of UK banks.
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Chart 8: Distribution of aggregate losses in the banking system when raising the cost of contagious default (2007 H2)**[(a)(b)]




(a) Loss expressed as a fraction of system-wide debt liabilities.
(b) Cost of contagious default raised to 15% of asset value, from 10% in the benchmark case.

**Kuva 5**

### 8.7.4 Fixing parameters for finding regulations macroeconomic influences

Webber and Willison (October 2011) also look at the influence macroeconomic factors on aggregate banking system losses to assess how leverage regulation of banks should evolve over time. The authors find that bank capital regulation should be countercyclical, hampering leverage increase at banks in cyclical upswings and preventing leverage decreases in downturns. (Webber and Willison; October, 2011) They base their arguments on the following methods and findings.

[38] In chart 7, biannual results on loss distribution are in groups of two. In the groups, left bar is systemic loss distribution with increased exogenous contagion cost of 15%; the right one is the benchmark case with initial contagious loss of 10%.
In chart 8, the above curve is the benchmark case distribution with initial asset value correlations and contagion loss of 10%; the right curve is loss distribution with contagion cost of 15%.

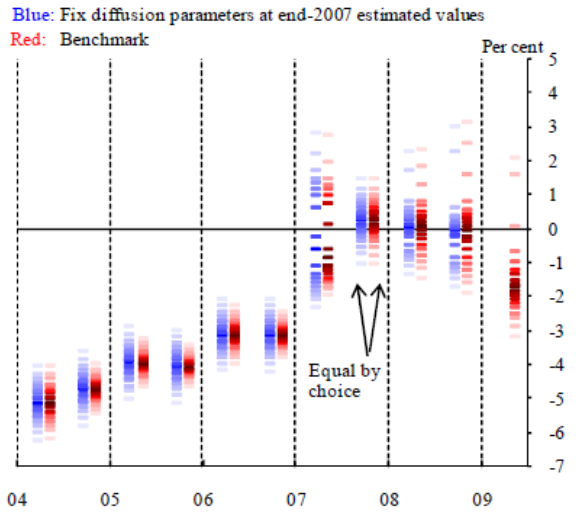
Source: Webber and Willison; October, 2011

Webber and Willison (October 2011) fix the expected value of banks' asset return and asset return correlation in-between them to the end-of-year 2007 levels. The two values reflect the composition and network of banks' balance sheets at that point of time. They then run the simulation on individual bank's asset value losses and their aggregate distribution over all study periods $[H1{,}2004; H1{,}2009]$. Using the fixed values, Webber and Willison (October, 2011) estimate how the aggregate distribution of individual banks' losses and the expected value of those losses would have been different had the characteristics of the financial system and consequently the financial regulation measures been in all studied periods what they were in the end of year 2007.

What the authors find is that the spread of individual banks' aggregate asset value losses would have widened in the run up to the recent banking crisis – expected by the authors to have begun in the beginning of year 2007 – and narrows slightly in the crisis periods observed $[H1{,}2008; H2{,}2008]$. Also, the highest single bank asset value loss in the crisis periods of the studied banks would have been smaller. (Webber and Willison; October, 2011) In other words, had the regulation measures on bank leverage been fixed all the time during the five-year-period studied, asset losses before the first half of 2007 would have been higher but would not have exceeded the aggregate banking system equity capital. The losses after the point of time 2007 first half, would have been less spread than what they actually were, although would still have exceeded the aggregate banking system equity capital. On this basis the authors conclude that bank capital regulation should have been countercyclical. Charts 9 and 10 (Kuva 6) below are Webber and Willison's depiction of the above-described findings.

39

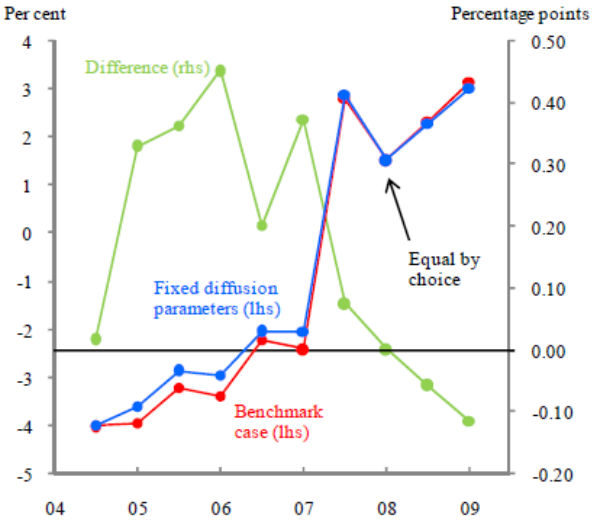
**Chart 9: Evolution of aggregate losses in the banking system over time, holding fixed statistical characteristics of assets**[(a)(b)]




(a) Percentiles of aggregate loss distribution across a panel of UK banks.

(b) Loss expressed as a fraction of system-wide debt liabilities.

**Chart 10: Tail of the distribution of aggregate losses, holding fixed statistical characteristics of assets**[(a)]




(a) Loss expressed as a fraction of system-wide debt liabilities.

**Kuva 6**

[39] In chart 9, biannual results on loss distribution are in groups of two. In the groups, left bar is systemic loss distribution with fixed parameters; the right one is the benchmark case with dynamic parameters.

Source: Webber and Willison; October, 2011

## 8.8 Systemic Capital Requirements

This section presents Webber and Willison's (October 2011) solutions for the banking system and individual bank capitalization questions according to how one bank's insolvency would impact the remaining banking system. The results are marginal additions, or surcharges, on banks' benchmark equity capital amounts. (Webber and Willison; October, 2011)

The results are presented in two parts: first, the benchmark banking system case with asset value correlations and interbank market contagion is presented to solve the standings of the banking system in the observation crisis period $[H1{,}2007; H1{,}2009]$. The objective is setting capital ratio such that the 95$^{th}$ percentile on the aggregate banking system asset value loss distribution is reached. Then, the capitalization solutions for banking system with altered features are solved.

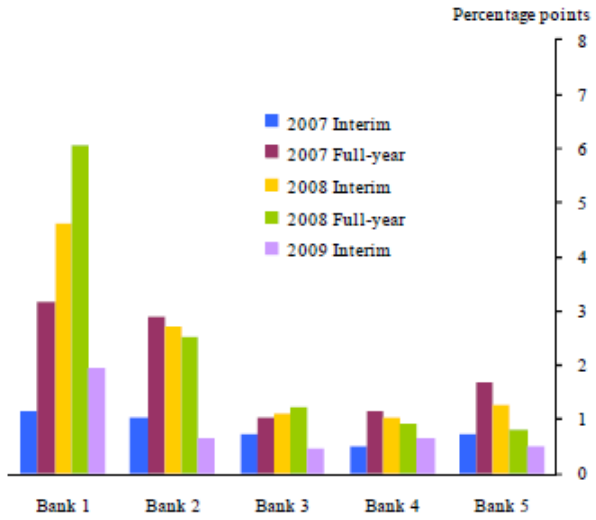
### 8.8.1 Benchmark capital allocation

Charts 11 and 12 below (Kuva 7) are Webber and Willison's depictions (October, 2011) for how much bigger capital ratios should optimally[40] have had to be in each bank in the observed crisis periods in relation to the actual capital proportions during the recent crises period $[2007, H1; 2009, H1]$ in order for the ideal aggregate loss distribution with policymakers' solvency target to appear. Webber and Willson (October, 2011) explain capital adding to vary between banks, since banks are different in balance sheet size and thus failure costs to other banks in the system vary depending on how big a bank collapses. Another affecting factor on the capital adding is varying probabilities in actual asset value losses from insolvencies. (Webber and Willison; October, 2011).

The chart 11 shows the trend for required adding to banks' capital ratios during the crisis years according to Webber and Willison. (October, 2011) The results correspond strongly to results yielded from Miles et al. (April, 2011) on the required capital adding range of 3,3% and 1,3%[41]. Only one bank would need higher capital boosts than four percentage points, and with this bank, only in two semiannual periods. (Webber and Willison; October, 2011) The chart 12 illustrates that when the aggregate systemic solvency is reduced to the 95$^{th}$ percentile with capital allocation in period H1,2009, frequencies of possible systemic losses would have been significantly smaller than possible actual aggregate losses obtained from simulation with realized asset value return drifts and correlations. Without optimization, the 95$^{th}$ percentile tolerance level would yield aggregate systemic insolvencies with possible losses piling up to around two per cent of aggregate debt liabilities of banks.

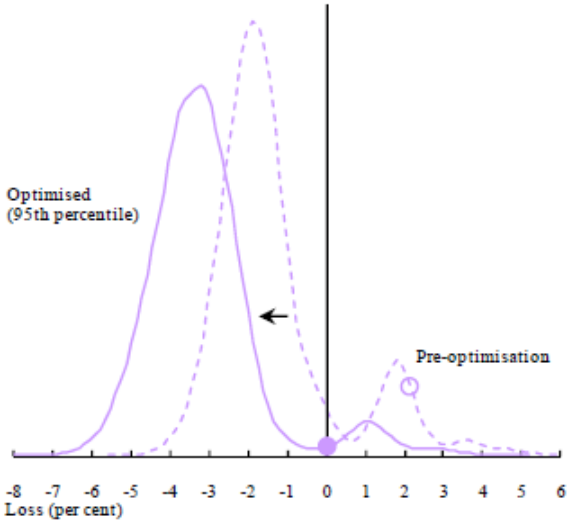
[40] Optimization here refers to policymakers' stability-cost optimization problem in equation **(3)**.
[41] The adding is based on the second half of 2011 realized UK bank leverage ratios.

**Chart 11: Systemic capital surcharges**[(a)]




(a) Change in the ratio of capital to assets for each bank in the network following the optimisation in equation (8).

**Chart 12: System loss distributions pre and post-optimisation (2009 H1)**[(a)(b)(c)]




(a) Accounting for asset correlation and explicit interbank exposures between firms, assuming contagious default carries a deadweight cost of 10% of assets.
(b) Following the optimisation in equation (8). Circles show location of 95th percentile.
(c) Loss expressed as a fraction of system-wide debt liabilities.

[42]

**Kuva 7**

## 8.9 Capital allocation with altered systemic features

This section presents Webber and Willison's (October, 2011) optimized capital surcharges to bank capital when certain systemic features are changed. The results are introduced in comparison to the optimized benchmark solution where asset value change correlations and contagious insolvencies through the interbank markets are allowed and introduced in the previous section. Again, the optimization of aggregate systemic capital and its distribution between banks is performed to reach the 95th percentile for aggregate insolvency of the banking system.

### 8.9.1 Capital surcharges with a doubled bank size

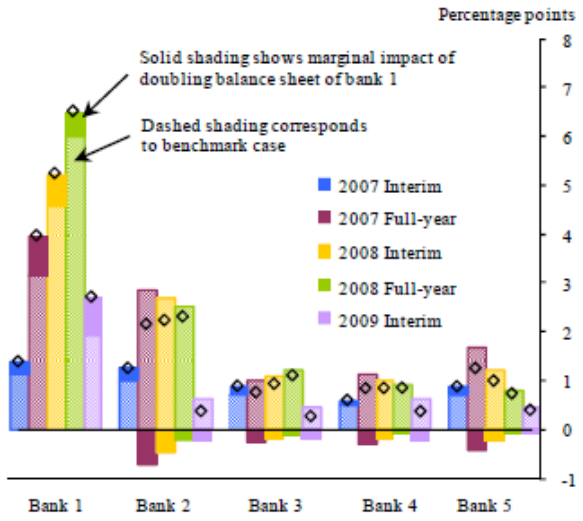
Charts 13 and 14 (Kuva 8) present Webber and Willison's (October, 2011) marginal adding to the hypothetical banking system when one bank's balance sheet size is doubled. The essential result is to attempt to contain the insolvency into the bank that has been size-doubled. (Webber and Willison; October, 2011) When banks' capitalization is performed with incorporated policymakers' target level, the bank with doubled size would need additional capital surcharges of approximately 0,5-1.0 percentage point to the benchmark capital adding. (Webber and Willison; October, 2011) In contrast, all the other banks could

[42] Source: Webber and Willison; October, 2011

lower their capital ratios from the benchmark level except for the first half of year 2007, although not from the observed levels that they carried in the crisis years. (Webber and Willison; October, 2011) The diamonds in chart 13 depict the required capital adding percentage points in relation to the actual capital proportions in every bank.

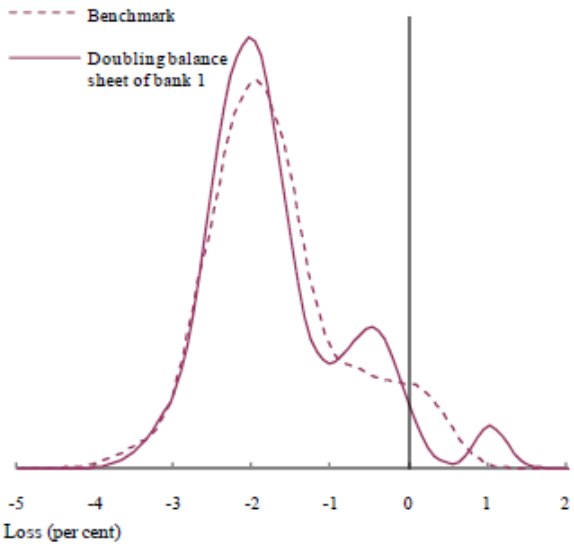
Chart 14 illustrates the optimization effect on the asset value loss distribution for the period 2007,H2. The distribution of losses does not shift in relation to the benchmark case, but becomes lumpier. This results from the increased size of contagious interbank obligation losses, should the bank with double-sized balance sheet become insolvent. (Webber and Willison; October, 2011)

**Chart 13: Systemic capital surcharges when one bank doubles in size**[(a)(b)]




(a) Change in the ratio of capital to assets for each bank in the network following the optimisation in equation (8).
(b) Diamonds show total change in capital requirement.
[43]

**Chart 14: System loss distribution when one bank doubles in size (2007 H2)**[(a)(b)]




(a) Following the optimisation in equation (8).
(b) Loss expressed as a fraction of system-wide debt liabilities.

**Kuva 8**

### 8.9.2 Capital surcharges with increased interconnectedness

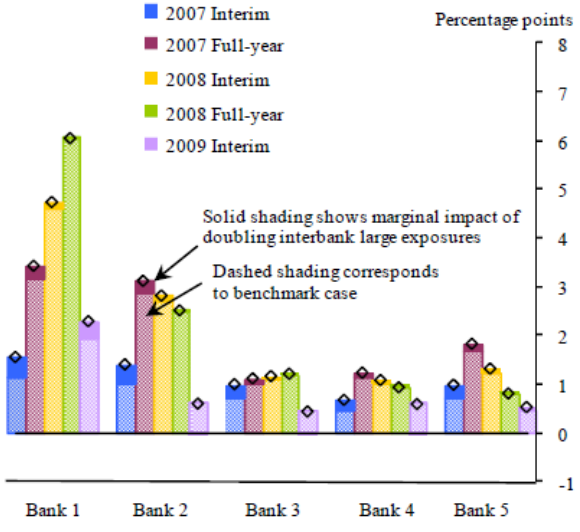
Increased interconnectedness represents degrees in which banks use short-maturity interbank market funding in their operations. According to Webber and Willison this poses a particular threat to massive contagious aggregate systemic losses through the interbank markets[44]. (Webber and Willison; October, 2011; Chart 1) The authors show that the consequences of doubled interbank lending at banks in the crisis

[43] Source: Webber and Willison; October, 2011
[44] Compare the distributions of the left (blue) and right (red) bars in chart 1. The differences in distribution spreads illustrate the effect of correlated and contagious losses on asset values.

years would have resulted to significantly higher aggregate systemic expected and tail losses, particularly in periods $[2007, H1; 2008, H1]$. (Webber and Willison; October, 2011; Charts 5,6)

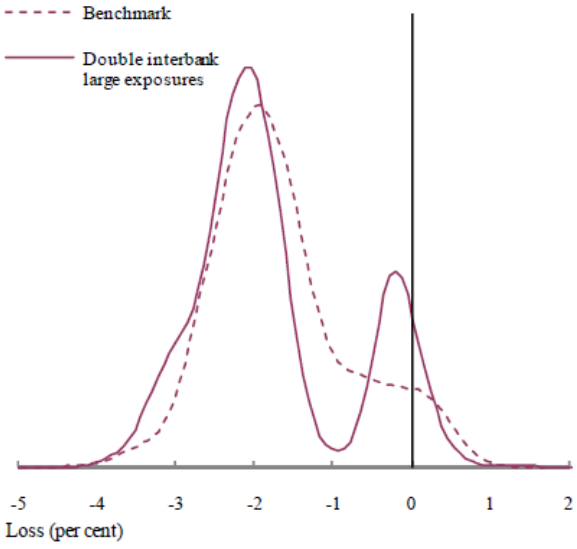
This amounts to significantly higher proportional bank capital amounts in periods 2007,H1 and H2. The equity capital funding proportions in every five bank studied by Webber and Willison (October, 2011) would have had to be up to 50% larger in period 2007 H1 depending on the bank balance sheet size, and 10% higher in 2007 H2 in relation to the benchmark case. However, the aggregate systemic capital would not have needed to be increased more than approximately five percentage points in 2007 H1. In later crisis periods observed by the authors $[2008, H1; 2009, H1]$ marginal capital adding at banks following optimized allocating could essentially have been those of the benchmark case. (Webber and Willison, October, 2011, chart 15) This points to conclusion that bank equity capital adding should follow emergence of shock in vis-à-vis basis. Chart 16 shows that although the needed aggregate adding is not particularly large, the costs to banking system solvency rise precipitously should the contagious insolvencies begin to spread with excessive interbank funding at banks. (Webber and Willison, October, 2011)

**Chart 15: Systemic capital surcharges when interconnections double in size**[(a)(b)]




(a) Change in the ratio of capital to assets for each bank in the network following the optimisation in equation (8).
(b) Diamonds show total change in capital requirement.

**Chart 16: System loss distribution when interconnections double in size (2007 H2)**[(a)(b)]




(a) Following the optimisation in equation (8).
(b) Loss expressed as a fraction of system-wide debt liabilities.

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**Kuva 9**

[45] Source: Webber and Willison; October, 2011

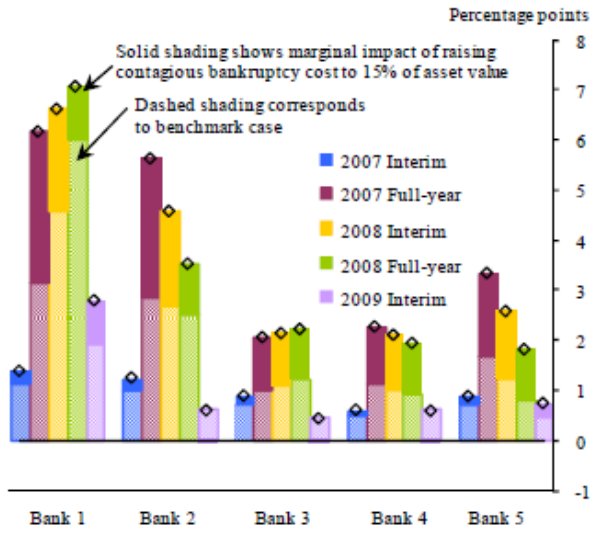
### 8.9.3 Capital surcharges with increased cost of contagion

Chart 7 on systemic loss distribution with increased cost of contagious bank insolvency by Webber and Willison (October, 2011) shows that in the case of higher bankruptcy costs, the deadweight contagion costs, the distribution of the losses spreads to the right. According to the authors (October, 2011) the mechanism for increased tail losses takes place at the interbank markets where contagious insolvencies would now cause higher damage and consequently would spread further in the banking system.

This results to massively higher capital requirements at banks to contain particularly the contagious insolvencies. Chart 17 (Kuva 10) by Webber and Willison (October, 2011) illustrate equity capital proportions at banks to have had to be up to seven percentage points higher than the actual proportions if contagion costs were 15% instead of the now assumed 10%. In relation to the benchmark case with asset value correlations and contagious interbank market driven insolvencies allowed, the marginal capital adding would have to be in range of 20-100 per cent higher in order for the hypothetical policymakers' 95 percentile solvency target to appear. (Webber and Willison; October 2011; Chart 17). The reason for such massive capital adding, the authors argue (October, 2011) is the aggregate loss distribution that is heavily right-spread that needs to be shifted to the left in order for the solvency level percentile to appear.

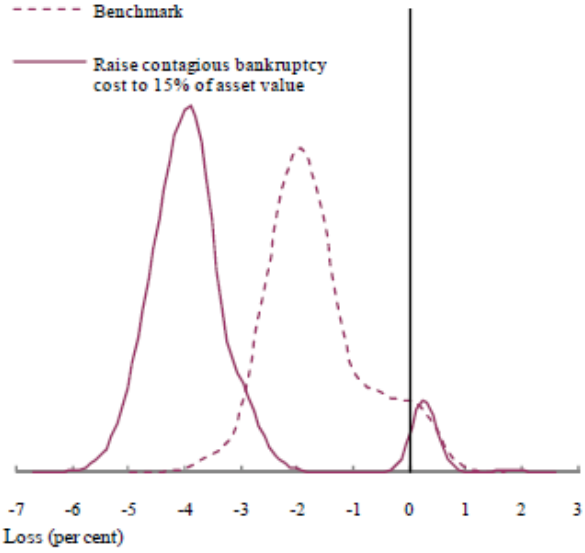
The findings imply that a smooth and globally wide-spread legislative bankruptcy processes should be created so that failing banks' asset could be liquidated and bank creditors reimbursed quickly. As bankruptcy costs consist largely of legislative fees, with fast insolvency processes the bankruptcy costs could be reduced and banking system efficiency thus increased as there would be less need for equity capital that in turn can be assumed to decrease non-financial firms' lending rates and consequently increase investments and economic growth.

**Chart 17: Systemic capital surcharges when raising the cost of contagious default**[(a)(b)]




(a) Change in the ratio of capital to assets for each bank in the network following the optimisation in equation (8).
(b) Diamonds show total change in capital requirement.

**Chart 18: System loss distribution when raising the cost of contagious default (2007 H2)**[(a)(b)]




(a) Following the optimisation in equation (8).
(b) Loss expressed as a fraction of system-wide debt liabilities.

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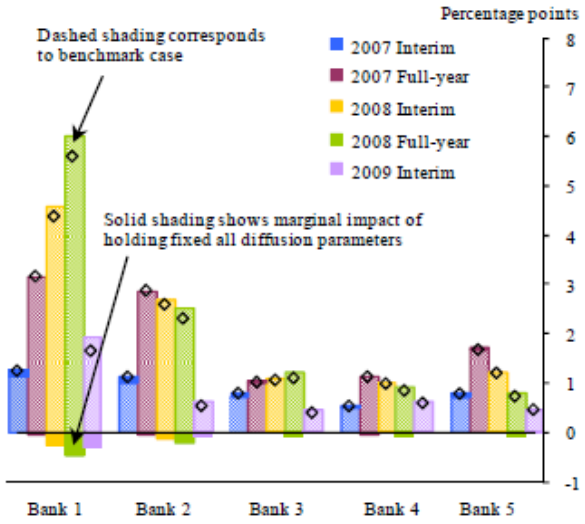
### 8.9.4 Cyclicality of capital surcharges

Webber and Willison (October, 2011) look the distribution of losses in the case where asset value change and correlation values are fixed for the observation period in order to depict results for how cyclicality of bank capital regulation affects the banking system's solvency, and how that further would affect necessary capital surcharges for banks.

The authors (October, 2011) conclude that fixing asset value change and correlation values for the study period – thereby making capital regulation countercyclical – would have slightly reduced the necessary marginal capital adding in aggregate level after the policymakers' optimization, while the size and frequency of systemic aggregate losses would have largely been the same. This would mean higher banking system efficiency. Charts 19 and 20 below (Kuva 11) are Webber and Willison's (October, 2011) results on optimal marginal capital adding with fixed asset parameter values, i.e. with countercyclical capital regulation.

[46] Source: Webber and Willison; October, 2011

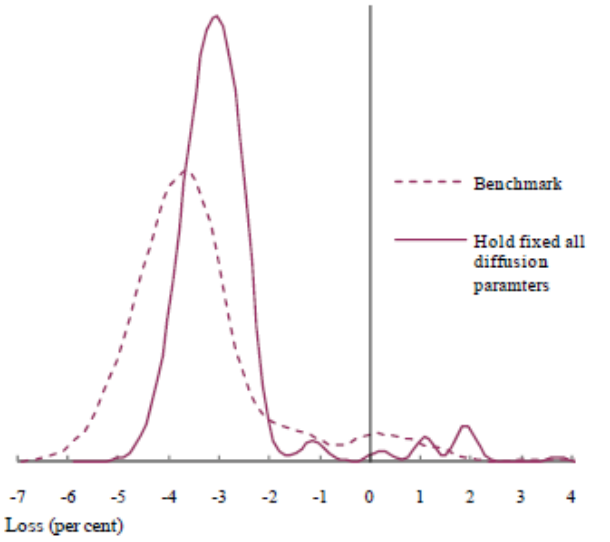
**Chart 19: Systemic capital surcharges, holding fixed all diffusion parameters**[(a)(b)]




(a) Change in the ratio of capital to assets for each bank in the network following the optimisation in equation (8).

(b) Diamonds show total change in capital requirement.

**Chart 20: System loss distribution, holding fixed all diffusion parameters (2008 H2)**[(a)(b)]




(a) Following the optimisation in equation (8).

(b) Loss expressed as a fraction of system-wide debt liabilities.

[47]

**Kuva 11**

[47] Source: Webber and Willison; October, 2011

# 9 Empirical research

The aim of the empirical study is to evaluate if increasing equity capital in bank funding in order to have greater bolsters against banking system insolvency is technically sound. Critical factor is whether bank equity capital is inexpensive in relation to other industries' equity capital as measured in weighted average cost of capital. If the bank equity capital is expensive, capitalizations in identical proportions in banks and non-financial industries show in proportionally much higher increases in weight total capital costs in banks than in other industries. As banks' offered lending rates are assumed to be the total capital cost, this would mean excessive increases in debt funding costs in non-financial firms, and switch to equity funding in these firms. The total capital costs of the non-financial companies would increase, meaning reduced investments and economic growth.

The study is performed by estimating changes in the weighted average cost of industry capital at realized and at halved leverage ratios. Changes are also estimated in two sequential time periods in order to estimate how financial market stress has affected the costs of capital. The relative cost of equity capital is estimated by comparing how much weighted average capital cost changes when leverage is halved.

The two periods are 2002H1-2008H1 and 2009H1-2011H2 of which the former is unstressed period and the latter is stressed. Financial market stress is assumed to have been triggered by the collapse of Lehman Brothers on Sept. 15, 2008.

The empirical study is performed on 16 British companies listed on the FTSE 100 in London stock exchange, as the overall literature on banking system insolvency and bank capitalization is focused on the UK.

## 9.1 Method

The study is performed in following steps. First, company stock market sensitivities or the betas and leverage ratios are estimated for all companies chosen for study. The beta figures are estimated from weekly returns on individual companies' stock returns and FTSE 100 index's value changes. For banking, mining, retail and telecom companies the beta and leverage figures are in six-month periods and in three-month figures for pharmaceutical companies. All data is collected from the Thomson ONE –database. The altering lengths in periods are due to each company's financial reporting standards. Next, average industry beta and leverage ratios are aggregated from individual companies' six-month figures for beta and leverage using balance sheet sizes as weights.

In the third phase, weighted industry betas and leverage ratios are regressed, and the resulting formula is used to estimate industry specific equity capital cost according to the CAPM-model as a function of its leverage, and further the total capital cost. The regression is performed using the OLS-method.

The regression is performed without the constant coefficient, since this would allow regression to incorporate results on leverage ratios of value below one that is not possible in practice.

The cost of debt for corporations in the study is assumed to be equal to the risk free rate of interest, 5.0%. This assumption is naïve and made for practical reasons; in practice, the credit ratings for the companies in the empirical study range between AA for HSBC and BB for CWC (S&P, Foreign) on the latest available credit ratings from Fitch(Foreign) - Long Term Issuer Credit Ratings[48].

Equations used in empirical study:

The least squares function used for beta estimation:

$\beta_{e,c(i)} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sum_{i=1}^{n}(x_i-\bar{x})^2}$, where

$\beta_{e,c(i)}$ = equity beta of company ($i$)

$x$ = weekly company equity return variable

$y$ = weekly FTSE 100 –index return variable.

The null hypothesis between industry beta and leverage is that the market sensitivity of company stock performance does not depend on the leverage ratio of the company, i.e.,

$\beta_{e,i} = (\alpha) + \gamma_i * l_i + u$, where

$\beta_{e,i}$ = market sensitivity, beta, of industry ($i$)

$\alpha$ = parameter for constant, excluded from the regression

$\gamma_i$ = beta coefficient of leverage of industry ($i$), and hypothesized in value to zero

$l_i$ = balance sheet size weighted leverage ratio of industry ($i$)

$u$= disturbance term

[48] See the appendix for the summary of long term corporate credit ratings of companies in the empirics

CAPM –function for required return on industry equity:

$R_{e,i} = R_f + \beta_{e,i} * \delta$, where

$R_{e,i}$ = required return of equity of industry ($i$)

$R_f$ = risk free rate of interest

$\beta_{e,i}$ = equity beta of industry ($i$)

$\delta$ = equity market risk premium

With beta-leverage –regression, the required return of industry equity is:

$R_{e,i} = R_f + (\gamma_i * l_i) * \delta$, where

$\gamma_i$ = beta coefficient of leverage of industry ($i$)

$l_i$ = leverage ratio of industry ($i$)

The formula for halving leverage:

$Halved\ leverage = \frac{(D+E-1)/2}{E} + 1.$

All the companies in the study are listed on the FTSE 100 –index at the time of study.

The industries and companies included in the study are:

- *Banking:* HSBC, RBS, Barclays, Lloyds, Standard chartered, Prudential
- *Pharmaceuticals:* Shire, Astrazeneca, Glaxosmithkline
- *Mining:* Rio Tinto, Angloamerican, BP
- *Retail:* Burberry, Tesco
- *Telecom:* Vodaphone, CWC

In the industry regression, there were 20 six-month beta-leverage samples with banking, mining, retail and telecom, and 35 for pharmaceuticals. Though not very numerous, for the purposes of the study I find the numbers to be sufficient for drawing conclusions. Due to inconsistencies in financial statement reporting, J Sainsbury and Marks and Spencer from retail-industry and BT Group from telecom-industry were excluded from the study.

## 9.2 Results

Empirical results on industry specific beta-leverage regression using STATA and cost of capital estimations with leverage alterations between 2002-2008 and 2009-2011 are below.

**Beta-Leverage regression:**

| Banking | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time period | Coefficient | R2 | degree of freedom | t | Significance (two-sided t-test) | P>\|t\| | F statistic (description in brackets) | P>F | Significance (F-test) |
| 09H1- 11H2 | 0.0112752 | 0.8284 | 5 | 4.91 | 1% | 0.004 | (1,5) 24.13 | 0.0044 | 1% |
| 02H1 - 08H1 | 0.0107966 | 0.833 | 11 | 7.41 | 1% | 0 | (1,11) 54.85 | 0 | 1% |

| Pharmaceutical | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time period | Coefficient | R2 | degree of freedom | t | Significance (two-sided t-test) | P>\|t\| | F statistic (description in brackets) | P>F | Significance (F-test) |
| 08Q4 - 11Q4 | 0.1566649 | 0.8411 | 12 | 7.97 | 1% | 0 | (1,12) 63.54 | 0 | 1% |
| 02Q1 - 08Q2 | 0.0736372 | 0.6983 | 23 | 7.3 | 1% | 0 | (1,23) 53.22 | 0 | 1% |

| Mining | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time period | Coefficient | R2 | degree of freedom | t | Significance (two-sided t-test) | P>\|t\| | F statistic (description in brackets) | P>F | Significance (F-test) |
| 09H1- 11H2 | 0.1669203 | 0.9043 | 5 | 6.87 | 1% | 0.001 | (1,5) 47.24 | 0.001 | 1% |
| 02H1 - 08H1 | 0.1541833 | 0.9076 | 11 | 10.39 | 1% | 0 | (1,11) 108.04 | 0 | 1% |

| Retail | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time period | Coefficient | R2 | degree of freedom | t | Significance (two-sided t-test) | P>\|t\| | F statistic (description in brackets) | P>F | Significance (F-test) |
| 09H1- 11H2 | 0.1655787 | 0.8345 | 5 | 5.02 | 1% | 0.004 | (1,5) 25.22 | 0.004 | 1% |
| 02H1 - 08H1 | 0.117961 | 0.8074 | 11 | 6.79 | 1% | 0 | (1,11) 46.11 | 0 | 1% |

| Telecom | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Time period | Coefficient | R2 | degree of freedom | t | Significance (two-sided t-test) | P>\|t\| | F statistic (description in brackets) | P>F | Significance (F-test) |
| 09H1- 11H2 | 0.2970965 | 0.8651 | 5 | 5.66 | 1% | 0.002 | (1,5) 32.07 | 0.0024 | 1% |
| 02H1 - 08H1 | 0.2121459 | 0.9136 | 11 | 10.78 | 1% | 0 | (1,11) 116.27 | 0 | 1% |

The null-hypothesis for company stock market insensitivity to company leverage is rejected for all industries at 1-per cent significance level, and leverage is statistically significant predictor of beta at 99-per cent significance level in all industries. Market sensitivity of equity capital cost in Pharmaceutical, Mining, Retail and Telecom industries appear to have depended much more on leverage than in banking. Noting that constant coefficients have been excluded, the dependency coefficients' goodness of fits is strong.

**Cost of capital:**

Risk free interest rate ($R_f$): 5.0%

Equity market risk premium ($\delta$): 5.0%

Pre 2008, H2:

| Industry | Beta-Lev. Coeff | Leverage | Halved leverage | Eqt cost (full leverage) | Eqt cost (half leverage) |
|---|---|---|---|---|---|
| Banks | 0.0107966 | 27.70 | 14.35 | 6.50% | 5.77% |
| Mining | 0.1541833 | 2.45 | 1.73 | 6.89% | 6.33% |
| Retail | 0.117961 | 2.39 | 1.70 | 6.41% | 6.00% |
| Pharmas | 0.0736372 | 2.90 | 1.95 | 6.07% | 5.72% |
| Telecom | 0.2121459 | 1.43 | 1.22 | 6.52% | 6.29% |

| WACC - Full leverage | | | | | |
|---|---|---|---|---|---|
| Industry | Debt proportion | Cost of debt | Eqt proportion | Eqt cost | **WACC** |
| Banks | 26.70 | 0.05 | 1 | 6.50% | **5.05%** |
| Mining | 1.45 | 0.05 | 1 | 6.89% | **5.77%** |
| Retail | 1.39 | 0.05 | 1 | 6.41% | **5.59%** |
| Pharmas | 1.90 | 0.05 | 1 | 6.07% | **5.37%** |
| Telecom | 0.43 | 0.05 | 1 | 6.52% | **6.06%** |

| WACC - Halved Leverage | | | | | |
|---|---|---|---|---|---|
| Industry | Debt proportion | Cost of debt | Eqt proportion | Eqt cost | **WACC** |
| Banks | 13.35 | 0.05 | 1 | 5.77% | **5.05%** |
| Mining | 0.73 | 0.05 | 1 | 6.33% | **5.77%** |
| Retail | 0.70 | 0.05 | 1 | 6.00% | **5.59%** |
| Pharmas | 0.95 | 0.05 | 1 | 5.72% | **5.37%** |
| Telecom | 0.22 | 0.05 | 1 | 6.29% | **6.06%** |

Post 2008, H2:

| Industry | Beta-Lev. Coeff | Leverage | Halved leverage | Eqt cost (full leverage) | Eqt cost (half leverage) |
|---|---|---|---|---|---|
| Pharmas | 0.1566649 | 3.72 | 2.36 | 7.92% | 6.85% |
| Retail | 0.1655787 | 3.11 | 2.05 | 7.57% | 6.70% |
| Banks | 0.0112752 | 23.79 | 12.40 | 6.34% | 5.70% |
| Mining | 0.1669203 | 2.49 | 1.75 | 7.08% | 6.46% |
| Telecom | 0.2970965 | 1.81 | 1.41 | 7.69% | 7.09% |

| WACC - Full leverage | | | | | |
|---|---|---|---|---|---|
| Industry | Debt proportion | Cost of debt | Eqt proportion | Eqt cost | **WACC** |
| Pharmas | 2.72 | 5.00% | 1 | 7.92% | **5.78%** |
| Retail | 2.11 | 5.00% | 1 | 7.57% | **5.83%** |
| Banks | 22.79 | 5.00% | 1 | 6.34% | **5.06%** |
| Mining | 1.49 | 5.00% | 1 | 7.08% | **5.83%** |
| Telecom | 0.81 | 5.00% | 1 | 7.69% | **6.49%** |

| WACC - Halved leverage | | | | | |
|---|---|---|---|---|---|
| Industry | Debt proportion | Cost of debt | Eqt proportion | Eqt cost | **WACC** |
| Pharmas | 1.36 | 5.00% | 1 | 6.85% | **5.78%** |
| Retail | 1.05 | 5.00% | 1 | 6.70% | **5.83%** |
| Banks | 11.40 | 5.00% | 1 | 5.70% | **5.06%** |
| Mining | 0.75 | 5.00% | 1 | 6.46% | **5.83%** |
| Telecom | 0.41 | 5.00% | 1 | 7.09% | **6.49%** |

Total capital costs do not change for any industry when leverage is halved neither when the financial system is not under stress, nor when it is. The capital costs do however increase for all industries when the system comes under stress.

Stock market sensitivity changes from unstressed to stressed market conditions vary drastically between different industries. In banking and mining industries, the sensitivity increases less than 10%, in retail and telecom industries sensitivity increases by 40%. In pharmaceutical industry, equity market sensitivity increases by 112.75%.

Looking at the effects of bank capitalization in raising banks' total cost of funding, and further those of non-financial companies, I assume that bank total capital cost represent banks' offered lending rates on one-on-one basis. As the total capital costs in banking do not change as a result of capitalization in normal, nor in crisis times, I conclude that decreasing bank leverage for higher bolsters against banking system insolvency is sound on the basis that decreased leverage does not increase lending rates and cost of financing of non-financial companies.

## 9.3 Discussion on results

Despite proving that additional bank capitalization is sound, the results on equity capital costs dependence on leverage pose a question why bank leverage is much less associated with risk of its assets' returns, the beta, than in other industries. Literature has found three possible factors to this: government safety net programs in banking, tax deductibility of interest payments and regulation on bank industry competitiveness.

Beta measures the degree of risk of asset's returns that cannot be eliminated by diversification, i.e. the variance of returns from the predicted rate of return that cannot be eliminated by diversification. Why bank return on equity does not depend on leverage? Conclusion would be that fixed revenues and operative expenses provided, banks could lever themselves as much as possible and yet earn a fixed average return on equity. In such a case, interest expenses should be enormous, reflecting their extreme riskiness for not becoming paid. The reason, interest expenses for banks are so small, implies that the interest payments must be essentially fully guaranteed.

Alessandri and Haldane (November, 2009) and Admati et. al., (March, 2011) explain that the leverage increases at banks are result of government safety nets for banks' solvency. Alessandri and Haldane (November, 2009) write that historical and cumulative safety net expansions have resulted to public authorities' time-consistency problem, causing them not to be able to commit to not bail banks out. The authors sight the safety net to consist of liquidity insurance for wholesale banking, capital insurance for recapitalization and deposit insurance for retail savings. The essential feature Alessandri and Haldane (November, 2009) sight that over the last century the safety net has been expanded one round of financial crises after another, thus guaranteeing banks' solvency under ever larger losses from the general markets to their balance sheets. [49]

A perfect safety net covering all unpaid interest and maturity payments to banks' creditors, supplying additional capital in threats of insolvency and keeping the banks afloat thus creates an incentive to take as much risk and leverage as possible. (Alessandri and Haldane; November, 2009) How this shows is that as bank debt is fully insured, its return sensitivity to bank creditors drops to zero and all general market return sensitivity fall on banks' own equity by the factor of leverage. Banks can thus multiply market returns by their leverage[50]. (Alessandri and Haldane; November, 2009)

Admati et. al., (March, 2011) write the joint mechanism of tax deductibility and government safety nets for bank debt default to provide incentives for banks to lever themselves, all else equal. The problem with tax

[49] In the UK, bank balance sheets ten folded since the 1970s. The total bank assets were five times the UK GDP at the end of the 2010s, while capital and liquidity ratios over the same time shrunk to fractional proportions. (Alessandri and Haldane; November, 2009)

[50] The deduction is shared by Miles et. al., (April, 2011). See p. 30-31.

shields is that the beneficiary from it is private – banks get to keep the value of the tax shield if they do not go bankrupt – but the costs are social – when levered banks go bankrupt, the reduction in financial market liquidity, information creation and repaying deposit insured households falls on the public sector. (Admati et. al., March, 2011) According to the authors (March, 2011) for the joint problem of tax shields and government safety nets, higher equity capital requirements would be good, as it would shift the default costs from the public sector to banks, their shareholders and creditors, and thus would neutralize the asymmetry of leverage financing benefits and losses at banks.

Another question posed by bank equity insensitivity to markets is why banks apparently have not been able to increase their equity returns in the UK as they have increased their leverage? Simple mathematics shows that fixed rate of interest on debt provided, return on equity remains intact when leverage increases if at the same time return on total assets decreases. This would imply that in the 2010s, while having increased their leverage, UK banks must have incurred ever larger amounts of under-performing loans as assets that have decreased their returns on total assets. As interest expenses thanks to the generous government safety programs have been negligible, the return on equity has remained unchanged all the years. [51]

As central bank interest rates were higher in the 1970s and the 1980s[52], banks intuitively should have had to pay bigger rates of interests from their own borrowing and thus would probably have found beneficial to use more equity in their funding and more scrutiny in lending[53]. As the central bank interest rates later decreased, banks chose to increase their own borrowing and extend more loans, with less scrutiny on borrowers' net worth. As loans subsequently began to default and banks had low net worth, government safety programs had to step in in massive extents.

On reasons why bank equity returns could remain fixed over time, Wolf (2011) deduces banking industry regulation on industry competitiveness to play part next to government safety nets and banks operating risky business. According to Wolf, banking industry has competed with substantial market entry-barriers and banks has reached a steady-state return on equity[54].

Cebenoyan and Strahan (2004) find better hedging results from securities trading to have provided banks incentive to lever themselves. They write that some banks have begun to manage their credit risk exposures through trading loans on second-hand loan markets. They find that holding leverage, balance sheet sizes and trading activities constant, banks that engage in both loan buying and selling in order to

[51] Royal Bank of Scotland's interest expense to total asset ratio was 1% according to bank's financial statement for year 2011.
[52] See appendix – Official UK bank rate -graph
[53] UK banks' leverage ratios varied between 15 and 25 in years 1970-2000 as opposed to 25 and 40 between 2005-2009. (See Miles et al; April, 2011)
[54] Wolf sights Lloyds to target 15% rate of return on its equity. (Financial times, Sept. 25, 2011)

manage their credit risk, have lower risk and higher profits than other banks. Therefore, being able to bear more risk thanks to better risk management techniques, these banks have operated with higher leverage and extended riskier illiquid loans to borrowers. The authors conclude that better risk management may have turned into greater availability of credit rather than reduced risk in the banking system.

van Binsbergen et al. (April, 2011) look leverage from perspective that optimal corporate capital structure is an outcome of different factors affecting marginal costs and benefits of debt financing. The authors use the balance of these costs and benefits as a point where firm value is maximized as a function of leverage.

According to van Binsbergen et al. (April, 2011), the benefits from using debt are tax deductible interest payments. The benefits are incurred as a tax saving on the dollar of profit that firm produces that comes from an additional dollar of tax deductible interest payment. This benefit function from using debt is same for all companies that share a common corporate profit tax rate. (van Binsbergen et al; April, 2011)

The marginal costs of debt are born in the authors' model (April, 2011) from collateral assets, essentially equity, logarithmic value of total book assets, and from the ratios of book to market equity, intangible to total assets and net cashflow to total asset, and finally whether or not a firm pays dividend. Leverage is measured by the ratio of interest expenses to total assets or by debt over total assets.

The marginal cost function for using debt by van Binsbergen et. al (April, 2011) is:

$MC(IOB) = \alpha + \beta * IOB, \ where$

$\alpha = 0.117 - 0.039\mathrm{COL} + 0.015\mathrm{LTA} - 0.018\mathrm{BTM} - 0.024\mathrm{INTANG} + 0.08\mathrm{CF} + 0.063\mathrm{DDIV}$

$\beta = 4.773$

$IOB =$ Interest expense total asset book value -ratio

$COL =$ Collateral asset to total asset –ratio

$LTA =$ Logarithmic value of total assets

$BTM =$ Book to Market equity price –ratio

$INTANG =$ Intangible to total asset –ratio

$CF =$ Net cashflow over total asset –ratio

$DDIV =$ Payment of dividend: 1, if firm pays dividend; 0, if firm doesn't pay dividend

The model on optimal capital structure by van Binsbergen et al. offers a way to estimate the effect of government safety net programs on banks' leverage. Using published records on Royal Bank of Scotland as a proxy for the UK banking system and slightly emulating the variables in the model to estimate the optimal leverage, the UK banking system's optimal leverage would be 0.18 as implied by the model, measured by

total liabilities over total assets. Having an actual leverage ratio of 0.95 by the same measure as opposed to 0.18 on December 31, 2011, indicates that banks in the UK would be severely over levered. Estimating the effect of the government safety net as a form of implicit bank equity on the optimal leverage ratio, the safety net would represent (0.95-0.18)/0.95) = 81 per cent of the actual equity value the UK banks[55]. As the sample banks total equity capital was £308 billion on Dec. 31, 2011, the above calculation would imply UK public authorities to have guaranteed UK bank liabilities at the end of year 2011 of the approximate total value of £1,316 billion, 82.10 per cent [56] of the UK nominal GDP in 2011and 185.40 per cent [57]of the UK Treasury's fiscal year 2011-2012 budget..

[55] Royal Bank of Scotland is used in the optimal leverage estimation as a proxy of the entire UK banking industry on the basis that on Dec. 31, 2011, bank's leverage was very much equal to the weighted average leverage of UK banks.
[56] UK GDP as estimated by the IMF. Source: IMF Statistics
[57] Source: HM Treasury Budget, 2011.

# 10 Conclusions

Compelling evidence provided by recent literature on financial crises claims that modern financial crises are born from investment information asymmetry between transacting parties in the financial markets. Information creators on investment projects are thus needed and those are banks and other institutions with intermediation expertise and capabilities. They cannot be disposed of. Based on findings, there seems however to be reason to ask if financial institutions have sufficiently been monitored by their creditors, i.e., the depositing households and public authorities. With current government safety nets including the deposit insurance programs in place, there may well be and have been incentives for intermediates to engage in excessive levering and overly risky activities. Indeed, previous modeling on banking has found support for additional bank capital next to the deposit insurance programs. Further research on this would be most commendable.

Looking the financial system strictly from the solvency perspective, financial system and bank regulation cannot be estimated from perspective that banks are isolated from one another. Banks share same asset in their balance sheets, thus making their balance sheet values to drift in some extent in correlation. Furthermore, banks are interconnected to each other via the interbank markets that transmit and increase financial distress costs to the banking system from a single bank insolvency. Altogether, banks in the UK should have had to carry larger equity capital to total asset ratio in range of six and one and a half percentage points compared to the actual ratios in the recent crisis years.

This point noticed, banking system becomes increasingly prone to aggregate insolvency when some bank in the system increases disproportionately in balance sheet size in relation to other banks in the financial system and when banks within the system increasingly rely on interbank market funding in their financing. Finally, there is room in regulation considerations for contemplating cyclicality of bank capital regulation: there is some advancement in the banking system resilience against insolvency to be had if capital regulation can be made somewhat countercyclical. The results also point to the need to establish geo-politically wide-spread and smooth legislative bankruptcy procedures for decreasing bank bankruptcy costs and further to improve financial system efficiency in fund intermediation.

Ideally, bank capital regulation should be designed in two recurring steps: first in defining the minimum aggregate capital for the aggregate system to achieve a socially desired solvency tolerance level, and then by allocating the capital stock between the financial system's banks so that the aggregate desired solvency level is reached with minimum amount of total equity capital. This however is likely to be considerably expensive and regulation resource consuming in practice.

Based on the cross-industrial total capital cost -study performed on 16 British companies in five industries, decreasing leverage does not change the weighted average cost of capital for any industry studied, neither

before, nor after the triggering of the recent crisis. Considering that bank weighted average cost of capital would present banks' offered lending rates to non-financial companies, I conclude that decreasing bank leverage for higher buffers against banking system insolvency is sound on the basis that decreased leverage would not, at least excessively, increase the offered lending rates. Also, financial system regulating authorities could strive in the UK for above 95 per cent financial system aggregate solvency risk levels, noting recent topical empirical studies.

The results on additional equity capital ratios above are not applicable as such outside the UK, since features of the banks, bank and financial system regulation, tax systems, government bank debt guarantee programs, nation-specific treasury budgets and history of economic growth are different. However, it is likely that in the other major countries as well, financial regulation has not sufficiently been approached from the systemic perspective.

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# 12 Appendix

**Summary of Corporate Bond Rating System and Symbols (Fabozzi, 2010)**

| Fitch / S&P | Definition |
|---|---|
| High Credit Worthiness | |
| AAA | Gilt edge, prime, maximum safety |
| AA+ | |
| AA | Very high grade, high quality |
| AA- | |
| A+ | |
| A | Upper medium grade |
| A- | |
| BBB+ | |
| BBB | Lower medium grade |
| BBB- | |
| Low Credit Worthiness | |
| BB+ | |
| BB | Low grade, speculative |
| BB- | |
| B+ | |
| B | Highly speculative |
| B- | |

**Credit ratings of companies in the study**[58]

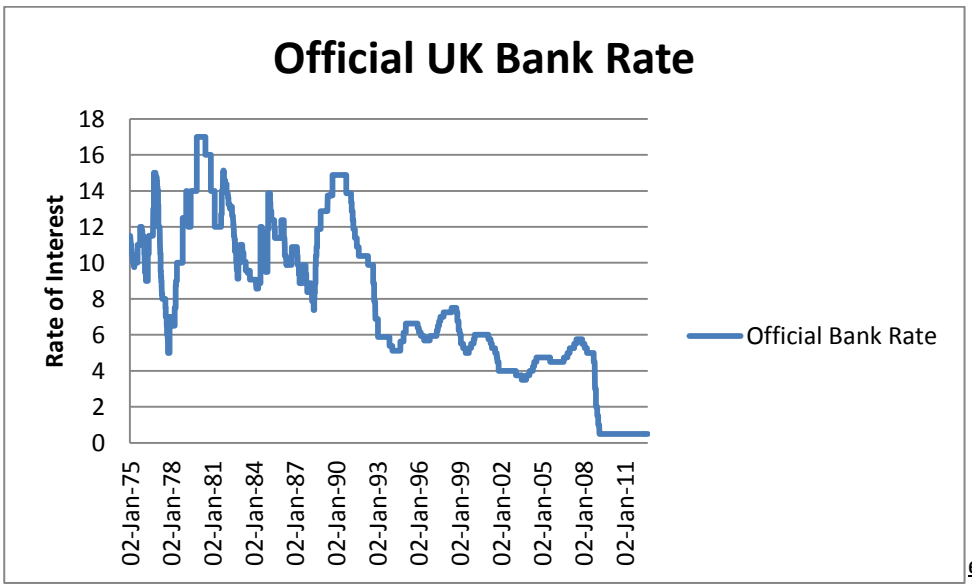
Fitch(Foreign) - Long Term Issuer Credit Rating

| Company | Rating | Date of rating |
|---|---|---|
| RBS | A | 19.3.2012 |
| HSBC | AA | 1.3.2012 |
| Barclays | A | 15.12.2011 |
| Prudential | A+ | 31.5.2012 |
| Lloyds | A | 19.3.2012 |
| Standard | AA- | 5.3.2012 |
| | | |
| Anglo American | BBB+ | 6.3.2012 |
| BP | A | 5.3.2012 |
| Rio Tinto | A- | 6.3.2012 |
| | | |
| Shire | N/A | |
| Glaxosmithkline | A+ | 11.8.2011 |
| Astrazeneca | AA- | 11.10.2011 |
| | | |
| Burberry | N/A | |
| Tesco | A- | 22.2.2012 |
| | | |
| Vodaphone | A- | 25.5.2012 |
| CWC[59] | BB | 26.3.2010 |

[58] Source: Thomson ONE –database, June, 2012

[59] Rating based on S&P (Foreign)

**Central Bank Interest Rates in the UK**



[60]

[60] Source: Bank of England; Sept. 11, 2012.