The Irish Risky Lending Gap

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Abstract

This paper develops a simple model of the gap between socially and privately optimal bank lending when a bank has an overhang of impaired loans, and analyzes government policies designed to close this gap. The impaired loans have risky cash flows but observable market values. A number of basic concepts are explicated including the risky lending gap, the capital component and asset risk component of the risky lending gap, capital injections versus asset purchases as policy tools, decomposition of the effects of asset purchases into loan substitution and risk absorption effects, the supply schedule of risky lending, the no-lending trap, and a risk-capital metric for comparing the various policy choices. The model is calibrated to match the current Irish banking environment and some tentative policy implications are suggested.

1 Introduction

This paper develops a simple closed-form model of the gap between socially-optimal and bank-management-optimal commercial bank lending when a commercial bank is suffering from an overhang of impaired, risky loans with

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observable market values. It uses the model to analyze banking intervention policies designed to encourage such banks to not excessively curb new lending.

The analytical framework described in the paper has general relevance to banking crisis resolution, but is crafted to fit the bank policy problems currently confronted in Ireland. Compared to the situation in other countries such as the USA, UK, and Germany, the current Irish banking crisis is notable for its simplicity. During the 2000-2006 period, the Irish banks[1] lent recklessly to their domestic property development industry and in 2007-8 this industry collapsed. Now these loans are greatly impaired, endangering the current and future viability of the banks and inducing the banks to sharply curtail new lending. Irish banks have little exposure to the credit and mortgage-related derivatives which increase the complexity of the banking problem in other countries.[2]

The US credit-liquidity crisis originated in three linked markets: the mortgage derivatives market, the bond repurchase market, particularly for subprime bonds, and the interbank lending market. A credit-liquidity crisis in these linked markets led to a near complete market breakdown of the mortgage derivatives and credit derivatives markets and the absence of tradeable market prices. See Brunnermeier (2009), Diamond and Rajan (2009), Gorton (2009) and Acharya, Gale and Yorulmazer (2009) for analysis and discussion focussed on the US environment, and Heider, Hoerova and Holthausen (2009) for similar analysis with a European focus. Several analysts argue that it is nearly impossible to provide meaningful market values for the complex housing-related derivatives held by US, UK and German banks, since the liquid market for these securities has collapsed; see Bebchuck (2009) regarding the difficulty of current valuation for US banks' mortgage-derivative and credit-derivative assets and Schafer and Zimmerman (2009) for similar points regarding German banks' complex derivative asset positions. This is consistent with the theoretical model in Diamond and Rajan (2009) arguing that the specialized, information-intensive analysis needed to value complex mortgage-related derivatives led to an effective closing of that market in re-

[1] For terminological simplicity I do not differentiate between banks and building societies, which are equivalent from the perspective of my model.

[2] See Honohan (2009). It should be noted that the liability side of Irish banks' balance sheets was less traditional, since they relied heavily on interbank foreign borrowing in the Euribor market for funding of mortage and property lending; this also is discussed in Honohan (2009).

sponse to increased mortgage default rates. Gorton (2009) also argues that reasonable market pricing collapsed in the mortgage derivatives market, but places more blame on turmoil in the linked funding markets, particularly the bond repurchase market.

The Irish banking crisis is simpler in structure, and my modeling approach reflects this. The impaired assets of Irish banks are conventional, property-backed development loans, many with additional recourse to the personal and corporate assets of the borrower. Although valuation is not trivial, it is reasonable to treat these impaired Irish bank loans as having discernable market values. Another distinguishing feature of the Irish banking policy problem is the tightness of Ireland's sovereign borrowing constraint compared to other developed markets.[3] Any policy proposals must be weighed carefully against other pressing demands on government cash flows and/or government risk capital.

The model provides a simple analytical framework for understanding the new-lending decisions of banks with a large overhang of bad loans. The model encompasses some of the key decision variables and policy trade-offs facing the Irish government in its interventionist bank policy designed to increase bank lending. A number of basic concepts are explicated in the paper, including the risky lending gap, the supply schedule of risky lending, capital injections versus asset purchases as policy tools, decomposition of the effects of asset purchases into loan substitution and risk absorption effects, and a metric for comparing the various policy choices in terms of their drain on government risk capital. It is shown that a capital injection ameliorates the capital component of the risky lending gap without affecting the asset risk component while an asset purchase scheme has no effect on the capital component but decreases the asset risk component. I also describe the no-lending trap of an impaired bank, which is an analytical representation of the widely discussed "zombie bank" problem. I show the relevance of the no-lending trap to current Irish bank intervention policies.

Section two considers the case of a *healthy bank*, defined as one without an overhang of bad loans, to set the framework and provide a benchmark. Section three considers an *impaired bank* defined as one with an overhang of bad loans; minus the difference between this bank's lending choice and that of an otherwise equivalent healthy bank I call the risky lending gap. Section four analyzes government intervention policies designed to decrease

[3] See IMF Staff (2009) and White (2009).

or eliminate the risky lending gap. Section five applies the key ideas from the model to evaluate current Irish banking policy alternatives. Section six considers various extensions and refinements of the model. Section seven summarizes the paper.

2 Socially-Optimal Lending by an Unimpaired Bank

This section considers a "healthy bank" environment to set the framework. The bank has book value of equity capital of B. At the beginning of the period, bank management chooses a level of lending L (encompassing all the various categories of bank lending such as business loans, home mortgages, etc.). This lending is supported by the bank's equity capital, plus savings accounts to customers paying a risk-free interest rate of r_0. The bank can freely adjust the amount of saving accounts that it issues and the risk free return stays fixed at r_0.

2.1 The Risky Lending Opportunity Set of the Bank

The bank's lending is risky since borrowers may default on their loans. For normal lending (property development loans will be considered later) the bank faces a continuum of infinitesimally-small loan opportunities, indexed on the positive real line, with random returns r_i, $i \in (0, \infty)$. The per-euro random return on loan i consists of constant (across i) expected return, plus market risk, plus lending-related non-market risk, plus loan-specific idiosyncratic risk:

$$r_i = \overline{r}_N + \beta \widetilde{r}_m + \gamma \widetilde{f}_L + \varepsilon_i,$$

where ε_i is mean zero, independently distributed[4] across i, and none of the other variables are loan-specific. The market factor, $\widetilde{r}_m$ and lending-related non-market factor, $\widetilde{f}_L$, are uncorrelated, zero mean random variables capturing (respectively) the market-related nondiversified risk and non-market-related nondiversified risk in the bank's loan book. The idiosyncratic risks ε_i are diversified away in the bank's loan book. The non-market factor $\widetilde{f}_L$

[4]There are some subtle measure-theoretic difficulties with assuming independence of a continuum of random variables but these can be overcome - see Judd (1985) and Duffie and Sun (2004).

impacts the risk of the bank's loan book, but is diversifiable risk from the perspective of capital market investors holding well-diversified portfolios of securities. The market beta β and factor exposure γ are assumed constant across loans; I weaken this assumption in section six below.

By assumption, the Capital Asset Pricing Model (CAPM) applies to all traded assets in the economy, including the market value of bank loans and bank equity. I assume that the expected book value return on normal loans equals their CAPM-required return, so that $\overline{r}_N = r_0 + \beta\pi$ where π is the market risk premium. This ensures that the book value of each loan equals its fair market value.

Recall that the euro amount of lending chosen by the bank is denoted L. The return on this lending is the integral of loan returns over the interval 0 to L :

$$r_N = \frac{1}{L}\int_0^L r_i d_i = \overline{r}_N + \beta\widetilde{r}_m + \gamma\widetilde{f}_L, \tag{1}$$

invoking the law of large numbers and independence across ε_i to impose $\int_0^L \varepsilon_i d_i = 0$. By the definition of return, the end-of-year value of the lending book is $(1 + r_N)L$.

I define the *risky lending opportunity function* as the relationship between the size of the loan book L and its return volatility $\sigma_N = (Var[r_N])^{\frac{1}{2}}$. In section six below we consider nonconstant risky lending opportunity functions:

$$\sigma_N = g(L), \tag{2}$$

by allowing β and γ to depend upon i. In the main part of the paper (sections two through five) we rely on (1),which gives constant return volatility for the lending book, in particular:

$$\sigma_N = (\beta^2 Var[r_m] + \gamma^2 Var[f_L])^{\frac{1}{2}}.$$

2.2 Bank Equity Market Value and Return

Next I consider the determination of the market value of the bank's equity. Recall that the expected return on normal bank lending is equal to its required return $\overline{r}_N$. The market discount rate for risk-free borrowing and lending is of course r_0. The CAPM has the non-arbitrage property that the discount rate on linear combinations of CAPM-priced assets is the value-weighted linear combination of their discount rates. It follows from Modigliana-Miller theory that the bank's lending choice has no effect on its equity market value; the bank engages in any chosen amount of zero-net-present-value borrowing and zero-net-present-value lending, but this always keeps it equity market value Q equal to book value B.

Let V denote the realized end-of-year value of bank equity. End of year value of equity is the value of the loan book minus the interest cost of the savings accounts:

$$V = (1 + r_N)L - (1 + r_0)(L - B) \tag{3}$$

where r_N is the realized return on the loan book. Return on equity is defined as the annual proportional increase in equity value, that is,

$$r_Q = V/Q - 1. \tag{4}$$

The realized return on equity can be inferred from the chosen level of lending and the realized return on the loan book:

$$V/Q - 1 = r_0 + (L/Q)(r_N - r_0). \tag{5}$$

Note that for simplicity in my definitions of realized equity value and return, equations (3) and (4), I do not allow equity shareholders to have limited liability. Unlimited liability allows the bank to issue risk-free savings accounts, which is analytically convenient.

2.3 Modeling the Bank's Lending Decision

Since in the model the bank engages in entirely zero-net-present-value lending and borrowing, the bank cannot increase or decrease equity value through its lending policy. Our modeling objective is to analyze the decreases in bank lending by banks with large overhangs of impaired loans. Within this context, it is sensible to model the bank as a risk-averse institution. The risk-return preferences of a bank, in terms of the imputed preferences from observable behaviour, depend upon a variety of influences: the risk preferences of bank shareholders holding underdiversified positions, managerial incentives toward risk-taking, and the costs of financial distress for the bank including reputational effects. For simplicity I assume that the bank "owner" (which can be viewed as an amalgam of the various stakeholders guiding its behaviour) has constant absolute risk aversion with risk aversion coefficient λ; that is:

$$U(r_Q) = E[-exp(-\lambda(1+r_Q))]$$

where r_Q is the one-year return on bank equity.

Calculating the mean and variance of the bank's realized return on equity:

$$E[r_Q] = (L/Q)(\overline{r}_L - r_0) + r_0, \tag{6}$$

$$Var[r_Q] = (L/Q)^2\sigma_N^2. \tag{7}$$

Both the expected return on equity (6) and its variance (7) are increasing functions of the chosen capital ratio (L/Q) of the bank.

I assume that $\widetilde{r}_m$ and $\widetilde{f}_L$ are multivariate normal, so that the realized return on lending r_N is normally distributed. This simple framework of constant absolute risk aversion and normally distributed returns has many weaknesses but it has the convenient property that preferences can be written in a simple linear mean-variance form. Applying the formula for the expectation of the exponential function of a normal:

$$U(r_Q) = -exp(-\lambda E[(1+r_Q)] + \frac{1}{2}\lambda^2 Var[r_Q]) \tag{8}$$

The left-hand-side preferences in (8) are only defined up to a monotonic transformation and are preserved under strictly increasing monotonic transformations. Taking the natural log of minus utility gives a monotonic inverse of preferences, and then multiplying by minus one restores the original monotonic ordering. Dividing by $\lambda > 0$ gives:

$$U^*(r_Q) = E[(1+r_Q)] - \frac{1}{2}\lambda Var[r_Q]), \tag{9}$$

which is an observationally equivalent (but simpler) version of the same preferences, restated as linear mean-variance preferences over equity return.

The bank owner's problem is to choose L to maximize $U^*(r_Q)$. The problem has a unique solution defined by its first-order condition $\frac{\partial U^*(r_Q)}{\partial L} \overset{set}{=} 0$ which becomes after simplification:

$$L = Q(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) \tag{10}$$

Figure 1 shows the optimal choice of lending by the bank. The parameters are calibrated to give a reasonable representation (annual units, billions of euros) for a medium-large Irish bank. In particular $B = 3$, $r_0 = 2\%, \overline{r}_N = 3.5\%, \sigma_N = 5.0\%$, and $\lambda = .36$.

FIGURE 1 HERE

Without further justification, I assume that the competitive lending choice by an unimpaired bank is the socially-optimal level of lending.

3 The Risky Lending Gap of an Impaired Bank

Now I consider the case of an impaired bank. The bank "inherits" a stock of bad loans from earlier bad decisions and/or bad luck (a combination of these, obviously, for the case of Irish banks circa 2009). I call these *developer loans*. Although the model remains a single-period static model, I think of the developer loans as due to decisions made sometime in "the past." Only the remainder of the loan book is a free choice variable for the bank.

3.1 Separating Out Developer Loan Losses

No matter how impaired, the developer loans should retain some positive expected value since some proportion of the loans may be repaid, or collateral seized and sold for cash. Let L_D denote the book value of developer loans with random return on book value of r_D. For simplicity I assume that there has been no book-value write down of developer loan impairment, so that L_D equals the loan original issue value.

The realized return on developer loans are uncertain with expected value $\overline{r}_D$ and standard deviation σ_D. I assume that the market discount rate on the developer loan losses is the same as on other loans, $\overline{r}_N$. However they have book value expected return substantially below their market value required return (it is clear empirically that $\overline{r}_D$ is negative) so that market value is substantially below book value. I assume that the returns on the developer loans and normal loans are joint normally distributed with correlation coefficient ρ.

Let L_N denote the normal loans (all loans other than the overhang of developer loans) with normal random return r_N. As before, these loans have returns given by (1). The total loan book is:

$$L = L_D + L_N.$$

Since normal loans have zero net present value, the market value of bank equity is equal to book value minus the discounted present value of the developer loan losses:

$$Q = B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N}) \tag{11}$$

The expected losses on the developer loans decrease the market value of bank equity and increase true leverage, even if these losses are not acknowledged in the published accrual-accounting balance sheet. A weakness of the model is that it cannot accomodate a negative-market-value bank, $L_D(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N}) \geq B$, since in that case equity return and bank owner risk preferences are undefined.

The risky lending opportunity function remains the same as in the case of the healthy bank. The bank is restricted to choosing $L_N \geq 0$ which implies that $L \geq L_D$.

3.2 Bank Equity Risk-Return and Optimal Lending Choice

The realized end-of-year equity value of the bank is now:

$$V = (1 + r_N)L_N + (1 + r_D)L_D - (1 + r_0)(L_N + L_D - B) \tag{12}$$

and return on equity is:

$$r_Q = \frac{V}{Q} - 1. \tag{13}$$

The expected return on equity and its standard deviation are easy to derive from (12) and (13):

$$E[r_Q] = \frac{L_N}{Q}(r_N - r_0) + \frac{L_D}{Q}(r_D - r_0) + \frac{B}{Q}r_0 \tag{14}$$

$$Var[r_Q] = (\frac{L_N}{Q})^2\sigma_N^2 + (\frac{L_D}{Q})^2\sigma_D^2 + 2\rho L_N L_D(\frac{\sigma_N \sigma_D}{Q^2}) \tag{15}$$

There are two basic changes in equity returns relative to the case of a healthy bank. One, the decrease in equity market value (11) causes leverage to increase, affecting mean return linearly and return variance quadratically. Two, the risk in the developer loan losses adds two positive terms to the expression for return variance. If we assume that at the optimum $L_N > 0$ then there is a unique solution to the bank's preference optimization problem defined by the first-order condition $\frac{\partial U^*(r_Q)}{\partial L_N} \stackrel{set}{=} 0$. Using (9) this becomes:

$$\frac{\partial U^*(r_Q)}{\partial L_N} = \frac{\partial E[r_Q]}{\partial L_N} - \lambda \frac{\partial Var[r_Q]}{\partial L_N},$$

where $\frac{\partial E[r_Q]}{\partial L_N} = \frac{(\overline{r}_N - r_0)}{Q}$ and:

$$\frac{\partial Var[r_Q]}{\partial L_N} = 2(\frac{L_N}{Q^2})\sigma_N^2 + 2\rho\sigma_D\sigma_N(\frac{L_D}{Q^2}) \quad (16)$$

Combining and simplifying the resulting expression for the first-order condition gives:

$$L_N = Q(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - \rho\frac{\sigma_D}{\sigma_N}L_D \quad (17)$$

subject to the inequality constraint $L_N \geq 0$. Adding developer lending to get total lending gives:

$$L = Q(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N} - 1)L_D \quad (18)$$

The case in which bank impairment is so severe that the first-order solution (18) does not obey the constraint $L_N \geq 0$ I call the *no-lending trap*. At the margin, such a bank has no lending sensitivity to government intervention efforts. Marginal increases in its capital or impaired asset purchases from it will have no effect on its lending policy. I will argue in section five that this no-lending trap has considerable policy relevance in the current Irish context.

3.3 The Risky Lending Gap and Its Two Components

In this subsection I first consider the case of an impaired bank that is outside the no-lending trap, and then generalize. The difference between optimal lending of the healthy bank (10) and of the impaired bank (18) is the risky lending gap (RLG). Using (10) and (18) and recalling that $Q = B$ for the healthy bank and (11) for the impaired bank:

$$RLG = [B(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2})] - \\ [(B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N}))(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N} - 1)L_D] \tag{19}$$

The risky lending gap (19) divides naturally into two components. Component one, called the *capital component*, involves recomputing RLG after setting $\rho\sigma_D = \sigma_N$ so that developer loans have the same marginal risk as normal loans:

$$capital\ component = \{\frac{L_D}{B}(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N})\}[B(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2})] \tag{20}$$

The term in curly brackets in (20) is the proportion of book value impaired due the expected loan losses; the proportion in square brackets is the socially-optimal level of bank lending. The capital component of the risky lending gap is the product of these two. The capital component captures the effect that the expected developer loan losses lower market value of equity and increase the bank's true leverage, leading it to curtail lending.

The second component I call the *asset risk component;* it involves setting $\overline{r}_D = \overline{r}_N$ so that developer loans have the same expected return as normal loans (but higher risk). Recomputing (19) in this case:

$$asset\ risk\ component = (\rho\frac{\sigma_D}{\sigma_N} - 1)L_D \tag{21}$$

The high volatility of developer loans, $\rho\sigma_D > \sigma_N$, increase marginal asset risk at any given level of bank lending, leading the bank to curtail lending.

Suppose now that the bank is in the no-lending trap, so that the inequality constraint $L_N \geq 0$ is binding. In this case the two components defined by (20) and (21) sum to more than the difference between optimal and impaired lending. In our application to Irish data, the capital component of the risky lending gap is always much larger than the asset risk component, so we absorb the inequality constraint into the capital component by subtracting from it the difference between $L_N = 0$ and the unconstrained solution. Assuming the inequality constraint is binding let $\widetilde{L}_N \leq 0$ denote the unconstrained solution to (17). We redefine the capital component as:

$$capital\ component = \{\frac{L_D}{B}(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N})\}[B(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2})] + \widetilde{L}_N.$$

4 Alternative Policies and Their Effectiveness

This section considers government policies to ameliorate or eliminate the risky lending gap, and discusses performance metrics for policy effectiveness. Where needed for clarity, I use an asterisk * to denote a variable after a policy intervention; so for example B is the bank's book value of equity without any government intervention and B^* is the book value taking account of the intervention.

As Honohan (2009) points out, policy analysis needs to distinguish between an asset purchase and a capital injection as policy tools to unfreeze bank lending. In an asset purchase, the government purchases the bank's bad loans in exchange for cash or financial securities. In a capital injection, the bank issues new equity which is purchased by the government for cash. These two pure policies can be combined: for example, the government can purchase risky loans and also boost bank equity by purchasing new shares issued by the bank. I consider both policies and combination policies.

I do not consider the case of a government cash subsidy, for example the government deliberately or covertly over-paying for the risky loans as a way to inject cash in the bank without diluting current equity holders' claims. Most analysts agree that any subsidy is inappropriate as a component of contemporary Irish bank policy.

4.1 Policy Effects for an Unimpaired Bank

In order to establish a baseline case I first consider the case of government intervention in a healthy bank. This is counterfactual since there is no reason for such intervention, but it provides baseline clarity when we examine the more relevant case of intervention for an impaired bank.

Recall from section two the case of a healthy bank. Suppose that the government chooses to inject G billion euros of equity capital into the bank. The market value of bank equity capital increases to $Q^* = B + G$. This decreases the bank's leverage ratio $\frac{V}{Q^*}$ for any chosen value of L. This induces the bank to increase L since the marginal increase in equity return variance is lower for any fixed L. Re-solving the bank's optimal lending problem with $Q^* = Q + G$ gives, in place of (10),:

$$L^* = L + G(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}).$$

Next I consider an asset purchase. The analysis is trivial. There are no impaired loans. The bank first chooses the optimal loan book size given by (10). Then, the government purchases loans from the bank with book value and market value of L_G in exchange for a cash payment of L_G. Next and last, the bank re-adjusts its loan book optimally. The bank simply reinvests the cash in additional loans and so reverts to its original optimal loan level (10). Since the government holds loans with a book value of L_G, the government' intervention has increased the total supply of loans associated with the bank from L to $L+L_G$. I call this induced increase in total bank-associated lending the *loan substitution effect*.

4.2 Capital Injections for an Impaired Bank

In this subsection I consider a capital injection of G into the impaired bank described in section three. This has no effect on the risk of the bank's loan book, but equity capital increases from $Q = B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N})$ to $Q^* = B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N}) + G$. Inserting into (14) and (15) and re-solving for optimal lending gives, in place of (18),:

$$L^* = [B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N}) + G](\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N} - 1)L_D. \tag{22}$$

Note that a capital injection deals one-for-one with the capital component of the risky lending gap, (20). Setting $G = L_D(\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N})$ eliminates the capital component of the risky lending gap completely.

4.3 Asset Purchases and Combined Policies for an Impaired Bank

We assume that the government pays a fair market value for the purchased assets, and purchases book value amount L_G. The fair price for purchasing developer loans with book value L_G is the present value of the expected cash flows from the loans:

$$PV(L_G) = L_G \frac{1+\overline{r}_D}{1+\overline{r}_N}.$$

The *haircut* on the purchase refers to the proportional difference between book value and the purchase price. Given fair pricing this equals the difference between L_G and $PV(L_G)$ as a proportion of L_G. By simple algebra the haircut equals $\frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N}$.

The asset purchase crystalizes the already-lost value in the developer loans, and mandates a write-down of the purchased loans' book value, and consequently the book value of equity as the residual liability on the balance sheet. The book value of equity falls by the difference between the loans' book value and the fair-value cash payment:

$$B^* = B - L_G \frac{\overline{r}_N - \overline{r}_D}{1+\overline{r}_N} \tag{23}$$

The effect on the market value of equity is, obviously, zero. This is because the decrease in book value is exactly offset by the decrease in value-impairment associated with the purchased loans, so that $Q^* = Q$.

The difference in the impact of an asset purchase on book value (23) and market value is relevant to current policy debates in Ireland. Analysts have cited the decline in "bank capital" as a painful consequence of any asset purchase plan. Note that in the model there is no effect on true market value of equity capital from the asset purchase; it is only (badly-measured) accounting book value that is affected. In my model, bank management-owners are fully aware of the decline in equity capital before the asset purchase mandates its recognition in accounting book values. The cosmetic adjustment in equity book value has no impact on bank behaviour in my model. Of course this badly measured book value can have implications for regulatory capital needs; this reveals a weakness in the regulatory regime, since it is not a change in "true" equity capital; see Jackson, et al. (1999).

As in the case of a healthy bank, an asset purchase has a loan substitution effect, directly increasing the loans associated with the bank by L_G. In the case of the impaired bank, there is a second potentially more important effect. I will call this second effect *government risk absorption*. The high-variance developer loan losses are removed from the bank's risk profile, which encourages the bank to pursue a riskier lending strategy. To see this effect, consider the loan book return variance as a function of L:

$$Var(r_Q^*) = (\frac{L_N}{Q})^2\sigma_N^2 + (\frac{L_D - L_G}{Q})^2\sigma_D^2 + 2\rho\sigma_D\sigma_N\frac{L_N(L_D - L_G)}{Q^2} \quad (24)$$

Finding marginal variance by taking the derivative of (24) with respect to L_N :

$$\frac{\partial Var(r_Q^*)}{\partial L_N} = 2\sigma_N^2(\frac{L_N}{Q^2}) + 2\rho\sigma_D\sigma_N(\frac{L_D - L_G}{Q^2}) \quad (25)$$

Given that $\rho\sigma_D > \sigma_N$, then $2\rho\sigma_D\sigma_N > 2\sigma_N^2$. If this holds, then the term $-L_G$ decreases the marginal increase in variance function (25) more than $+L_N$ decreases it, and so increases in L_G lead to increases in optimal bank lending $L^* = L_N + L_D - L_G$.

Inserting the new expressions for mean return and return variance into the first order condition for optimal normal lending, and simplifying, gives:

$$L_N^* = (B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N}))(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N})(L_D - L_G),$$

where we only consider the case $L_N > 0$ which implies $L_N^* > 0$. Adding in the remaining developer loans to get total lending of the bank:

$$L^* = (B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N}))(\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N} - 1)(L_D - L_G) \quad (26)$$

hence an asset purchase has no leverage effect (Q is unchanged) but deals directly with the asset risk component of the risky lending gap, shown in (21). Setting $L_G = L_D$ eliminates the asset risk component.

Note that (26) gives the bank's chosen lending book after an asset purchase; there is also the loan substitution effect, adding L_G to total bank-associated lending, since the government agency holds these additional loans.

Suppose that the government chooses to inject equity capital G and purchase L_G book value of developer loans. We denote such a combination policy as a pair (G, L_G). Taking the first order condition for optimal normal lending L_N^* as above and then adding $L_D - L_G$ gives:

$$L^* = [B - L_D(\frac{\overline{r}_N - \overline{r}_D}{1 + \overline{r}_N}) + G](\frac{1}{\lambda})(\frac{\overline{r}_N - r_0}{\sigma_N^2}) - (\rho\frac{\sigma_D}{\sigma_N} - 1)(L_D - L_G). \quad (27)$$

This is the bank's optimal lending; due to the loan substitution effect the total lending associated with the bank is $L^* + L_G$.

4.4 A Metric for Policy Cost-Benefit

An important policy question is which policy or combination policy offers the best cost-benefit tradeoff for the Irish government.

This paper assumes fair-market-value transactions between the government and bank, so they are all "costless" in terms of the government's net loss in market value terms. However, even given that the government pays fair market value, there is a hidden cost to these policies. In the absence of a risky lending gap, the government would not freely choose to hold bank shares or a portfolio of bad property loans. The government has not given the bank a direct subsidy, but it has provided risk capital. The provision of risk capital is the implicit cost. Policy alternatives can be compared by examining their relative demands on Irish government risk capital.

We will describe the cash flow volatility of the government's asset position for the two pure policies and the combination policy. The cash flow volatility of a capital injection of G is the current market value of the position times the volatility of equity capital return:

$$[var(G)]^{\frac{1}{2}} = G[var(r_Q^*)]^{\frac{1}{2}}.$$

The cash flow volatility of an asset purchase of L_G book value of the developer loans is their book value times the volatility of their return on book value:

$$[var(L_G)]^{\frac{1}{2}} = L_G \sigma_D.$$

A combination policy, denoted (G, L_G), has cash flow volatility:

$$[var(G, L_G)]^{\frac{1}{2}} = [G^2 var(r_Q^*) + L_G^2 \sigma_D^2 + 2GL_G(cov(r_D, r_Q^*))]^{\frac{1}{2}}, \tag{28}$$

where :

$$cov(r_Q, r_D) = (\frac{L_N^*}{Q^*})\rho\sigma_N\sigma_D + (\frac{L_D - L_G}{Q^*})\sigma_D^2.$$

Consider the policy pairs (G, L_G) which set the risky lending gap equal to zero: these pairs are defined implicity by setting (27) plus L_G equal to (10). The risk-capital-minimizing policy pair (G, L_G) is the one of these that minimizes $var(G, L_G)$. Note that there are inequality constraints on the optimization, $0 \leq L_G \leq L_D$ and $G \geq 0$, so that a "pure" solution $(0, L_G)$ or $(G, 0)$ can be optimal.

Whether a capital injection or an asset purchase is a more appropriate solution to the risky lending gap partly depends upon whether the gap is due to the expected losses on developer loans, $\overline{r}_D$, or the riskiness of these loans in the bank's loan portfolio, captured by $\rho\sigma_D$. If it is the expected losses then a capital injection seems more appropriate, since the problem is then a shortage of capital, whereas if it is due to the riskiness of the developer loans then an asset purchase seems a more appropriate policy tool.

5 Application to Irish Bank Bailout Policies

In this section I calibrate the model to the domestic Irish banks. The nine parameters which must be set are the risk-free rate r_0, expected return on normal loans $\overline{r}_N$, expected return on book value for developer loans $\overline{r}_{D,}$ book value of bank equity B, book value of developer loans D, volatility of return for normal loans σ_N, volatility of return for developer loans σ_N, the bank risk aversion parameter λ, and the correlation between the returns on normal loans and developer loans ρ. I relied on a variety of resources, including White (2009), IMF Staff Report (2009), Honohan (2009), Irish newspapers, and informal discussions with market professionals. The parameter values are based on my own interpretation/evaluation of these various sources.

The model has a static one-period risk horizon; I consider three versions of the model with a risk horizon of T years, $T = 1, 5, 10$. For the version of the model with a one-year horizon I set $r_0 = .02, \overline{r}_N = .035, \sigma_N = .05$, which seem uncontroversial. The developer loans are given a much higher volatility, $\sigma_D = .15$, to reflect their great degree of uncertainty. The correlation between normal and developer loan returns is set at 0.8. To get return volatilities for the $T-$year horizon model I simply[5] multiply the one-year values by $\sqrt{T}$. For r_0 and $\overline{r}_N$ I use the equivalent $T-$period return with annual compounding, e.g., $r_0^T = (1+r_0^1)^T-1$. In all cases, the risk aversion parameter λ is set so that an unimpaired bank chooses an equity capital ratio of 6%. This gives $\lambda =$ 0.360, 0.401, 0.460 for $T = 1$, 5, 10, respectively. The book value of equity for each bank is set equal to 125% of the Tier 1 capital shown in White (2009, Table 6). The addition of 25% equity capital to the White (2009) figures is intended to adjust for Tier 2 capital and recent equity capital enhancement

[5] The "square root of time rule," as it is called, for converting shorter-term into longer-term volalities overstates long-term volatilities in the presence of mean reversion; see Lo and Mackinlay (1988). There are strong grounds for positing mean reversion in Irish property asset prices over coming years, but I use the standard rule for simplicity.

activity by the banks.[6]

Two critically important and difficult to determine parameters are the book value of "developer loans" (meaning the poor quality, impaired loans at each bank) and the expected book value return on these loans. There is little information about the distribution of developer loans across banks and so my estimates are somewhat arbitrary. My total estimated book value of the developer loans across the banks sums to 78 billion. This is less than the 90 billion which has been earmarked for the Irish government's loan purchase plan[7], but that plan includes provisions for accepting some relatively unimpaired loans[8]. For example it is intended to include loans for development properties in southeast England where the property downturn has been less severe and where there is already evidence of price recovery[9]; some of these loans belong in my "normal" rather than "developer" category.

For all the banks I assume that the developer loan assets have expected book value return over one year of -50%. The collateral for the bad-loan portfolios of the banks mostly consists of development land, unfinished construction projects, completed but unsold commercial and residential real estate, and completed investment properties (many with less than full occupancy rates), plus personal and corporate general guarantees on the loans. The market for development-property-related assets is distressed in Ireland in 2009, with deep falls in market values and no immediate prospects for recovery. There is hope among analysts that the market value of some of the loan collateral might partially recover, if held for a sufficiently long period. For the five and ten year horizons I assume that the cumulative (not annual) book value returns are -35% and -10%, respectively. Suppose that the original loans had loan-to-value ratios of 80%, which is very aggressive by traditional standards in Irish banking for this type of lending, but consistent with the excesses of the boom period.[10] In this case, the one-year book value return of -50% implies that the underlying asset values will have fallen by 60% since issuance, assigning zero value to any personal or corporate

[6] See Carswell (2009) for a description of some of these recent bank capital enhancements, which are ongoing.

[7] See Taylor (2009).

[8] See the discussion in Whelan (2009), and the quote from government minister Mary Harney contained therein.

[9] See the discussion in Quinn (2009).

[10] See Honohan (2009) for a discussion of irrational exuberance and over-aggressive market share rivalry in Irish banking in the post-2000 period.

guarantees on the loans. In order to have expected returns of $-35\%, -10\%$ over the five-year and ten-year horizons, respectively, property asset prices including impounded interest must increase by 30.00% (6.78% per annum with annual compounding) during years 2-5 and 38.46% (6.72% per annum) during years 6-10. This return includes any rental income received during the period, impounded into the price. It still leaves property prices 28% down on their peak values from when the developer loans were issued, including any interest income received over the ten-year period impounded into the price. These calculations rely on the assumption that the current book value of the loans equals the initial loan amount; it can differ if the book value includes rolled-up unpaid interest (increasing book value) or impaired loan charges (decreasing it).

Figure 2 shows the fair-value haircuts implied by various expected book value returns over the three horizons. For my chosen expected returns, the 1, 5, and 10 year holding periods imply haircuts of 51.69%, 45.27%, and 36.20%, respectively. The longer holding periods give lower haircuts due to the assumption of asset price recovery.

FIGURE 2 HERE

Table 1 shows the risky lending gap of the six domestic Irish banks, using each of the possible risk horizons (Panels A, B, and C of the table). Using a one-year horizon, the entire banking sector is in dire straits. Three of the banks, AIB, Anglo Irish, and Irish Nationwide, have negative equity value. Two other banks are in the no-lending trap, which means government aid (at least at the margin) will have no impact.

TABLE 1 HERE

Within the context of my model the negative equity value of three banks in Panel A seems an accurate depiction of the current state of the Irish banking sector. Only the government's unconditional guarantee on bank liabilities, put in place in September 2008, has prevented one or more bank failures in Ireland. Within the model, this government liability guarantee is implicitly included in equity value as a negative-value liability.

Using a five year horizon, Anglo Irish bank still has a negative equity value. Even with a ten-year horizon, Anglo Irish remains insolvent. From the perspective of the model, any government resources used to support

Anglo Irish are wasted, since the government intervention will not generate any new lending in the absence of a truly enormous capital injection.

For the five and ten-year horizons, the five solvent banks all show large risky lending gaps. The balance of the risky lending gap between the capital component and asset risk component is illuminating. The problem for the Irish banks is a capital shortage rather than a too-risky loan book. Consider the five-year horizon. Roughly four-fifths of the risky lending gap comes from the capital component and only one-fifth from the asset risk component, despite upward biased[11] forecasts of developer loan return volatility. According to my model, it is the capital component not the asset risk component that is generating the risky lending gap.

Table 1 illustrates both the strengths and weaknesses of this simple theoretical model. The model does not give believable forecasts of bank lending (noone believes that any of the five solvent banks will shrink new lending to zero) but shows succinctly the deep nature of their problem, and its source in too-low fair market value of equity capital.

Table 2 shows three government policies which attempt to set the risky lending gap equal to zero: two pure policies and a policy pair (G, L_G). It excludes the one-year horizon which has almost all the banks insolvent or deep in the no-lending trap. For all five solvent banks, the optimal government policy is to inject equity capital rather than purchase impaired assets. In all cases, the risk-capital-minimizing policy is a pure capital injection[12], involving a very substantial capital outlay. An asset purchase plan on its own is insufficient to eliminate the risky lending gap, but it can do so when combined with a smaller capital injection. Comparing the market values of equity capital in Table 1 with the proposed capital injections shown in Table 2, in all cases the capital injection implies a controlling government equity stake (above 50%) after the policy intervention.

TABLE 2 HERE

The calibration exercise highlights the advantages of a longer risk-return time horizon in resolving the Irish banking crisis. If an asset purchase plan allows the government to substitute a five or ten year risk-return perspective in place of the banks' one-year horizon, then the asset purchase plan could

[11] Due to mean reversion in property prices; see footnote 6 above.

[12] The inequality constraint $L_G \geq 0$ is active at the risk-capital minimizing optimum.

add considerable economic value. One can think of the current Irish banking dilemma as a very extreme version of the standard liquidity mismatch problem of banks (issuing short-term liabilities to fund long-term assets) as in Diamond and Dybvig (1983).

Figures 3 and 4 show, for all the banks except Anglo Irish, the dependence of the risky lending gap and its two components on the assumed values for the expected book value return on the developer loans and on the total book value of these loans, using the five-year horizon. Figures 5 and 6 illustrate the sensitivity of bank equity market value to these same two parameters for the same horizon.

FIGURES 3-6 HERE

The model is not able to accomodate all the complications of the contemporary Irish bank policy problem, but it captures in a simple way some key ideas that are important to the policy debate. In the next section I will examine some of the limitations of the model and explore ways that it could be extended.

6 Extensions and Limitations

6.1 Nonconstant Risky Lending Opportunity Functions

In this subsection I consider an extension of the model, allowing bank asset return volatility to depend upon the amount of lending that the bank chooses. To increase lending, the bank must lend to riskier borrowers. Hence the riskiness of the loan book is a function of the magnitude of lending.

I keep the same type of loan opportunity function as in section two, but assume that the relationship between loan i and its per-euro return volatility differs across i:

$$r_i = \overline{r}_N + \beta\widetilde{r}_m + \gamma_i\widetilde{f}_L + \varepsilon_i \tag{29}$$

where for simplicity γ_i has the linear form

$$\gamma_i = \gamma_0 + \gamma_1 i.$$

Taking the integral of (29) from 0 to L gives the same expression for r_N as in (1) except for an additional term $\gamma_1 L$. Computing the variance:

$$\sigma_N^2 = a + bL^2 \tag{30}$$

where $a = \beta^2\sigma_{rm}^2 + \gamma_0^2\sigma_{fL}^2$ and $b = \gamma_1^2\sigma_{fL}^2$.

Note that the presence of L^2 in (30) gives rise to a second term in the marginal risk function of the bank. In addition to the leverage effect (more loans means more risk per unit of equity capital) there is now a direct impact on asset riskiness – more loans means that the bank must take on riskier assets. Consider the marginal risk function of the impaired bank (16) replacing constant σ_N^2 with the function (30) in (16) and recomputing the derivative:

$$\frac{\partial Var[r_Q]}{\partial L} = 2(\frac{L}{Q})\sigma_N^2 + 2\rho(\frac{\sigma_N\sigma_D}{Q^2}) + 2(\frac{L}{Q})^2 bL + \frac{1}{2}\rho L^3(\frac{\sigma_D}{\sigma_N Q^2})b. \tag{31}$$

The sensitivity of bank lending to an overhang of developer loan losses is potentially much higher in this case, reflected in the extra terms and higher powers of L in (31). In this case the sensitivity of bank lending to asset purchase policies could be stronger than as given by (26) and (27).

As mentioned earlier I have assumed that the expected return on all loans is the same irrespective of their level of volatility. Suppose instead that the market risk parameter β in (29) is also a function of i. In this case both the expected return on loans, $\overline{r}_N$, and the required return on bank equity capital, $E[r_Q]$, will depend upon the bank's lending policy.

My model treats the bank's lending decision as a univariate choice of L, whereas in practice banks have independent control over the risk composition of their lending books. Impaired banks, rather than or in addition to decreasing their total lending, can shift their loan book toward lower-risk loans.

Since loans for new business ventures and business expansion are riskier than home mortgages and consumer lending, variation in the risk composition of bank loan books can magnify the impact of bank impairment on jobs and output. This has particular relevance in an open economy like Ireland's. Suppose that low-risk Irish bank loans are used to purchase holiday homes in Spain and luxury automobiles imported from Germany; these loans will have limited multiplier effects for Irish output and employment. Suppose high-risk Irish bank loans are used to hire additional staff and expand Irish export businesses; these could have substantial multiplier effects. Any such loan book risk-composition effects are missed by my model.

Another possible extension of the model concerns time-series dynamic variation in the lending opportunity set, particularly variation related to the business cycle. There are two ways to capture business cycle sensitivity in my model. One, by assuming an upward shift in the risky lending opportunity function (2) during business cycle contractions. Two, by making the risky lending opportunity function (30) more steeply sloped during contractions. In either case, the optimal level of lending falls in a contraction when banks are most likely to have impaired loans, making the measurement of the risky lending gap more difficult.

6.2 Delegated Monitoring, Bank-Client Relationships, Managerial Incentives

The theoretical model of this paper gives a very one-dimensional description of commercial banks and misses some of their essential features. A classic view, as in Diamond (1984), Boyd and Prescott (1986) and Gorton and Penacchi (1990), is that banks are essentially information-gathering institutions monitoring borrower quality and borrower actions. Diamond and Rajan (2001) argue that a bank establishes mutually beneficial, ongoing relationships with its borrowers, and this ongoing relationship gives the bank a flow of proprietary information about borrowers, and an enhanced ability to monitor lender behaviour and collect loan payments; see also Chan, Greenbaum and Thakor (1986) for a related model. Kashyap, Rajan and Stein (2002) argue that the ability and willingness to service credit lines to existing customers is another fundamental feature of commercial banks.

These deeper theories of banking have direct relevance to the policy questions at hand. Banks must be understood as information-and-relationship businesses, not simply asset portfolios.[13] In practice, an asset purchase scheme is not a simple transfer of the loans' cash flows from the bank to a government agency. The realized value of the loan cash flows can depend upon who is managing the impaired loans and their relationship to the borrower. Similarly, an infusion of government equity capital G can have adverse consequences on bank incentives and behaviour, and on borrowers'

[13] Boyd, Nicolo and Jalal (2006) make the distinction between portfolio allocation versus optimal contracting models of banks.

relationships with the bank. These important issues are not addressed by my model.

6.3 Non-equity Capital Injections

I have assumed the simplest possible bank capital structure: an all-equity firm issuing one type of savings deposit and purchasing two types of loans. Both capital injection and asset purchase plans might be enhanced by using more complex financial contracts. Determining the optimal contract design requires a more sophisticated analysis of the banking industry taking account of agency and monitoring issues and costly proprietary information, along the lines discussed in the previous subsection.

7 Summary

This paper is motivated by the current crisis in Irish banking. During the global credit-liquidity bubble of 2000-2006, Irish banks lent recklessly to domestic property developers. The Irish property development industry collapsed during 2007-2008, and Irish banks now hold a crushing burden of impaired property development loans. This burden has induced them to sharply curtail new lending, worsening the recession in Ireland. The Irish government has initiated a range of policies to encourage new lending, including equity capital injections in the banks by the government, and the proposed purchase by the government of some or all of the banks' impaired loans. The paper provides a simple theoretical model to evaluate these policy initiatives, and uses it to examine current policy choices.

The paper defines a healthy bank as one without an overhang of bad loans, and an impaired bank as an otherwise equivalent bank with such an overhang. The difference between the chosen lending level of a healthy bank and an impaired bank I call the risky lending gap. The risky lending gap has two components: a capital component, reflecting the decline in the market value of bank equity associated with the overhang of bad loans, and an asset risk component, reflecting the riskiness of the bad loans and their consequent impact on the bank's marginal risk-return tradeoff. A government equity injection addresses the capital component of the risky lending gap, whereas an asset purchase scheme addresses the asset risk component. An asset purchase scheme also has a direct impact on economy-wide bank lending since the purchased loans are fully or partially replaced within the free-market banking system while remaining outside that system, held on the books of a government agency. I call this the loan-substitution effect.

The model assumes subsidy-free policies so that all transactions between the government and the impaired bank are at market value. There is still an implicit "cost" to the policies since they absorb government risk capital. I describe a way to measure relative cost-benefit of the alternative policies based on their absorption of government risk capital.

The model parameters are calibrated to provide some insight on the Irish bank policy dilemma. Using a one-year risk-return horizon, the Irish banking sector is in dire straits. Netting out the government liability guarantee, three of the banks have negative market value. One of the remaining two banks is incentivized to cut all new lending to zero, staying in business simply to service its overhang of bad loans (this behaviour is what I call the no-lending trap).

With a five-year or ten-year horizon and an assumption of some property asset price recovery during that period, only one bank, Anglo Irish, is insolvent. All five of the solvent banks are incentivized to drastically cut normal lending relative to an equivalent healthy bank. The risky lending gaps of the five banks are mostly due to the capital component rather than the asset risk component. The problem of the Irish banks seems to be a shortage of equity capital rather than the presence of a too-risky loan book.

The risk-capital-minimizing government policy is to use a pure capital injection to eliminate the risky lending gap. An asset purchase plan on its own is insufficient since it leaves the banks short of capital. An asset purchase plan plus capital injection is a feasible alternative policy to the pure capital injection. If an asset purchase plan could serve to lengthen the effective risk-return horizon of banks, then this could serve as a major source of value-added for the policy.

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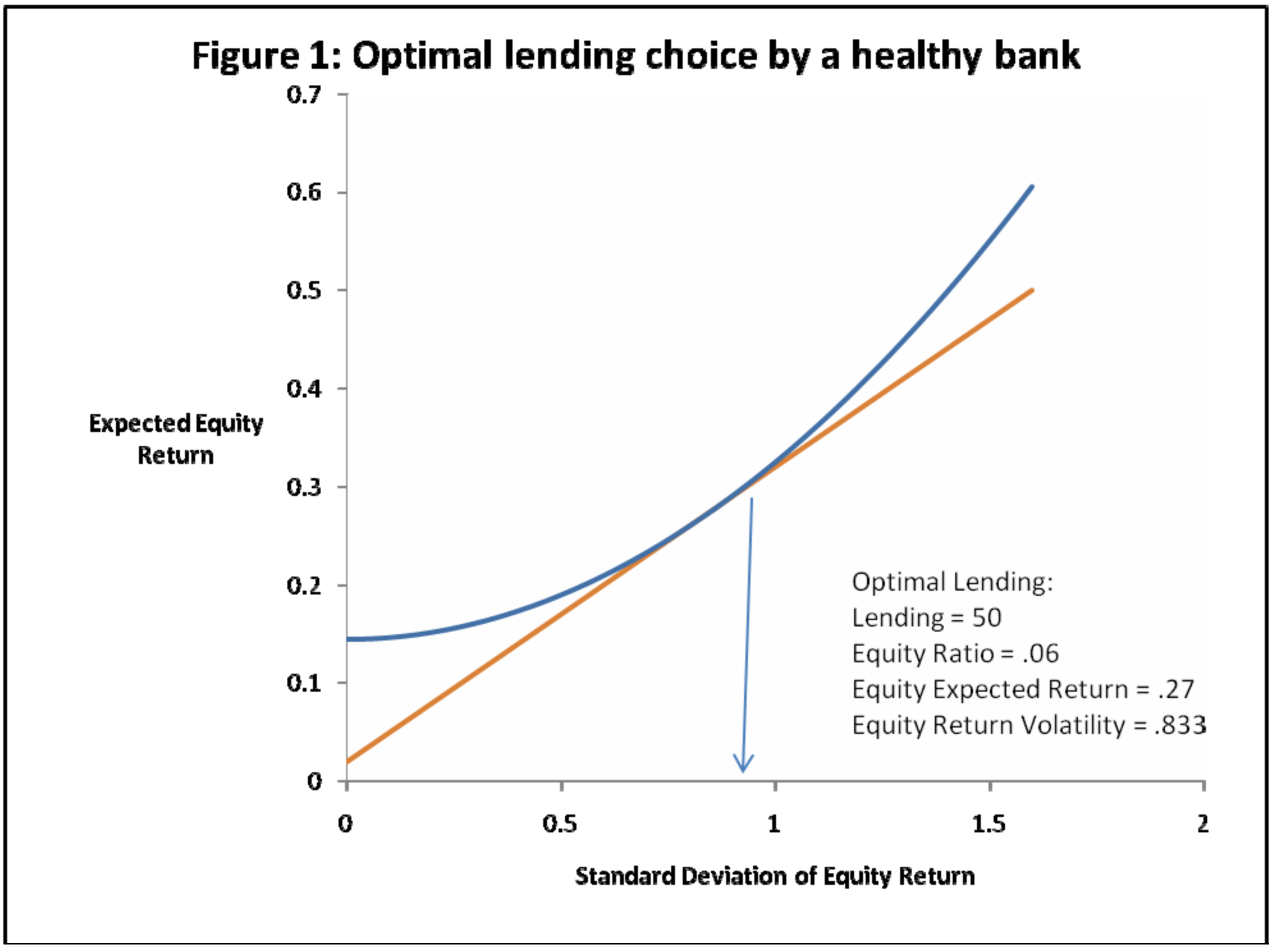
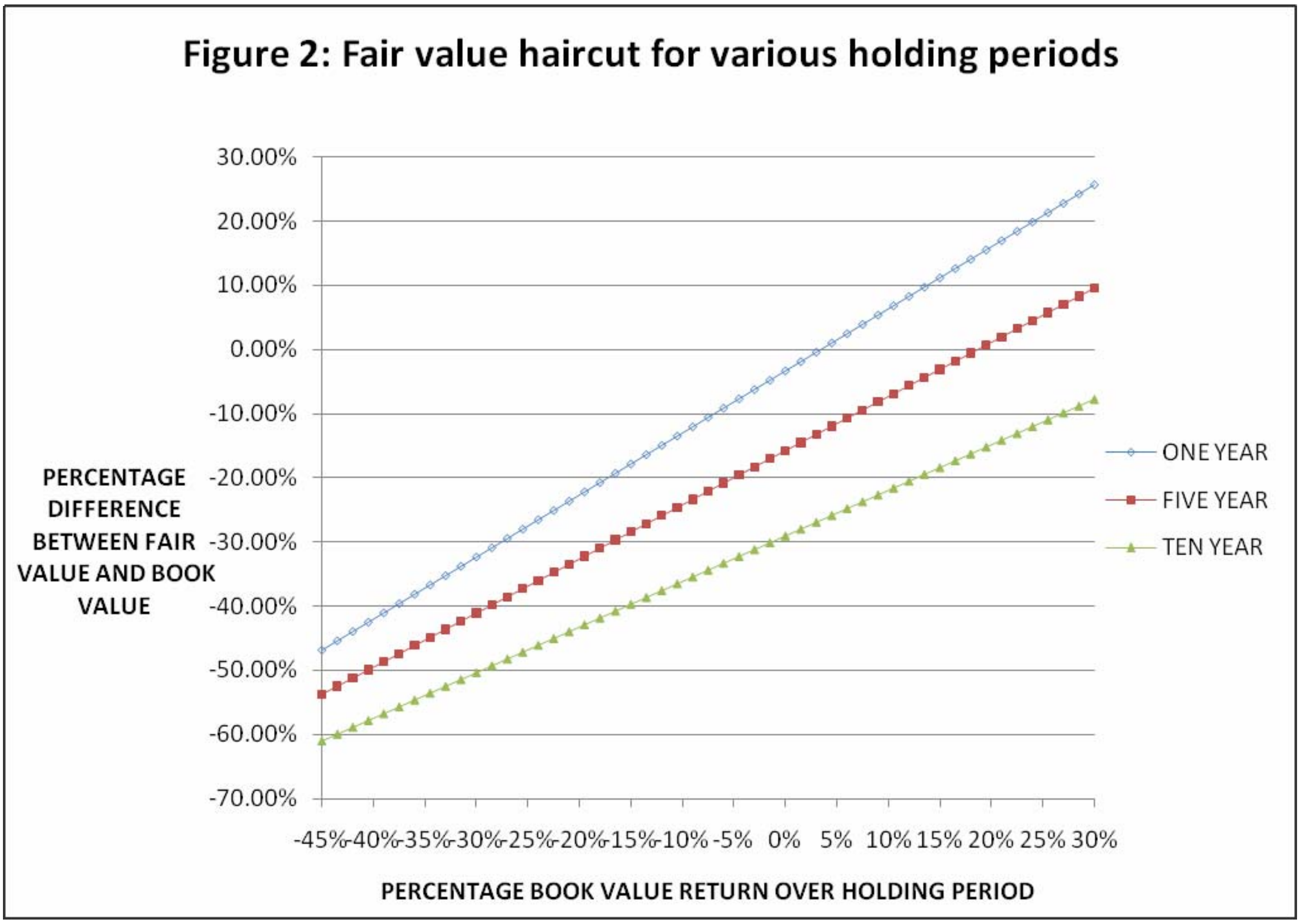
Table 1: The Risky Lending Gap of Domestic Irish Banks All Units (Except Fair Value Haircut) in Billions of Euros								
One-year horizon								
Bank	Book Value of Equity	Book Value of Developer Loans	Market Value of Equity	Total Lending	Risky Lending Gap	Capital Component of the Risky Lending Gap	Asset Risk Component of the Risky Lending Gap	Fair Value Haircut on Developer Loans
Bank of Ireland	8.125	15	0.371	15*	120.417	99.417	NA	51.69%
Allied Irish Bank	9.625	20	-0.713	NA	NA	NA	NA	51.69%
Anglo Irish Bank	5.875	35	-12.217	NA	NA	NA	NA	51.69%
Permanent TSB	2.625	4	0.557	4*	39.750	34.150	5.600	51.69%
Irish Nationwide	1.5	3	-0.051	NA	NA	NA	NA	51.69%
Educational Building Society	0.75	1	0.233	2.485	10.015	8.615	1.400	51.69%
*=no-lending trap, total lending equal to outstanding developer loan amount.								
Five-year horizon								
Bank	Book Value of Equity	Book Value of Developer Loans	Market Value of Equity	Total Lending	Risky Lending Gap	Capital Component of the Risky Lending Gap	Asset Risk Component of the Risky Lending Gap	Fair Value Haircut on Developer Loans
Bank of Ireland	8.125	15	1.334	15*	120.419	99.419	21.000	45.27%
Allied Irish Bank	9.625	20	0.571	20*	140.419	112.419	28.000	45.27%
Anglo Irish Bank	5.875	35	-9.970	NA	NA	NA	NA	45.27%
Permanent TSB	2.625	4	0.814	7.969	35.782	30.182	5.600	45.27%
Irish Nationwide	1.5	3	0.142	3*	22.000	17.800	4.200	45.27%
Educational Building Society	0.75	1	0.297	3.555	8.945	7.545	1.400	45.27%

Table 2: Alternative Government Policy Interventions and their Impact
All Units in Billions of Euros

Five-year Horizon	Capital Injection Only*			Asset Purchase Only			Asset Purchase Plus Capital Injection			
Bank	Capital Injection	Risky Lending Gap	Risk Capital	Book Value Assets Purchased	Risky Lending Gap	Risk Capital	Book Value Assets Purchased	Capital Injection	Risky Lending Gap	Risk Capital
Bank of Ireland	6.549	0	4.509	15	51.605	5.031	15	3.294	0	8.702
Allied Irish Bank	8.732	0	5.194	20	68.807	6.708	20	4.391	0	11.528
Anglo Irish Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Permanent TSB	1.746	0	1.474	4	13.761	1.342	4	0.878	0	2.371
Irish Nationwide	1.310	0	0.818	3	10.321	1.006	3	0.659	0	1.731
Educational Building Society	0.437	0	0.413	1	3.440	0.335	1	0.220	0	0.603
*=in all cases, the pure capital injection is the risk-capital minimizing combination policy for setting the risky lending gap to zero.										
Ten-year Horizon	Capital Injection Only*			Asset Purchase Only			Asset Purchase Plus Capital Injection			
Bank	Capital Injection	Risky Lending Gap	Risk Capital	Book Value Assets Purchased	Risky Lending Gap	Risk Capital	Book Value Assets Purchased	Capital Injection	Risky Lending Gap	Risk Capital
Bank of Ireland	7.117	0.000	6.011	15.000	60.493	7.115	15.000	3.861	0.000	12.929
Allied Irish Bank	9.489	0.000	6.777	20.000	80.658	9.487	20.000	5.148	0.000	17.226
Anglo Irish Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Permanent TSB	1.898	0.000	2.039	4.000	16.132	1.897	4.000	1.030	0.000	3.519
Irish Nationwide	1.423	0.000	1.073	3.000	12.099	1.423	3.000	0.772	0.000	2.581
Educational Building Society	0.474	0.000	0.584	1.000	4.033	0.474	1.000	0.257	0.000	0.898

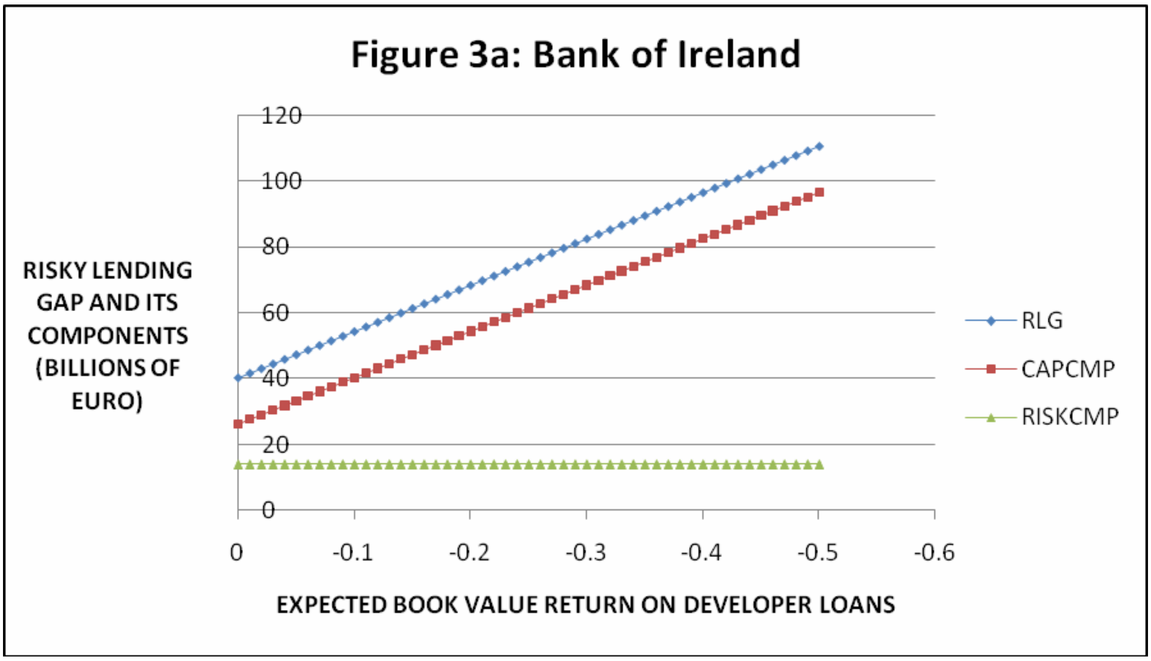


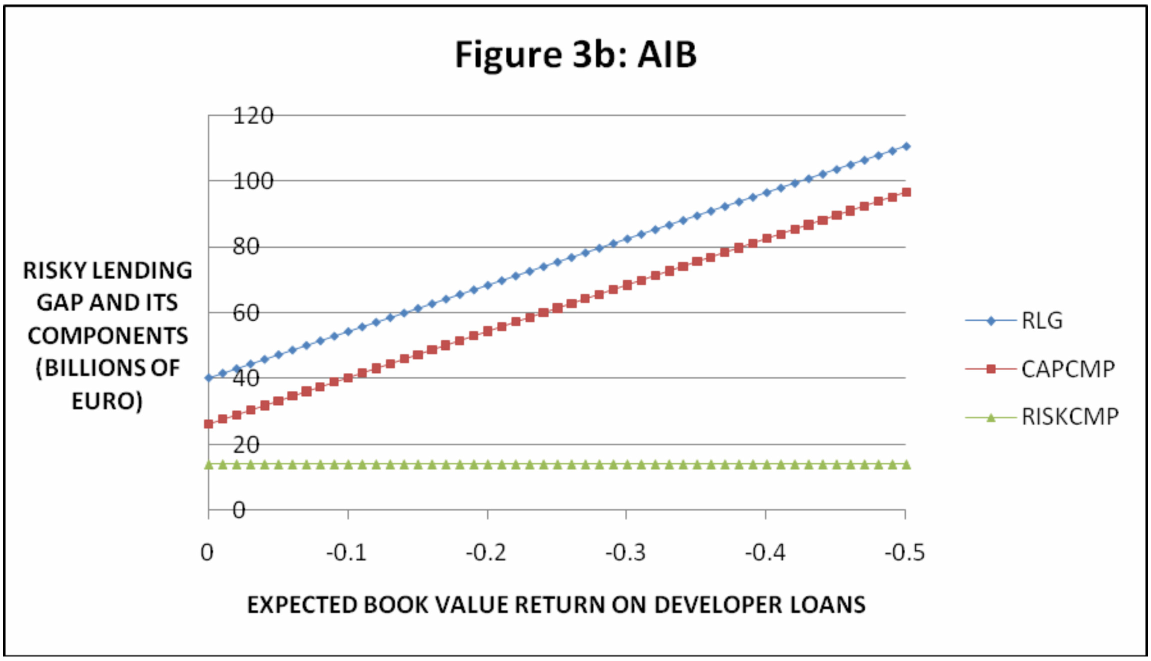
Notes for Figure 1: The figure shows the risk-return opportunity set of a healthy bank with equity capital of 3 Billion Euros, and other parameter values as discussed in the text.



Notes for Figure 2: The figure uses the parameter values from the calibrated models for one, five and ten years, except book value return of developer loans, which is varied.

Figure 3: The risky lending gap and its components as a function of the expected book value return on developer loans





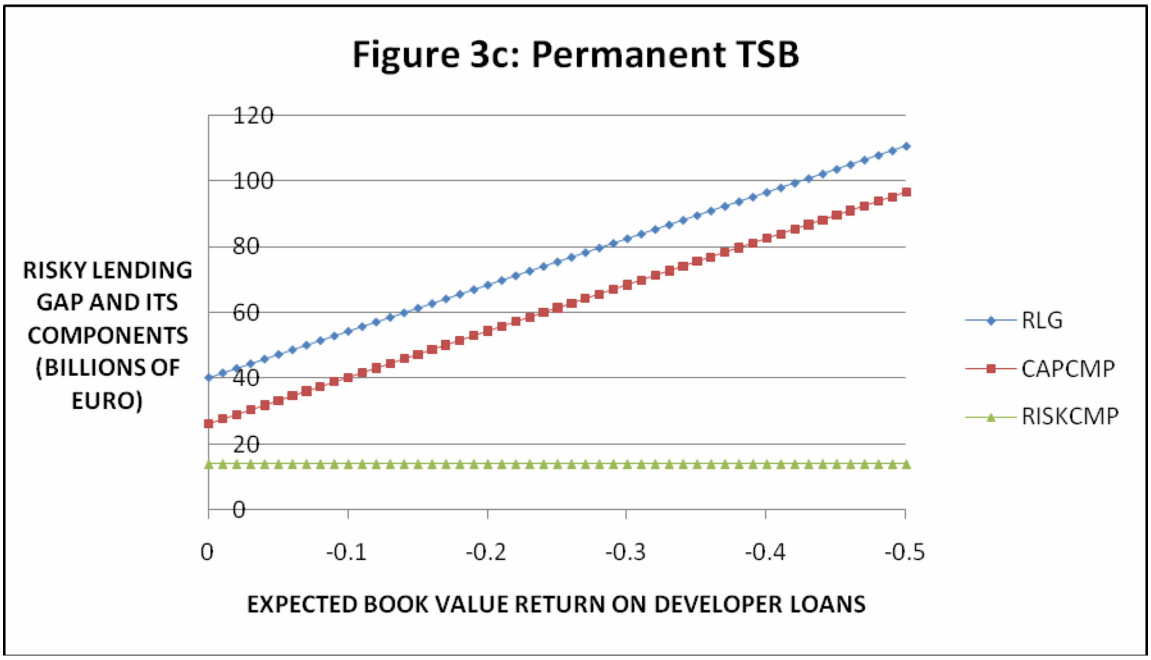


Figure 3c: Permanent TSB
120
100
80
60
40
20
0
RISKY LENDING GAP AND ITS COMPONENTS (BILLIONS OF EURO)
0
-0.1
-0.2
-0.3
-0.4
-0.5
EXPECTED BOOK VALUE RETURN ON DEVELOPER LOANS
RLG
CAPCMP
RISKCMP

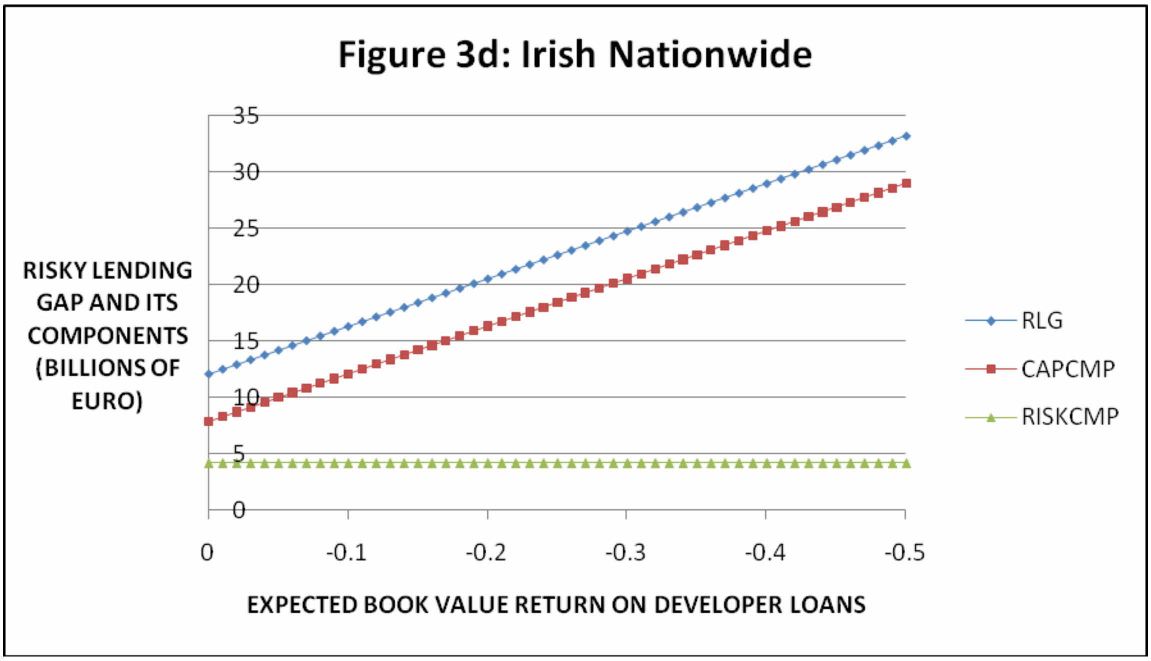
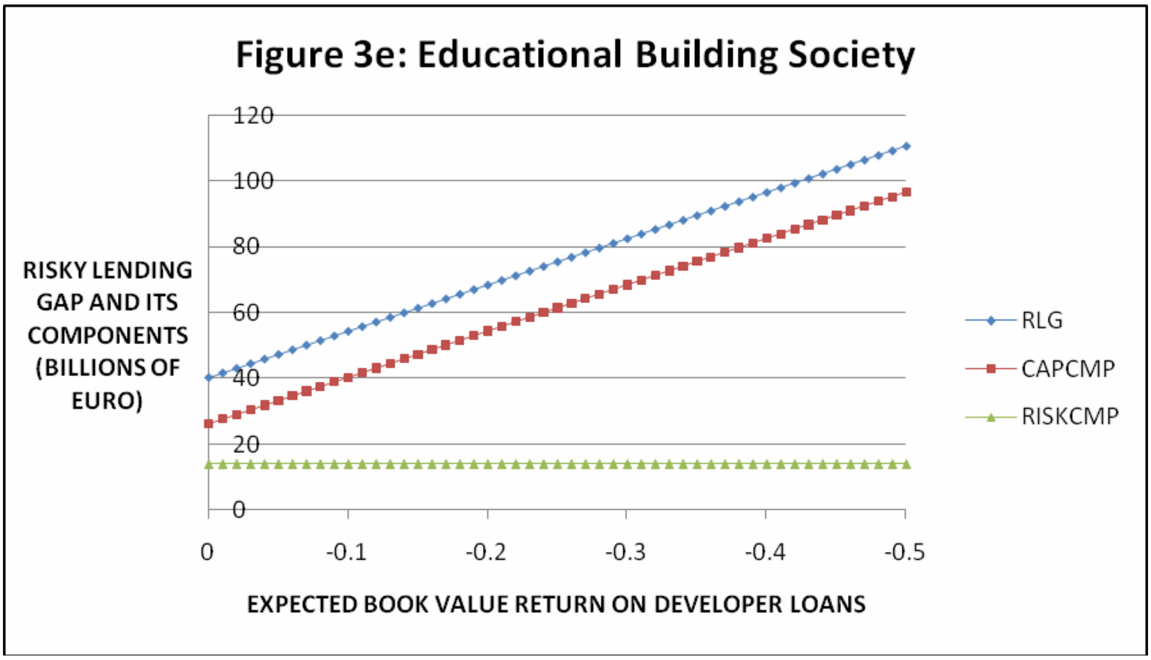


Figure 3d: Irish Nationwide
35
30
25
20
15
10
5
0
RISKY LENDING GAP AND ITS COMPONENTS (BILLIONS OF EURO)
0
-0.1
-0.2
-0.3
-0.4
-0.5
EXPECTED BOOK VALUE RETURN ON DEVELOPER LOANS
RLG
CAPCMP
RISKCMP



Notes for Figure 3: The figures show the risky lending gap (RLG), its capital component (CAPCMP) and asset risk component (RISKCMP) for each of the five banks using the five-year model parameters except the book value return of developer loans, which is varied.

Figure 4: Market value of equity as a function of the 5-year book value return on developer loans

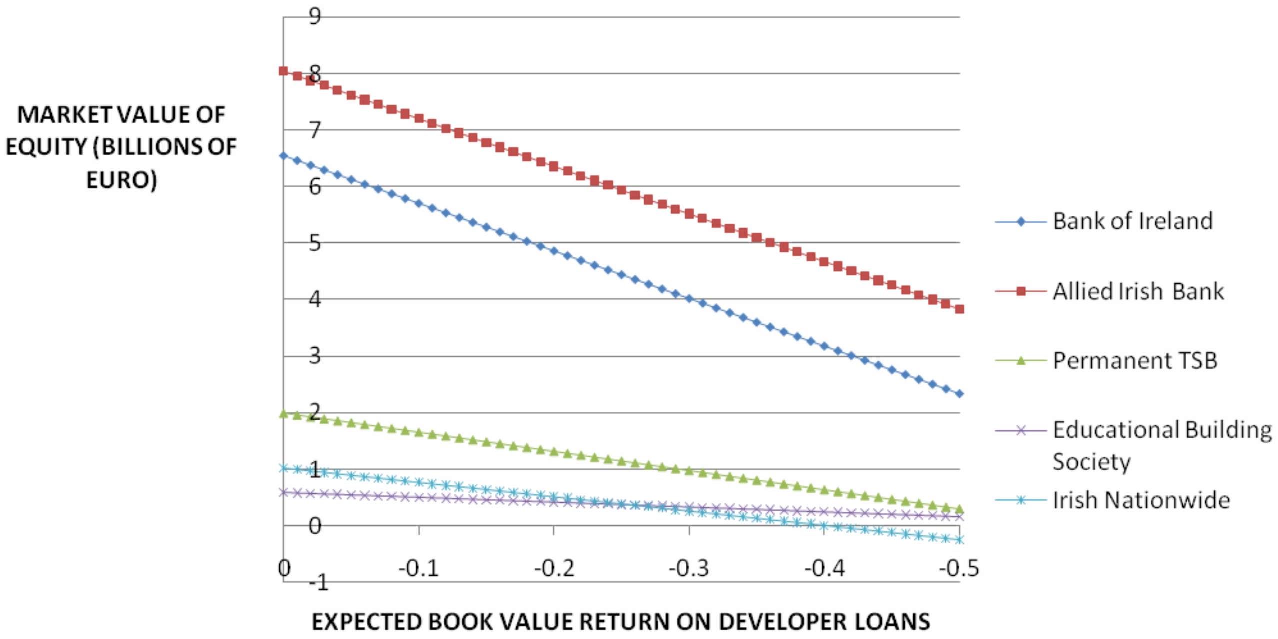
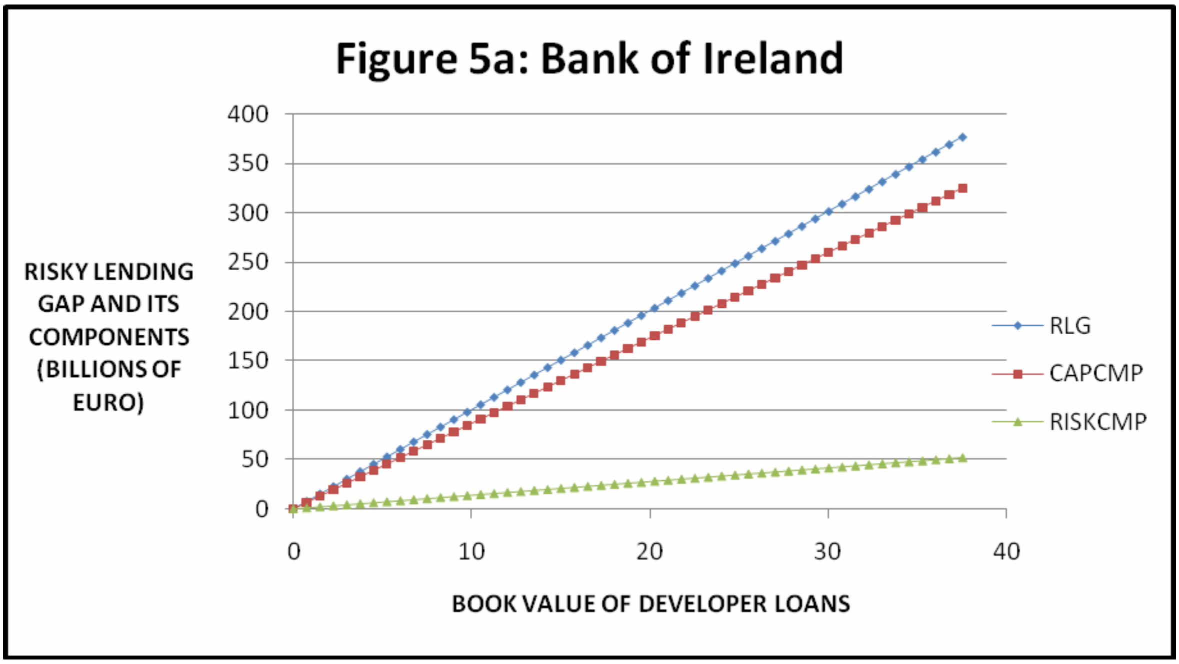
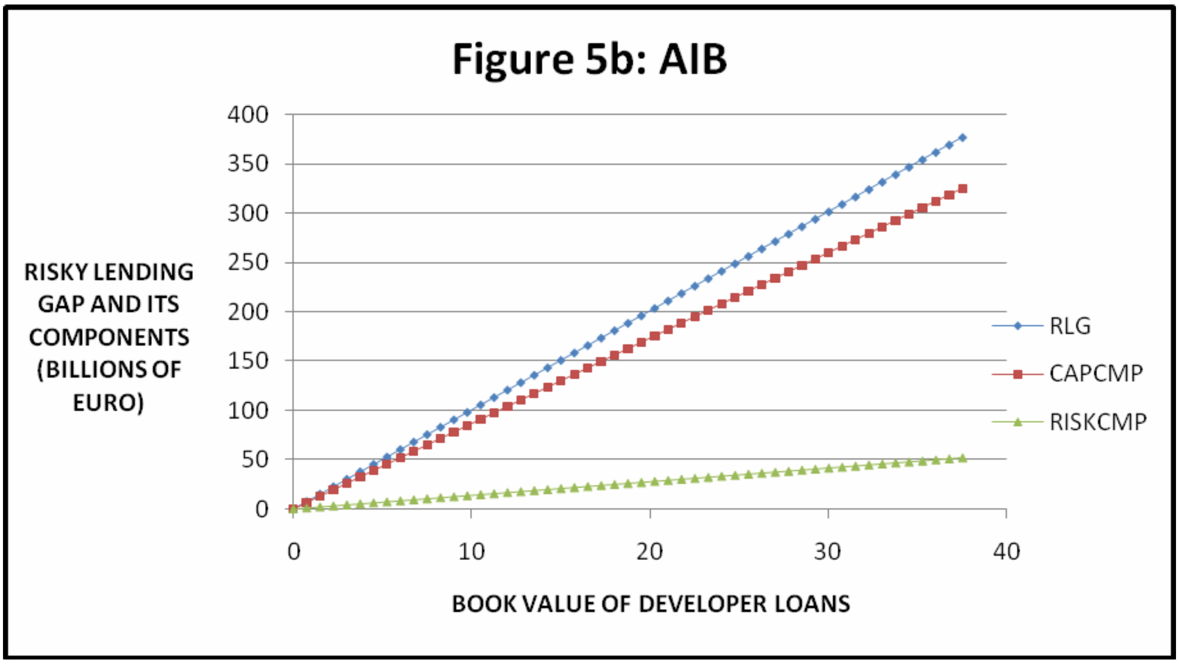


Figure 5: The risky lending gap and its components as a function of the total book value of developer loans





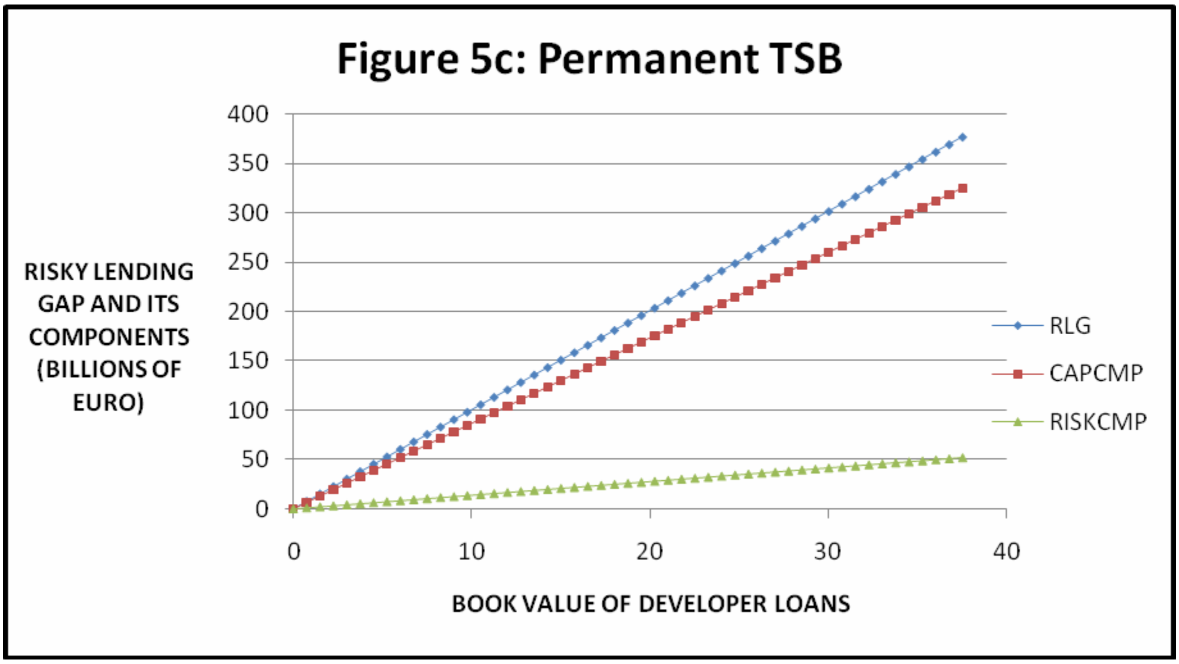


Figure 5c: Permanent TSB
400
350
300
250
200
150
100
50
0
RISKY LENDING GAP AND ITS COMPONENTS (BILLIONS OF EURO)
0
10
20
30
40
BOOK VALUE OF DEVELOPER LOANS
RLG
CAPCMP
RISKCMP

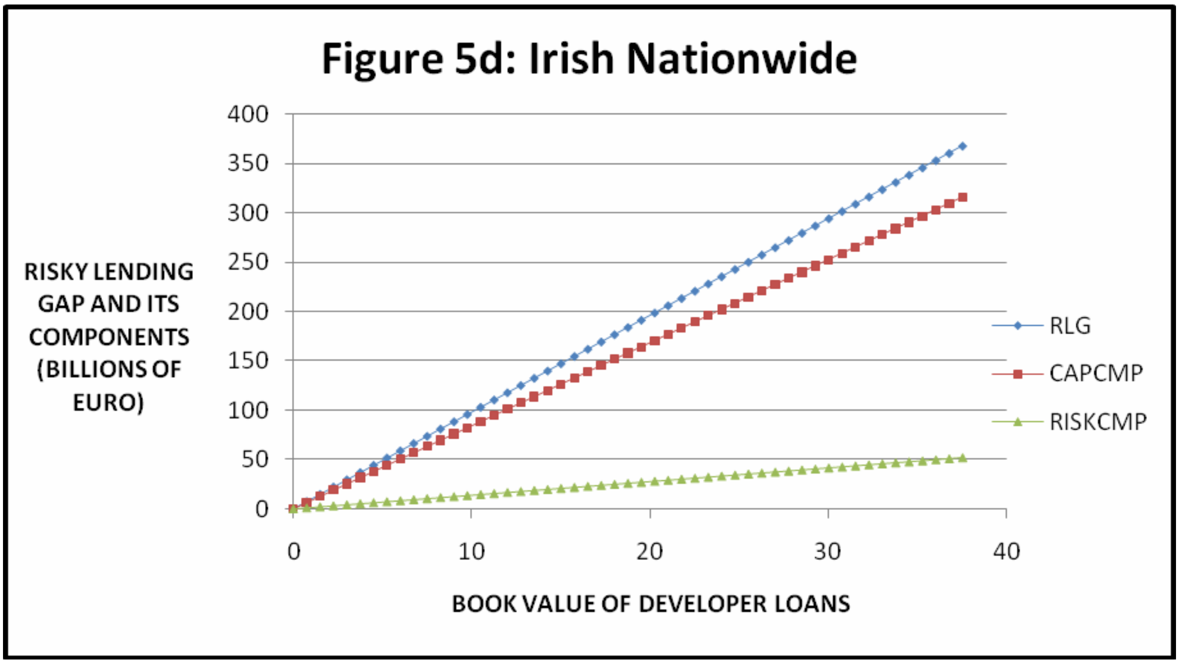
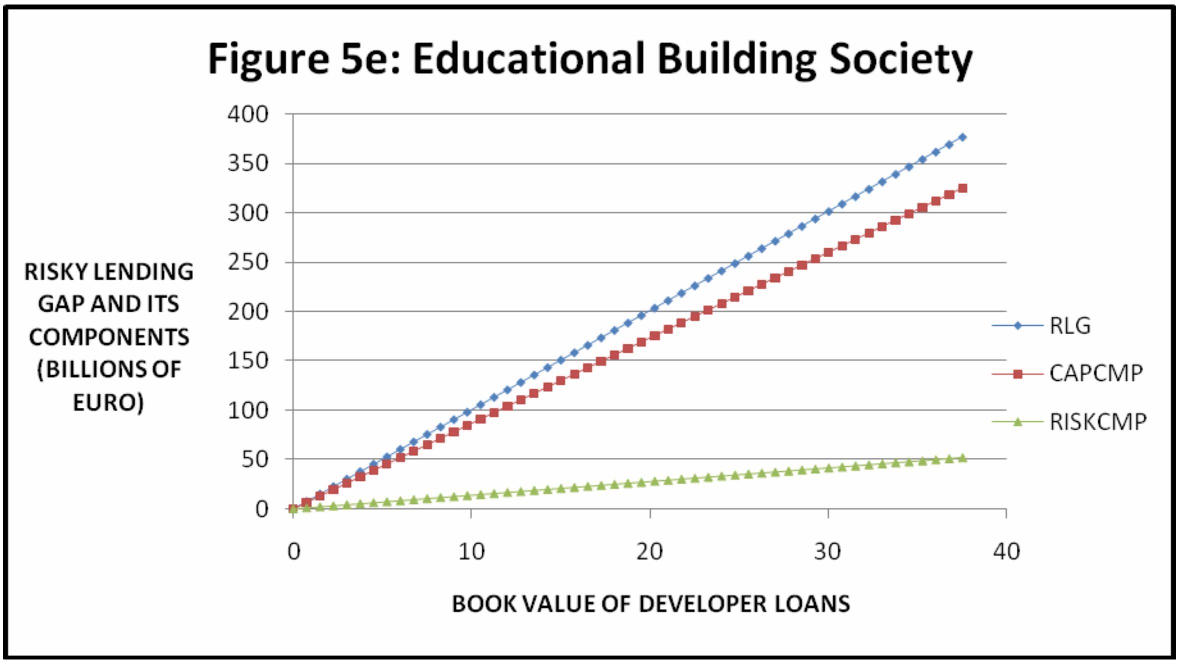


Figure 5d: Irish Nationwide
400
350
300
250
200
150
100
50
0
RISKY LENDING GAP AND ITS COMPONENTS (BILLIONS OF EURO)
0
10
20
30
40
BOOK VALUE OF DEVELOPER LOANS
RLG
CAPCMP
RISKCMP



Notes of Figure 5: The figures show the risky lending gap (RLG), its capital component (CAPCMP), and its asset risk component (RISKCMP) as a function of the book value of developer loans for each of the five banks, using the five-year model parameters.

Figure 6: Market value of equity as a function of the amount of developer loans for five banks