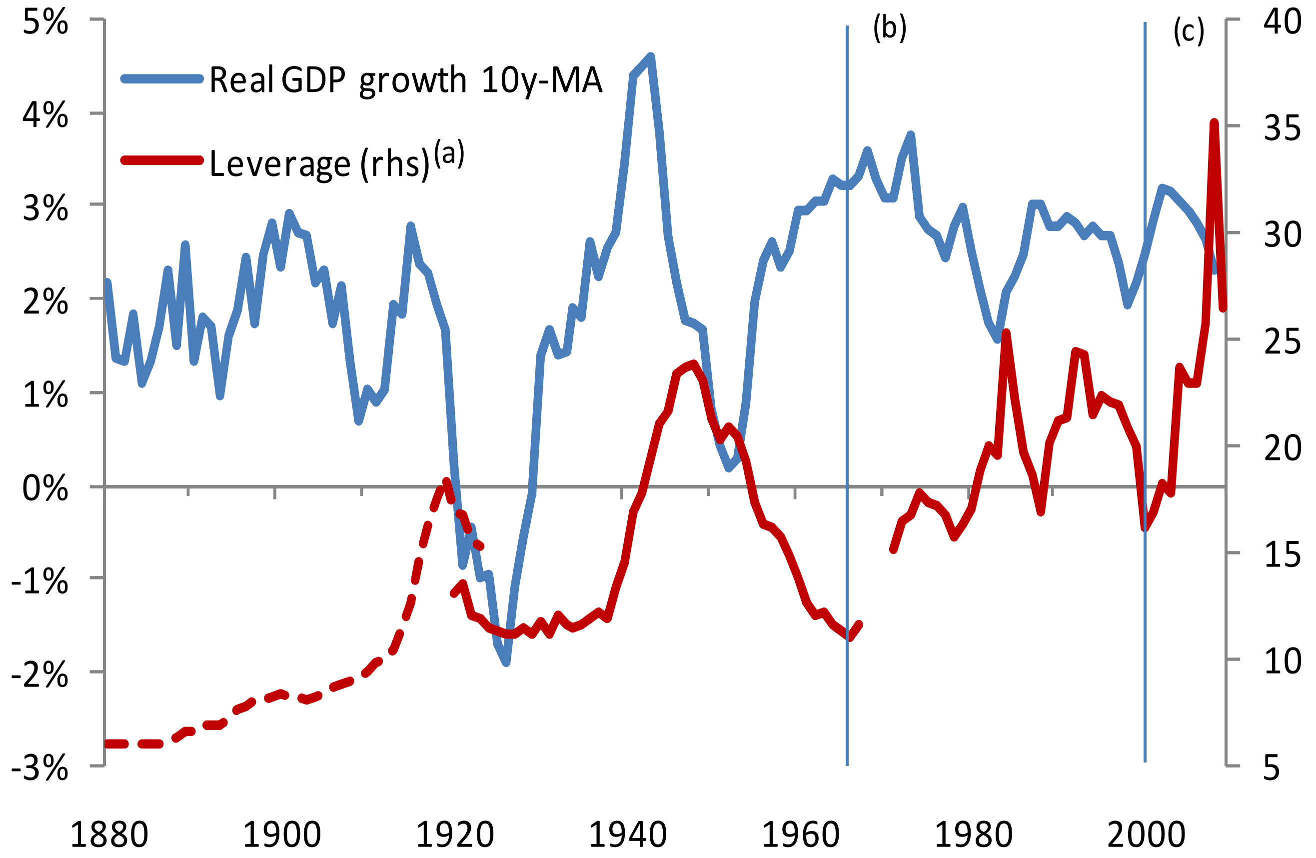
Optimal Bank Capital

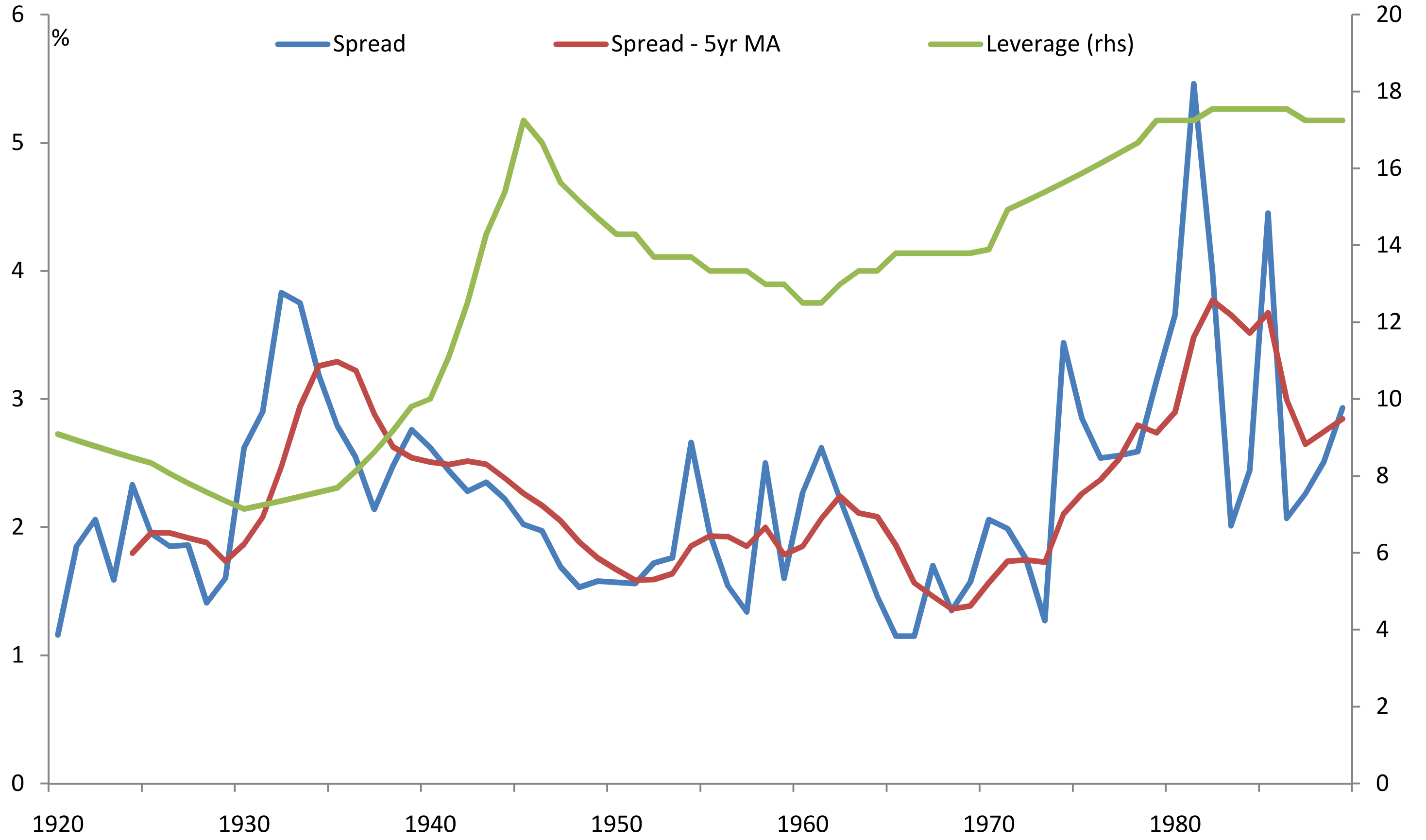
David Miles
Monetary Policy Committee
The Bank of England
September 2011

UK Banks' leverage and real GDP growth (10-year moving average)



Source: United Kingdom: Sheppard, D (1971), The growth and role of UK financial institutions 1880-1962, Methuen, London; Billings, M and Capie, F (2007), 'Capital in British banking', 1920-1970, Business History, Vol 49(2), pages 139-162; BBA, ONS published accounts and Bank calculations. (a) UK data on leverage use total assets over equity and reserves on a time-varying sample of banks, representing the majority of the UK banking system, in terms of assets. Prior to 1970 published accounts understated the true level of banks' capital because they did not include hidden reserves. The solid line adjusts for this. 2009 observation is from H1. (b) Change in UK accounting standards. (c) International Financial Reporting Standards (IFRS) were adopted for the end-2005 accounts. The end-2004 accounts were also restated on an IFRS basis. The switch from UK GAAP to IFRS reduced the capital ratio of the UK banks in the sample by approximately 1 percentage point in 2004.

Leverage and spreads of average business loan rates charged by US commercial banks over 3-month Treasury bills



Source: Homer and Sylla (1991).

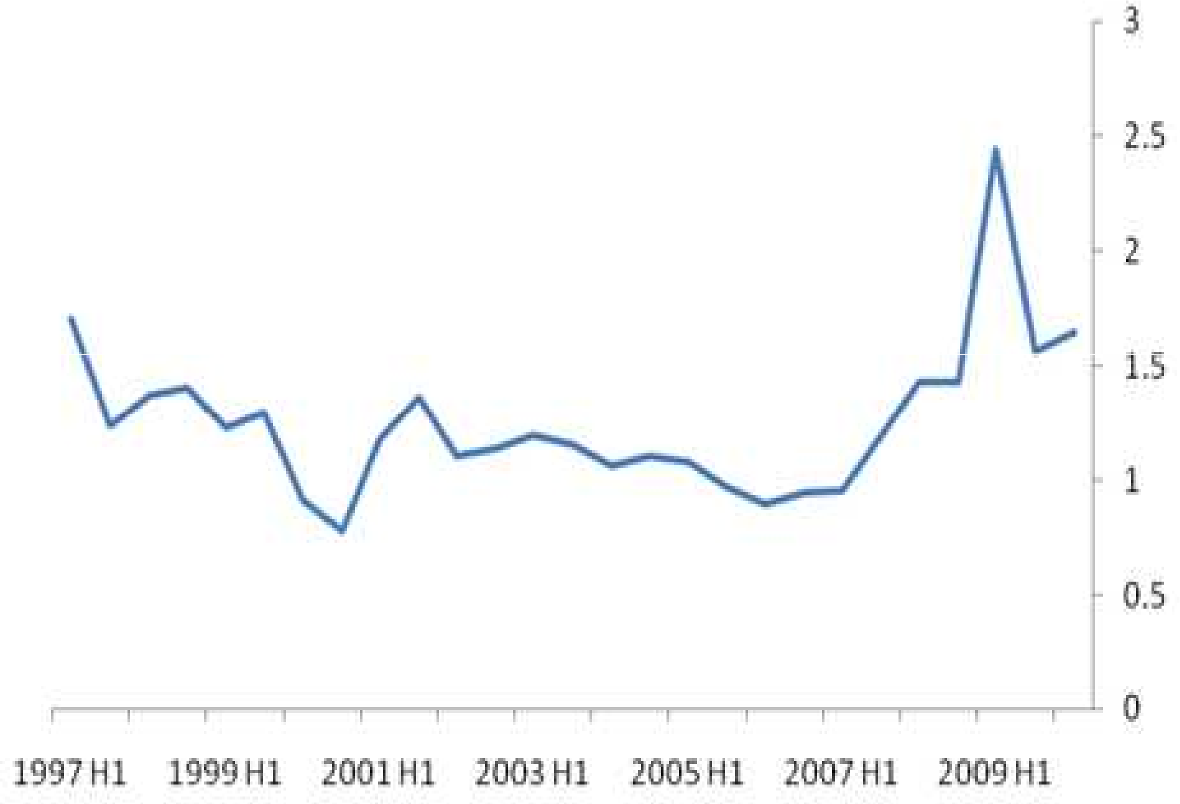
The link between equity beta and the leverage ratio: Theory

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

Assuming that debt is riskless,

$$\beta_{equity} = \frac{D+E}{E} \beta_{assets}$$

Average equity beta across major UK banks, 1997-2010



The link between equity beta and the leverage ratio: Estimation

$$\hat{\beta}_{i,t} = \alpha_i + X_{i,t}^{'} b + \varepsilon_{i,t}$$

i indexes banks and *t* time periods

X includes leverage, year dummies

Estimation techniques: OLS, fixed effects, and random effects.

Bank equity beta and leverage: Estimation results

Variable	OLS	FE	RE
leverage	0.025	0.031	0.025
	(4.22)	(3.49)	(5.35)
Const	1.238	1.072	1.237
	(3.99)	(3.72)	(5.55)
R-sqr _overall	0.671	0.664	0.671
R-sqr _between		0.634	0.670
R-sqr _within		0.658	0.654

Regression of bank equity beta on leverage, measured as total assets/tier 1 capital. All specifications include year effects. In all three regressions, standard errors are robust to clustering effects at the bank level. Coefficient t statistics are in parenthesis. A Hausman test is used to compare FE and RE estimators. The null hypothesis is that the differences in coefficients are not systemic. Chi-square (12) = 2.84 with P-value = 0.99.

The link between the required return on equity and leverage

The CAPM states that the required return on equity can be expressed as

$$R_{equity} = R_f + \beta_{equity} \cdot Riskpremium$$

Inserting our estimate of the link between beta and the leverage ratio yields

$$R_{equity} = R_f + \left(\hat{a} + \hat{b} \cdot \frac{D+E}{E} \right) \cdot Riskpremium$$

The link between the required return on equity and leverage: Results

At a leverage ratio of (D+E)/E = 30,

$$R_{equity} = R_f + \left(\hat{a} + \hat{b} \cdot leverage\right) \cdot Riskpremium$$
$$= 5\% + \left(1.07 + 0.03 * 30\right) \cdot 5\%$$
$$= 14.85\%$$

$$WACC = R_{equity} \frac{E}{D+E} + R_f \frac{D}{D+E}$$
$$= 14.85\% \cdot \left(1/30\right) + 5\% \cdot \left(29/30\right)$$
$$= 5.3\%$$

If leverage fell to 15, the required return on equity would fall to 12.6%.; the WACC would rise to 5.5% - a rise of about 20bp. The MM offset is about one half of its "theoretical" level

Bank equity beta and leverage: Estimation results (log specification)

	OLS	FE	RE
leverage	0.602	0.692	0.602
	(6.58)	(3.76)	(6.81)
_cons	-1.405	-1.693	-1.405
	(-4.45)	(-2.69)	(-4.35)
R-sqr _overall	0.62	0.66	0.67
R-sqr _between		0.54	0.61
R-sqr _within		0.64	0.636

Regression of the log of bank equity beta on log leverage, measured as total assets/tier 1 capital. All specifications include year effects. In all three regressions, standard errors are robust to clustering effects at the bank level. Coefficient t statistics are in parenthesis.

Required return on capital and leverage: Estimation results

Variable	OLS	FE	RE
leverage	0.0021	0.0023	0.0023
	(2.52)	(1.97)	(2.52)
cons	0.0520	0.0467	0.0456
	(1.59)	(1.45)	(1.59)
R-sqr _overall	0.0801	0.0801	0.0801
R-sqr _between		0.2037	0.2037
R-sqr _within		0.0584	0.0584

Regression of banks' required return on equity (E/P) on leverage. In all three regressions, standard errors are robust to clustering effect at the bank level.

Translating changes in bank funding costs into changes in output

- Funding cost increase passed on to customers
- Households' and non-financial firms' cost of capital increases
- Reduction in investment and output: calibrated using a CES production function

$$\varepsilon_{Y|r} = -\sigma \frac{\alpha}{1-\alpha}$$

- ε = elasticity of output with respect to funding cost;
- σ = elasticity of substitution between capital and labour;
- α = elasticity of output with respect to capital (capital share).

Economic Impact of halving Leverage from 30 to 15 relative to Tier 1 capital; or from 50 to 25 based on assets to CET1 – Basis Points

- Equivalent to doubling capital as percent of risk-weighted assets.

	Tax effect, no M-M	Tax effect, 45% M-M	Base case: no tax effect, 45% M-M	No tax effect and 75% M-M
Change in banks WACC	38.0	22.5	17.9	7.7
Change in PNFC WACC	12.7	7.5	6.0	2.6
Fall in long run GDP	31.7	18.8	14.9	6.4
Present value of GDP lost	1268	751	596	256

Sensitivity of base case estimates to changes in various assumptions – basis points

	Base case (no tax effect & 45% MM)	Higher discount rate (@ 5%)	Lower share of banks in PNFC finance (@ 16%)	Higher Equity Risk Premium (@ 7.5%)
Change in banks WACC	17.9	17.9	17.9	26.8
Change in PNFC WACC	6.0	6.0	2.9	8.9
Fall in long run GDP	14.9	14.9	7.1	22.3
Present value of GDP lost	596	298	286	894

Quantifying the benefits: Frequency distribution of annual falls in GDP

Annual 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

Quantifying the benefits: The distribution of permanent falls in GDP

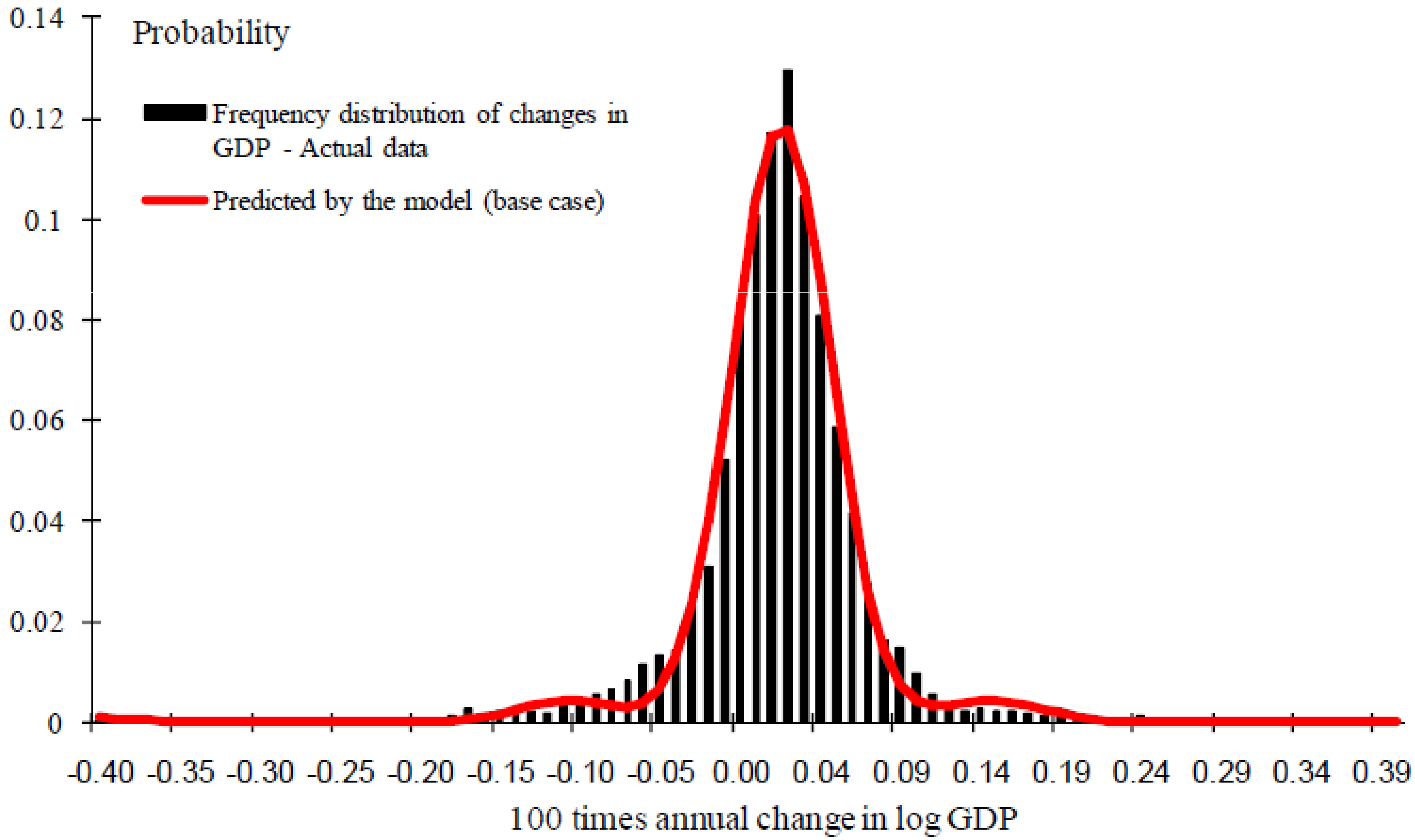
- Assume that mean per-capital GDP, *y*, follows a random walk with drift and two random components:

$$\log(y_t) = \log(y_{t-1}) + \gamma + u_{t-1} + v_{t-1}$$

where the random components follow

$$v_t = \begin{cases} 0 & \text{with probability } (1 - p - q) \\ -b & \text{with probability } p \\ +c & \text{with probability } q/2 \\ -c & \text{with probability } q/2 \end{cases}$$

Annual GDP Growth: Comparing the Economic Model with Actual Data (1821-2008)



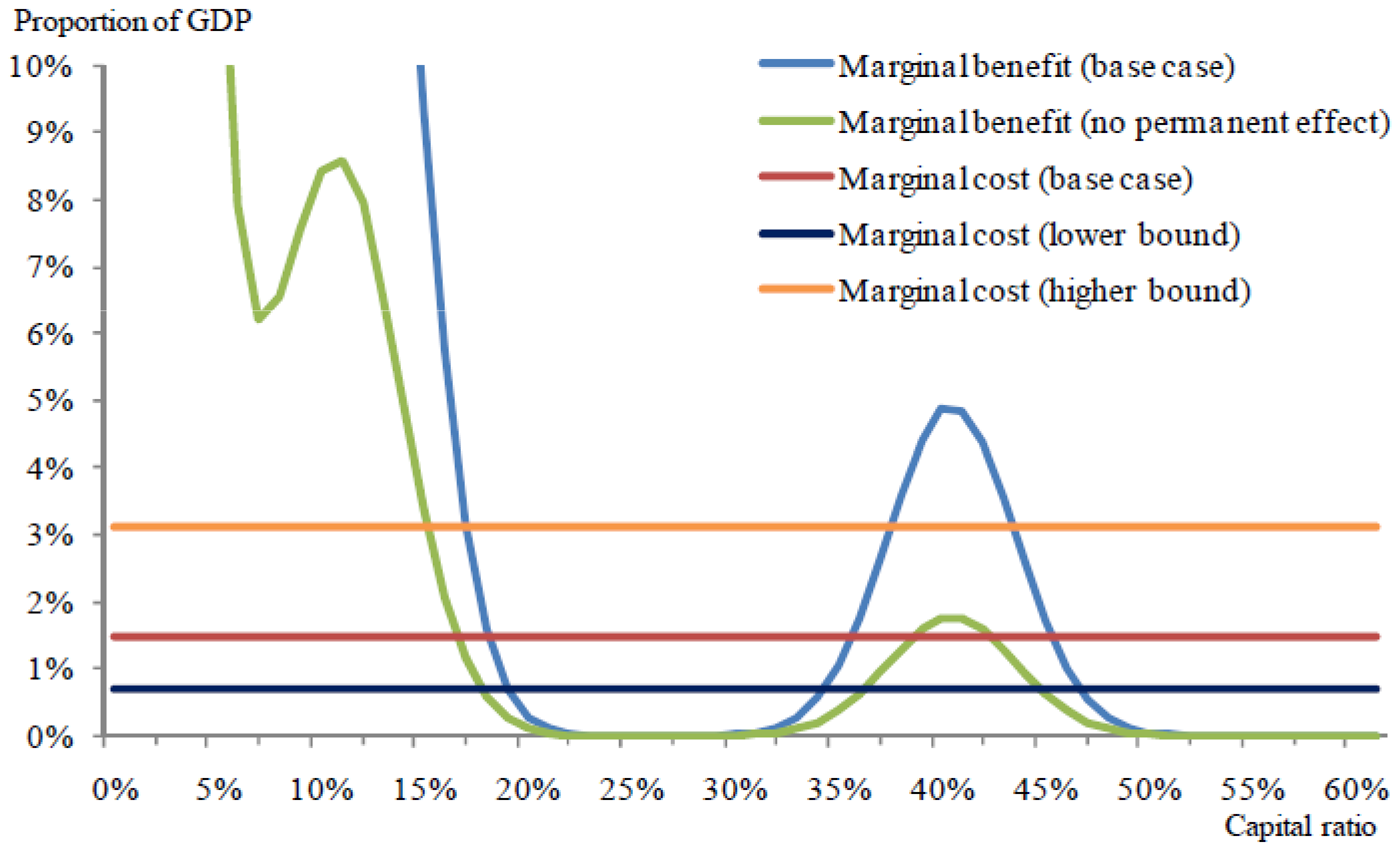
Quantifying the benefits: Key parameters

Parameter	Value
Std. deviation of GDP growth in normal times (σ)	3.1%
Average productivity growth (γ)	2.1%
Annual probability of extreme negative shock (p)	0.7%
Scale of extreme negative shock (-b)	-35%
Annual probability of less extreme, symmetric shock (q)	7.0%
Scale of less extreme, symmetric shock (c)	±12.5%

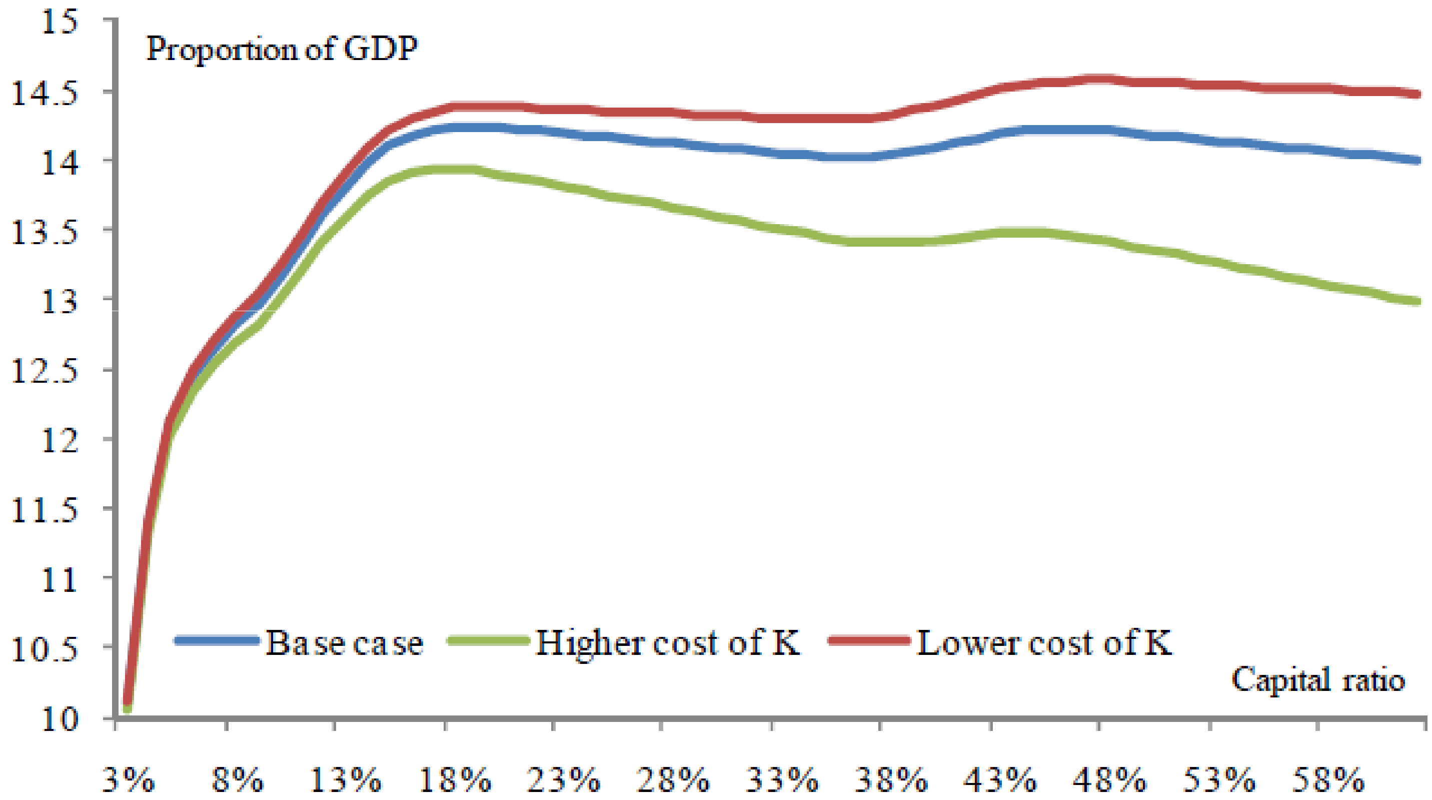
Actual growth in GDP per capita (1821-2008) and model fitted to GDP growth

	Actual data	Model Prediction
Mean (%)	1.81	1.80
Standard deviation (%)	5.7	5.9
Skewness	-2.40	-2.65
Excess Kurtosis	39.0	20.0
observations	4472	
Percent of observations less than...		
-20%	0.4	0.7
-15%	1.2	1.1
-10%	2.5	2.9
-5%	7.0	5.0
-2%	13.8	12.7
0%	27.1	27.1
Percent of observations more than...		
0%	72.8	72.9
+2%	51.1	50.9
+5%	19.5	19.5
+10%	3.6	3.7

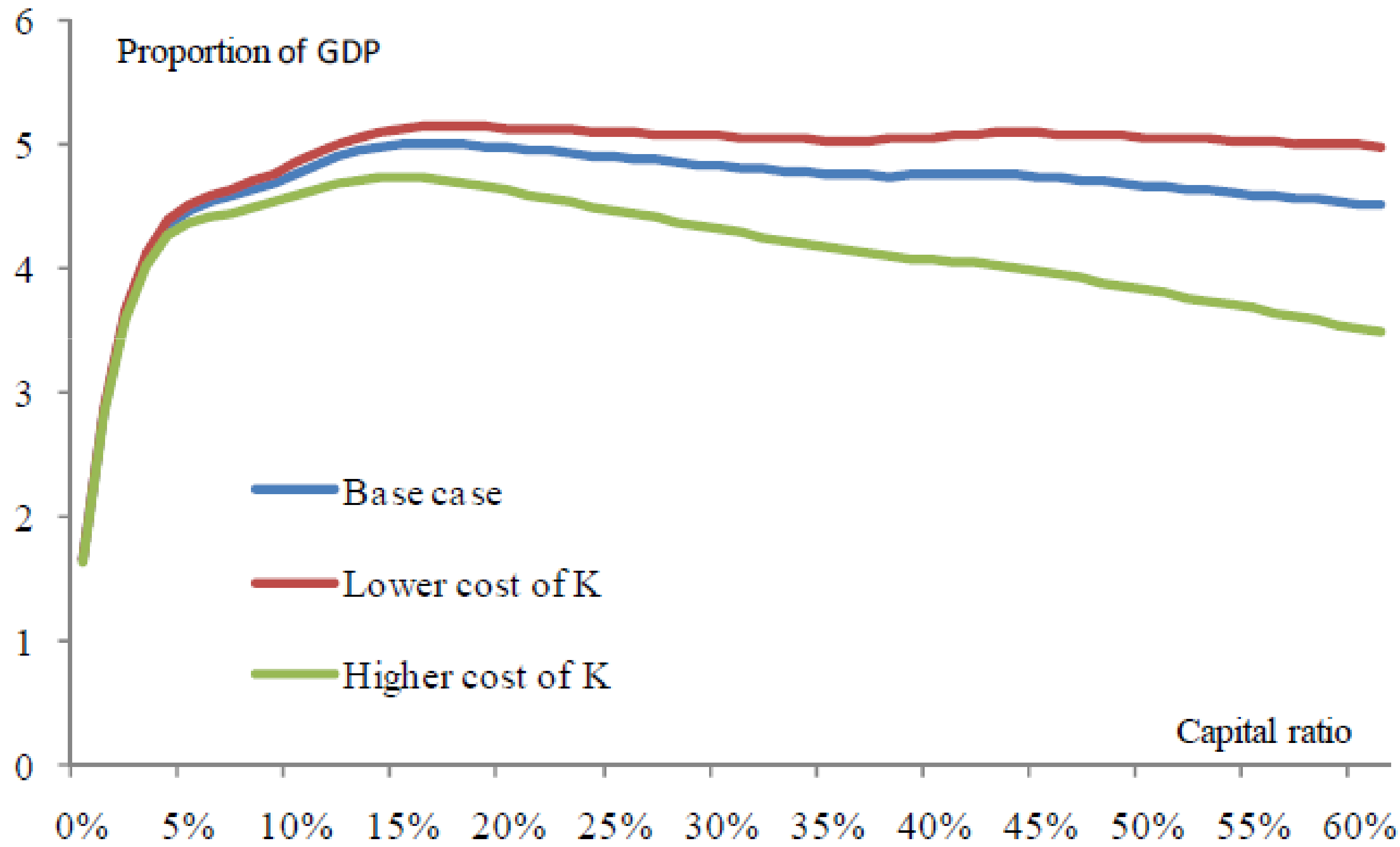
Finding the optimal capital ratio: Expected costs of financial crises and macro cost of banks capital



Net benefit of capital assuming financial crises have some permanent effect on GDP growth



Net benefit of capital assuming financial crises have no permanent effect on GDP growth



Optimal capital ratios considering full distribution of bad events

	Crises have some permanent effects on GDP growth	Crises have no permanent effects on GDP growth
Base cost of capital	19%	17%
Lower cost of capital	47%	18%
Higher cost of capital	18%	16%

Optimal capital ratios ignoring the most extreme bad events

	Crises have some permanent effects on GDP growth	Crises have no permanent effects on GDP growth
Base cost of capital	19%	17%
Lower cost capital	20%	18%
Higher cost capital	18%	16%