Stress Testing Credit Risk: The Great Depression Scenario

Simone Varotto
ICMA Centre, Henley Business School, UK

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Introduction

- Subprime crisis and mispricing of risk
  - "…risk premiums were too low and long-term volatility reflected a false belief that future short-term volatility would stay at its current low levels" (Acharya et al 2009)

- Stress test scenarios should be extreme but plausible
  - Haldane (2009) shows that plausibility may be the result of very long observation periods

- Short histories are sometimes preferred to avoid structural breaks
  - But, crises are structural breaks!

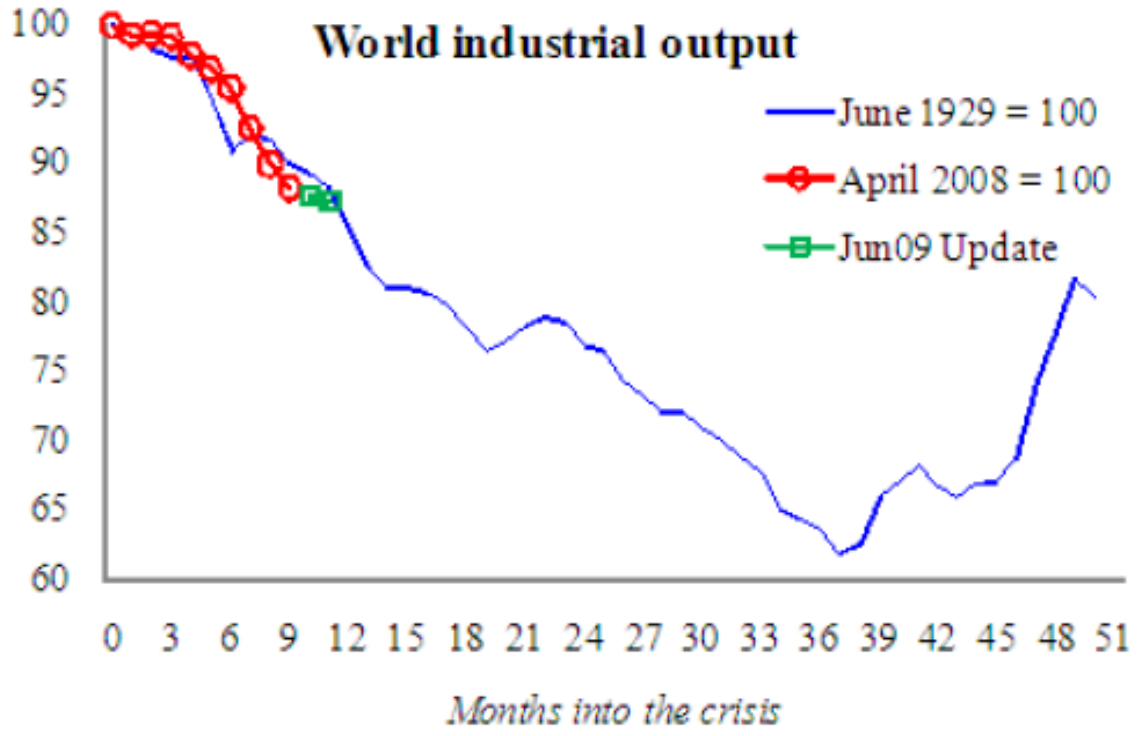
- Data limitations curtail the usefulness of historical stress testing
  - However, historical default rates for corporate bonds and loans available since 1920

- Limitations of stress tests employed by banks before the subprime crisis (Basel Committee on Banking Supervision, 2009):
    - Low severity and short lived scenarios compared with magnitude and time persistence of the crisis.
    - Correlation across and within asset classes was underestimated.
    - System-wide interactions (i.e. systemic risk) and feedback effects largely ignored.
    - Scenarios that were considered extreme and innovative were often regarded as implausible by the board and senior management

- Why the Great Depression?
    - Addresses limitations of stress tests during the recent crisis
        - High severity and long lived scenarios
        - Correlation and feedback effects embedded in historical PDs
    - We have been there before
        - Psychological explanation: if things go really bad how bad can they go?
    - Great Depression scenario used in the industry
        - In October 2008, Mark Tucker, chief executive of Prudential, stated that the Great Depression is one of the stress scenarios Prudential consider in order to test the resilience of their capital position

- Similarities of recent crisis with Great Depression (Eichengreen and O'Rourke 2009)

Updated Figure 1. World Industrial Output, Now vs Then (updated)



- Moody's historical speculative grade default rates

Year	Sorted Default Rates (from highest)
1933	15.4
2009	13.0
1932	10.8
2001	10.3
1990	10.0

- Contributions of the paper
    - The paper tackles the question of how much capital banks should hold to be able to absorb credit losses in a Great Depression (GD) scenario.
    - Default and migration risk taken into account
    - Measured impact of extended holding periods, up to 3 years
    - Comparison of our results with Basel II and Basel III bank capital regulation for the banking book
    - Explored counter-cyclical capital buffers generated through GD stress tests

- Recent Literature
    - Carey (2002) looks at the Great Depression scenario. Focus on pre-Basel II regulation. Default mode only.
    - Stress testing by using macroeconomic models of credit risk: Pesaran, Schuermann, Treutler and Weiner (2006), Jokivuolle, Virolainen, Vahamaa (2008) and Huang, Zhou and Zhu (2009), among others. For an excellent survey of macro credit risk models adopted by several national regulators and central banks see Foglia (2008).
    - Limitations of the above models: Alfaro and Drehmann (2009)

- Stress testing and regulation:
  - Basel Committee (2006, 2009 various),
  - Committee of European Banking Supervisors (2009),
  - Financial Services Authority (2009)
  - IMF and World Bank's Financial Sector Assessment Programs (1999 to date)

- Giesecke, Longstaff, Schaefer and Strebulaev (2009) study the properties of corporate bond default rates using a new data set covering the 1866−2008 period.

  They conclude that "in coming to grips with the current financial market situation which has been termed a 'historic crisis' or 'the worst financial crisis since the Great Depression,' nothing is so valuable as actually having a long-term historical perspective."

- Relevance:

2009 IMF Estimated Bank Portfolio Composition by Type of Asset

	US Banks	UK Banks	Europe w/out UK	Asian Banks*
Loan Exposures				
Consumer	17	12	13	20
Residential mortgage	52	23	25	26
Commercial mortgage	6	6	5	5
Corporate	15	49	43	27
Other	11	10	14	22
Total	100	100	100	100

* Asian banks domiciled in Australia, Hong Kong SAR, Japan, New Zealand and Singapore

The model:

- Objective: to measure the amount of capital needed to absorb worst-case default losses. Worst case capital is computed from corporate default and rating migration histories going back to 1921.

- We define worst-case capital as,

  Worst case credit loss – Expected credit loss

- We measure worst case and expected losses for a buy-and-hold investor over a period of up to 3 years

Why should we use the buy-and-hold paradigm?

- "For bank loan portfolios, substantial rebalancing [to a safer portfolio] is usually difficult to accomplish quickly, especially during the periods of general economic distress" (Carey 2002)

- "… several years frequently elapse between the onset of distress [due to large credit losses] and recapitalization" (Barakova and Carey 2002)

- Drawing from the Japanese experience during the "lost decade" Caballero et al (2008) conclude that banks tend not to write off non-performing loans in a crisis,
  - To avoid breaching minimum capital requirements
  - To prevent criticism from the public and the media
  - Owing to political pressure to keep lending channels open (especially to SMEs)

- The implication of a buy and hold paradigm is that risk premia become irrelevant and we can determine credit losses under risk neutrality with physical default probabilities (Elton et al 2001, JF).

  This is because the buy and hold investor is not expected to liquidate his assets before expiry and hence will not face the cost of discounting them at prevailing market rates.

  - Then, the only relevant risk is whether a borrower defaults or not.

- The value of a credit exposure at a given time τ can be computed with the following iterative equation,

$$V_t = \frac{aP_{\tau,t+1} + (C + V_{t+1})(1 - P_{\tau,t+1})}{1 + f_{t,1}} \quad \text{for } t = \tau, \tau+1, \ldots, \tau+n-1$$

where C is the interest charge, n the time to maturity in years, a is the recovery rate, $P_{\tau,t+1}$ is the (physical) probability of default in period t conditional on no bankruptcy in the τ to t period, $f_{t,1}$ is the one-year zero-coupon risk free forward rate at time t.

- The conditional default probability $P_{\tau,t+1}$ are given by

$$P_{\tau,t+1} = \frac{CP_{\tau,t} - CP_{\tau,t-1}}{1 - CP_{\tau,t-1}}$$

where $CP_{\tau,t}$ is the cumulative default probability from τ to t and is obtained through the product of annual rating transition matrices under the heterogeneous markov chain assumption.

- We define the default loss for a buy and hold investor as,

$$L_t = \frac{G_t - V_t}{G_t}$$

Where V denotes the hold to maturity value of a corporate exposure and G is the hold to maturity value of a default risk free exposure with the same cash flows as V.

- We define worst case (W) and average (A) default loss for a corporate exposure with given rating and maturity as follows,

$$L_W = \underset{t}{Max}\left(L_t \middle| a = a_W\right)$$

$$L_A = \underset{t}{Average}\ \left(L_t \middle| a = a_A\right)$$

Where a_W and a_A are the worst case and average recovery rate respectively. Then, worst case capital is $L_W - L_A$. Maximum and average losses are computed over the whole sample period, 1921-2009.

Data

- Moody's bond and loan default and transition rates by rating for the period 1921-2009

Varying "Mobility" of Rating Transition Matrices Over Time

	Average 1921-2009		Great Recession 2008-2009		Great Depression 1931-1935		Worst Case 1932	
	No Migration	Default Rate	No Migration	Default Rate	No Migration	Default Rate	No Migration	Default Rate
Aaa	92.3	0.00	76.2	0.00	82.7	0.00	67.7	0.00
Aa	91.7	0.07	81.1	0.28	80.2	0.29	53.5	0.69
A	91.4	0.10	89.1	0.28	77.3	0.67	56.0	0.92
Baa	89.5	0.28	91.7	0.65	75.3	1.34	53.3	0.94
Ba	86.5	1.14	79.0	1.86	69.6	5.87	50.2	6.33
B	85.6	3.64	76.3	4.87	68.2	10.27	54.4	15.21
Caa-C	78.1	14.67	69.0	25.78	67.9	24.15	68.4	26.32
Mobility	11.7		21.0		25.5		44.5	

Minimum and Average Recovery Rates for Bank Loans

Paper	Minimum Recovery (%)	Average Recovery (%)	Notes
Araten et al. (2004)	46.50	63.06	JPMorgan Chase data, 1982-1999 sample.
Asarnow et al. (1995)	52.39	66.04	Citigroup data, 1970-1993 sample.
Emery (2008)	50.00	65.00	Moody's estimates
Felsovalyi et al. (1998)	53.40	69.66	Citibank data, 1970-1996 sample.

Worst Case Capital
based on the Great Depression Scenario

	Portfolio Credit Quality			
	High	Average	Low	Very Low
Holding Period (yrs)		Default Risk Only		
1	1.69	3.32	5.48	5.99
2	2.63	5.16	8.75	9.65
3	3.14	6.18	10.56	11.76
		Default and Migration Risk		
1	1.69	3.32	5.48	5.99
2	4.07	6.60	10.14	10.99
3	5.27	8.34	12.58	13.69

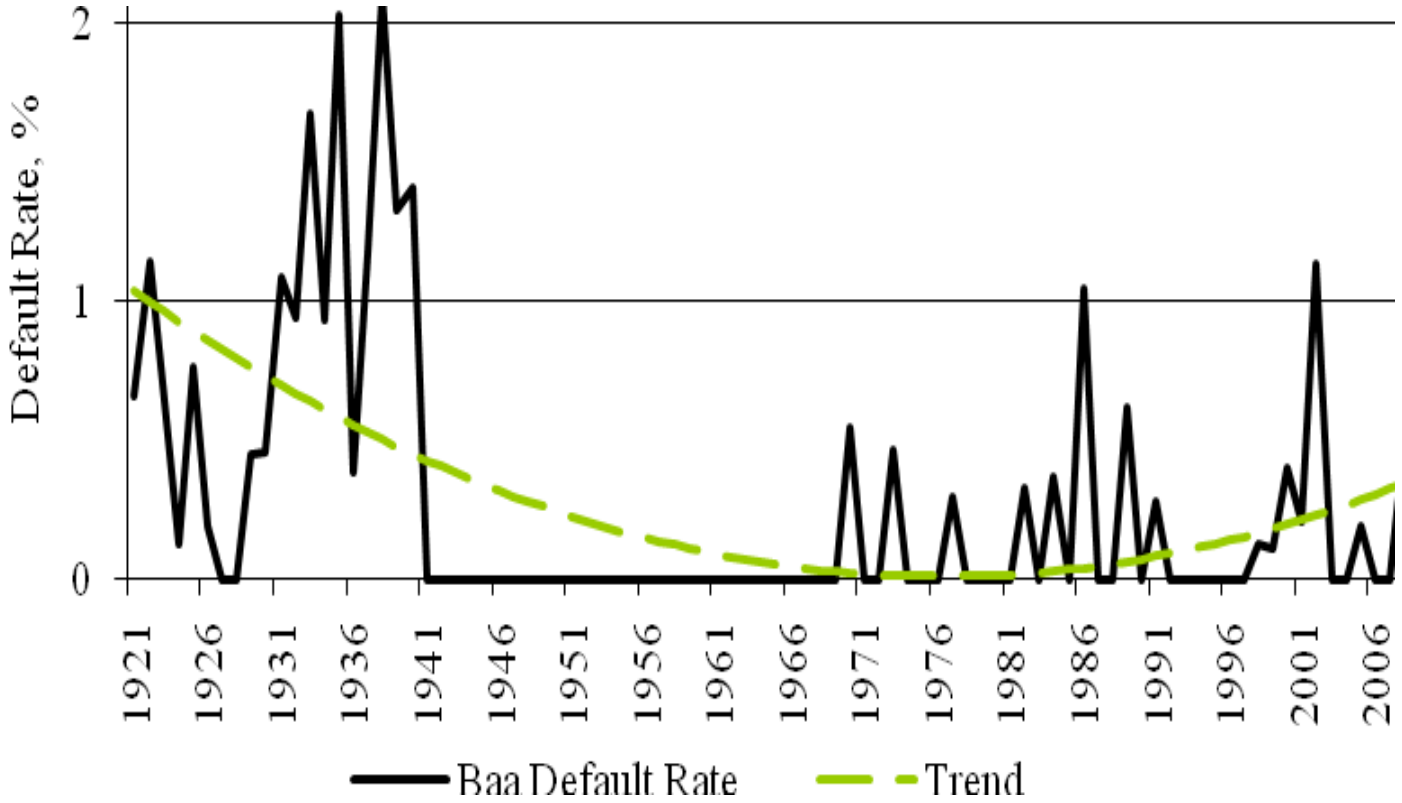
Ratios of Worst Case Capital to Basel 1, Basel 2 and Basel 3 Capital across Portfolios

	Portfolio Credit Quality			
	High	Average	Low	Very Low
Maturity (years)		Basel 2		
1	43.2	56.8	64.7	65.0
2	85.5	97.7	107.6	108.3
3	94.1	109.4	121.9	124.2
		Basel 3 buffers		
1	69.1	90.9	103.5	104.1
2	136.8	156.4	172.2	173.2
3	150.6	175.0	195.0	198.7
		Basel 3 Total Capital		
1	26.6	35.0	39.8	40.0
2	52.6	60.1	66.2	66.6
3	57.9	67.3	75.0	76.4

Great Depression Implied Capital Buffers

	Portfolio Credit Quality			
	High	Average	Low	Very Low
1	3.5	4.5	5.2	5.2
2	6.8	7.8	8.6	8.7
3	7.5	8.7	9.7	9.9

Non-Linear Trend in Baa Default Rates



Worst Case Capital to Basel Ratios under Tighter Baa Credit Standards During the Great Depression

	Portfolio Credit Quality			
	High	Average	Low	Very Low
Maturity (years)		Basel 2		
1	36.6	53.2	63.4	64.1
2	64.6	86.0	103.2	105.0
3	67.0	93.0	115.5	119.4
		Basel 3 buffers		
1	58.6	85.2	101.4	102.5
2	103.3	137.5	165.2	168.0
3	107.2	148.9	184.8	191.1
		Basel 3 Total Capital		
1	22.6	32.8	39.0	39.4
2	39.7	52.9	63.5	64.6
3	41.2	57.3	71.1	73.5

Conclusions

- Basel 2 capital would be enough to absorb Great Depression style losses over the first year of the crisis. But over a three year horizon only banks with high quality portfolios would be able to limit losses within the Basel 2 regulatory minimum.

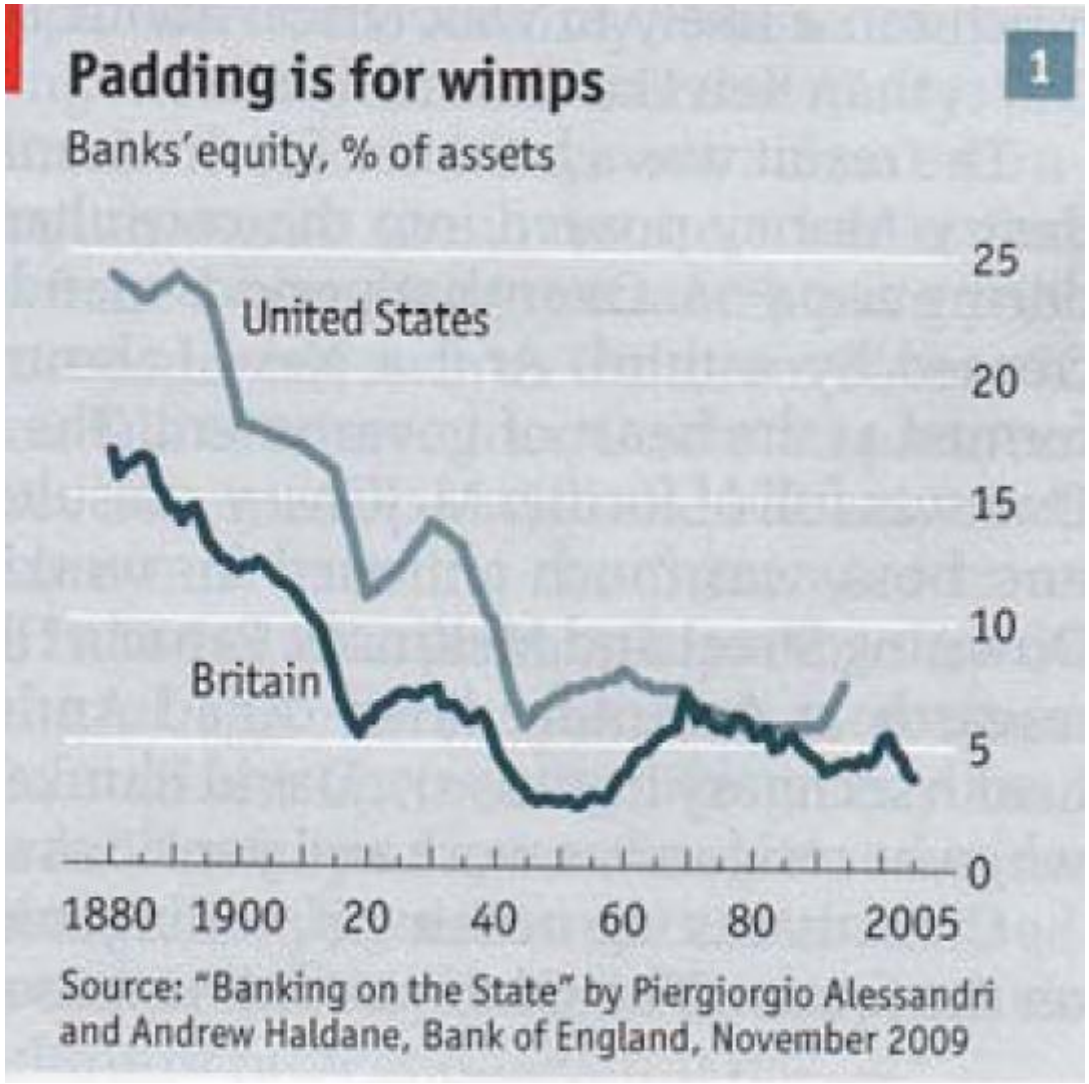
- Basel 3 capital would be sufficient under all time horizons considered. However, capital buffers would be depleted over a 2 year or longer horizon independently of portfolio quality. To provide adequate protection to most banks, buffers may need to double.

- Increasing the holding period from 1 year to 3 years may increase capital needs by 3 times.

- Including migration risk in the analysis may rise capital up to 67%.

- Results are robust to alternative recovery rate assumptions, changes in rating standards, and different interest rate assumptions.

- Recent research that focuses on the costs and benefits of bank capital indicates that more substantial capital levels, such as those implied by our analysis, may not only be feasible but also advisable (Admati, DeMarzo, Hellwig, Pfleiderer, 2010; Kashyap, Stein and Hanson, 2010; Basel Committee 2010).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Banks' equity, % of assets
United States
Britain
25
20
15
10
5
0
1880
1900
20
40
60
80
2005
Source: "Banking on the State" by Piergiorgio Alessandri and Andrew Haldane, Bank of England, November 2009