Balance sheet constraints and firesale externalities

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26.8.2015

Goal of research

- A semi-structural model of financial crisis exposure
  - Building on Vasicek one-factor model of credit portfolio risk
  - Exploring risk versus return at time of crisis, looking ahead to ´post-crisis'
  - Intention: calibration against commercial property exposure
- Key decision is foreclosure, reducing both risk and return
  - risk
    - lower potential for future losses
    - less risk of future breach of capital requirements
  - return
    - reduced current loan valuations ("firesale externality")
    - reduced future values (potential for recovery of non-performing loans)

- In this particular project we investigate:
  - Co-ordinated versus privately optimal levels of foreclosure
  - Impact of capital/ capital requirements and costs of breaching minimum requirements
    - esp "conservation buffer"/ privately chosen buffer
  - It appears that little previous research addresses role and magnitude of conservation buffer

Warning: non-standard modelling style

- Seeking realistic calibration to data
  - Novelty is the combination of mechanisms (each individually well known), to make model "realistic"
    - loan valuation and foreclosure in portfolio context
    - firesales
    - capital management
- Requires multiple parameters. e.g.:
  - Effect of aggregate shocks on loan valuation
  - Loan foreclosure impact on loan valuations and recovery values ("firesale")
  - Distribution and correlation of shocks
    - inividual v. aggregage,
    - period 1 (crisis) v period 2 (post crisis)
  - preferences of banks
  - structure of market
    - here 2 banks of equal size

- Results obtained via simulation
  - not theoretical propositions or empirical estimation
  - a never ending task, many parameter choices, model can always be tweaked further
  - non-linearities result in 'phase transitions'
    - so model outcomes vary substantially with parameter choice

We draw on three branches of literature

1. Credit portfolio risk (Vasicek)
2. Firesale externalities in security markets
   - See Shleifer and Vishny, Journal of Economic Perspectives, 2011 for a review.
   - Does not seem to have been applied to property exposures
   - In our context decision making not immediate
     - hence possibility of co-ordinated solution improving on private decision making
3. Bank capital management
   - Franchise value / capital buffer theory
   - Costs of financial distress / recapitalisation

- Also can be related to recent literature on financial networks
  - Ours is a simple 2 bank network, linked via common exposure to property market

Why commercial property?

- The bank exposure most involved in previous financial crises
  - much the largest contribution to rise of commercial bank losses in 2007-2009 crisis
    - though less impact on financial markets than sub-prime residential
  - Also the primary source of loss in many previous financial crises
- Relatively "clean" calibration of crisis and post-crisis
  - Highly cyclical market, loan performance and collateral values driven by aggregate risks
  - Impairment/ Default driven by "ability to pay" not willingness to pay
  - Some (BIS) data on prices, patchy data on loan performance (we refer to UK)

- Other exposures difficult to calibrate
  - small business great variation in quality
  - larger corporate exposures highly idionsyncratic
  - sovereign default rests on willingness to pay
  - residential mortgages, behavioural factors difficult to calibrate
  - unsecured household lending, losses high but variabilty of loss low

Overview

- Two banks a, b;three periods 0 (pre-crisis), 1 (crisis), 2 (post-crisis)
  - Period 0 exogenous determination of capital C_0^a , C_0^b and lending L_0^a, L_0^b
    - debt funding implicit, not modelled, no modelling of liquidity/ lender of last resort
    - absolute scale irrelevant, key variable of interest is initial capital ratio $c_0 = C_0/L_0$ and its evolution c_1, c_2
    - relative scale / number of banks is relevant
  - "Credit cycle" periodicity, we think of period 1 as being about 3 years, period 2 the indefinite future
- Period 1 materialisation of the crisis (aggregate shock X in Vasicek portfolio model)
  - X and default threshold k determines triggers loan impairment *and* loan writeoffs (accounting valuation)
  - Interpretation: a single risk factor driving both rental incomes and commercial property valuations
  - Banks decide what proportion of impaired loans they will foreclose in period 1

Overview

- Period 2 recovery
  - A second aggregate shock X_2, in expectation loans recover but may deteriorate further
- Bank preferences, linear weighting of
  - median outturn for C_2 (γ_0)
  - period 2 risk (we employ percentile spread of C_2) (γ_1)
  - costs of recapitalisation (probability that $c_2 = C_2/L_2 < c_{\min}$) (γ_0)

Period 1

- Loan valuation

$$v_i = \begin{cases} \exp\left[\sigma\left(\rho X + \sqrt{1-\rho^2}\epsilon_i\right) + \mu + z\right] < 1 & \epsilon_i < \epsilon^* \\ l_i = 1 & \epsilon_i \geq \epsilon^* \end{cases} \quad (1)$$

  - A continuum of loans indexed by i, normalised to 1.
  - X, ϵ_i standard normal variables, representing aggregate and idiosycratic risk. ρ is correlation of default
  - $z \leq 0$ is the shift in values resulting from foreclosures (specification later). With no foreclosures $z = 0$.
  - μ, σ represent the distribution of underlying collateral values

- non-performance threshold for every individual obligor

  - $$\epsilon^* = -\frac{\sigma^{-1}(\mu + z) + \rho X}{\sqrt{1-\rho^2}}$$

- Aggregation
  - total loans given by $\int l_i di = L$
  - "conditional" probabiliy of non-performance (given X) i.e. the proportion of non-performing loans is $N(\epsilon^*)$

$$\text{PD} = N(k)$$

    - Used in Basel IRB 'risk curves'
  - Integration over l_i we obtain the following expression for the revaluation of loan portfolio and loss of capital

$$\Delta L = L_1 - L_0 = C_1 - C_0 = \int (v_i - 1) f(\varepsilon_i) d\varepsilon_i$$
$$= N(\epsilon^*) - \exp\left[\frac{1}{2}\phi^2 - \epsilon^*\phi\right] N(\epsilon^* - \phi) < 0$$

    - here $\phi = \sigma\rho$ is the value impact of aggregate shock, which depends on extent of correlation of shocks ρ and on the the standard deviation of individual corporate property values σ
    - note similarity to Black-Scholes formula

Period 2

- Further draws for both aggregate and idiosyncractic shocks, standard normal densities but correlated with period 1

$$X_2 = \sqrt{1-\zeta^2} X_1 + \zeta Z$$
$$\epsilon_{i,2} = \xi \epsilon_i + \sqrt{1-\zeta^2} z_i$$

- Double default

$$v_{i,2} = \begin{cases} 1 & \text{if } \varepsilon_2^i \leq \left\{\varepsilon_2^* + \varphi \max\left(\varepsilon^* - \varepsilon^i, 0\right)\right\} \\ e^{\phi\left[\varepsilon_2^i - \left\{\varepsilon_2^\dagger + \varphi \max\left(\varepsilon^\dagger - \varepsilon^i, 0\right)\right\}\right]}, & \text{if } \varepsilon_2^i < \left\{\varepsilon_2^* + \varphi \max\left(\varepsilon^\dagger - \varepsilon^i, 0\right)\right\} \end{cases}$$

  - ε_2^* is the default trigger for loans that performed in period 1
  - the additional parameter φ allows for the fact that a loan that defaults in period 1, will face additional loss in period 2 and so must "climb back" in order to fully recover

- Bank preferences

$$\Omega = \gamma_0 \text{ median } C_2 - \gamma_1 \text{ percentilerange}_{10,90} \ C_2 - \gamma_2 P\left(\frac{C_2}{L_2} < c_{\min}\right) L_0$$

Foreclosure

- Banks choose foreclosure thresholds $\varepsilon_a^\dagger < \varepsilon^*$, $\varepsilon_b^\dagger < \varepsilon^*$ and all loans with $\varepsilon^i < \varepsilon_a^\dagger$ and $\varepsilon^i < \varepsilon_b^\dagger$ are terminated.
- Reduces further the total amount of lending, which now becomes

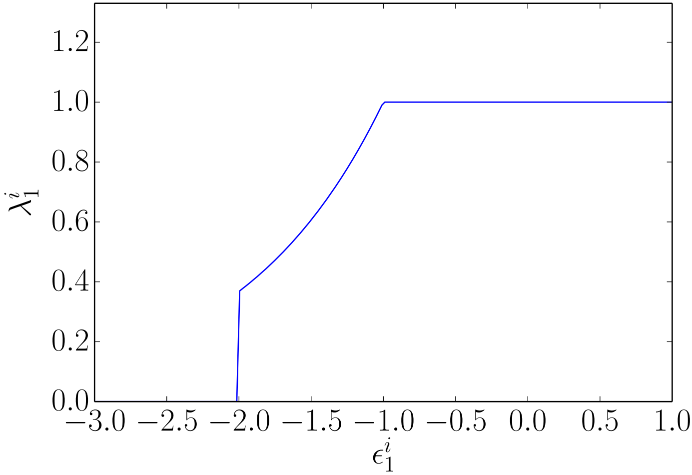
$$\Delta L = L_1 - L_0 = -\int_{-\infty}^{\varepsilon^\dagger} f\left(\varepsilon_i\right) d\epsilon_i - \int_{\varepsilon^\dagger}^{\varepsilon^*} \left(1 - v_i\right) f\left(\varepsilon_i\right) d\varepsilon_i$$

- Further effect on capital, but this only arises indirectly via the firesale impact on X
  - X is shifted lefwards by:

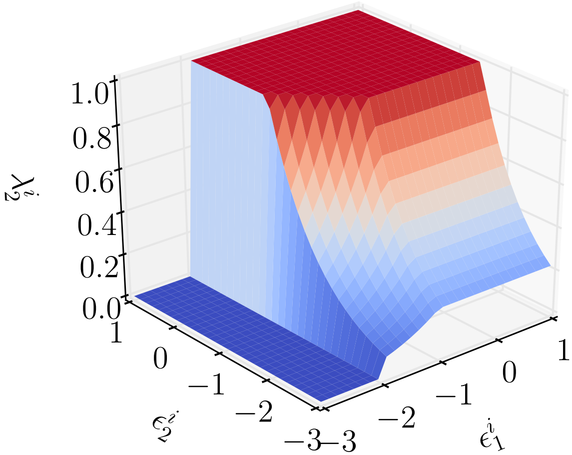
$$z = -\gamma \frac{\Delta L_a + \Delta L_b}{L_{a,0} + L_{b,0}}$$

  - this in turn increases ε^* and hence both loan impairment and the extent of loan losses for all banks
  - example $\psi = 5$ and termination 10% of outstanding loans, shifts X by $5 \times 10\% = 0.5$ standard deviations.

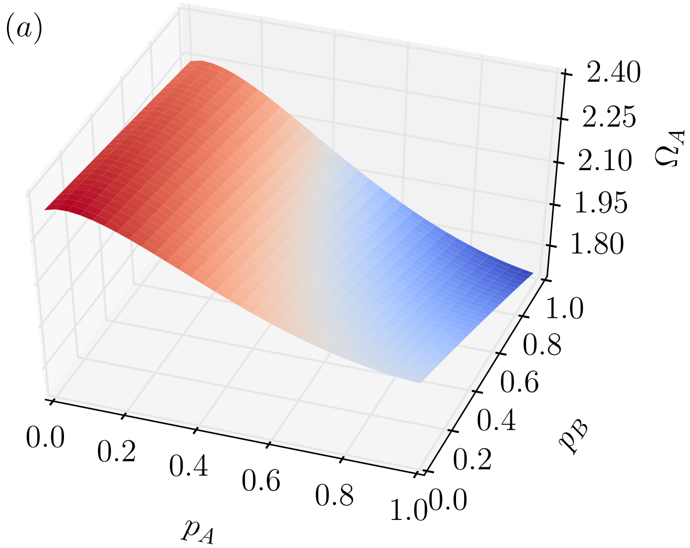
Period 1 loan revaluation factor



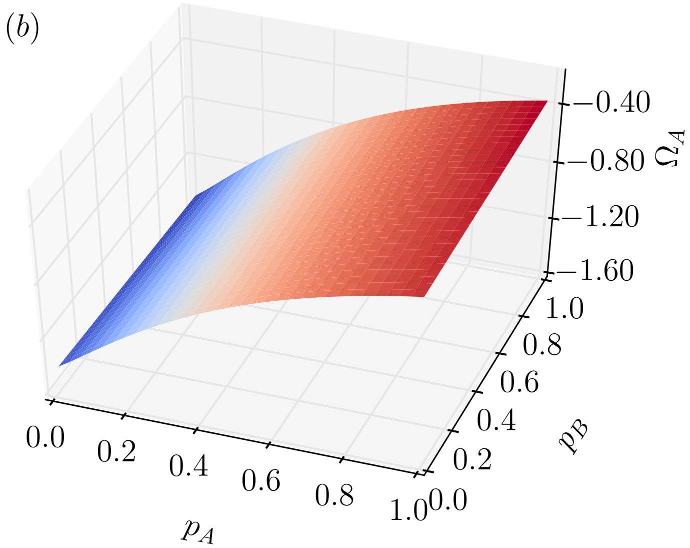
Period 2 loan revaluation factor



Period 2 objective – return only



Period 2 objective – systematic risk only



Period 2 objective – franchise risk only

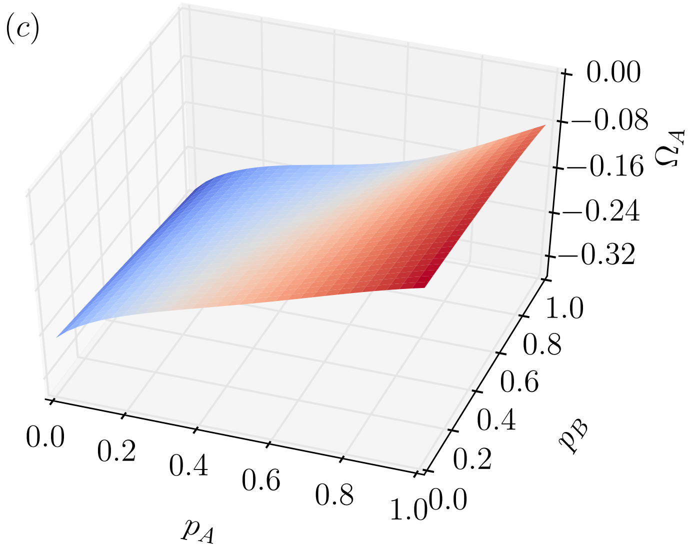
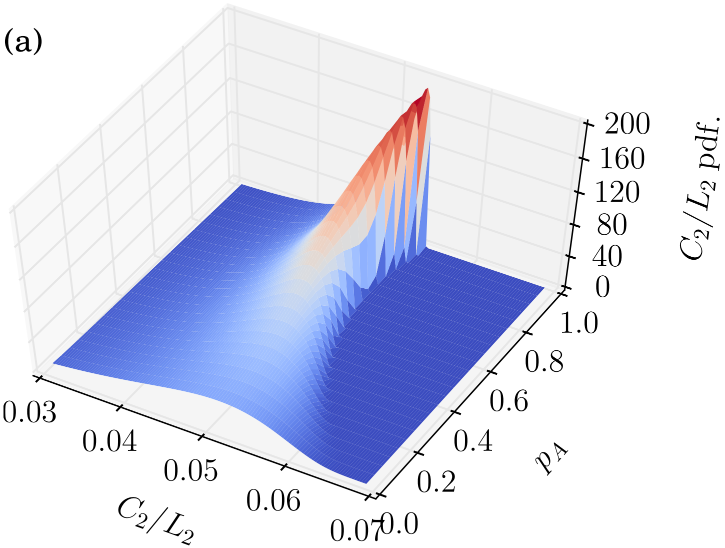


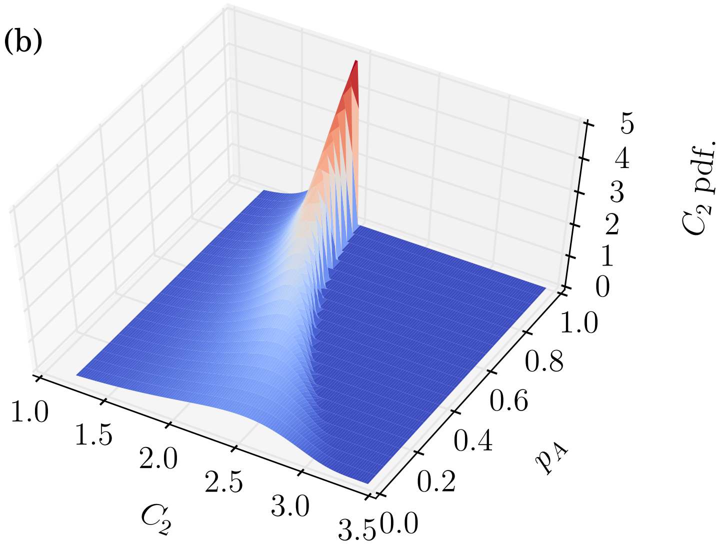
Table of parameters

Symbol	Interpretation	Baseline
c_0	Initial capitalisation	7%
$\bar{c}$	Minimum capitalisation	4%
X	Period 1 aggregate shock (represents "crisis")	-2
L_a, L_b	Portfolio size (only relative values matter)	50,50
ρ	Correlation of individual loan performance	0.4
μ	Mean growth of asset values (corporate property)	
σ_1	Standard deviation asset values, period 1	
σ_2	Standard deviation asset values, period 2	
φ	Implied value impact of aggregate shocks	1
k	Implied default threshold in terms of standard normal	-1.5
ξ (xi)	Correlation of idiosyncratic shock periods 1 and 2	0.6
ζ	Correlation (xeta) of aggregate shock periods 1 and 2	0.87
ψ (psi)	Firesale market impact (% of stock on std. deviations)	0.7
γ_0	Preferences: Weight on period 2 median capital C_2	0.25
γ_1	Preferences: Weight on period 2 interpercentile range C_2	0.0
γ_2	Preferences: Weight on period 2 recapitalisation	1.0

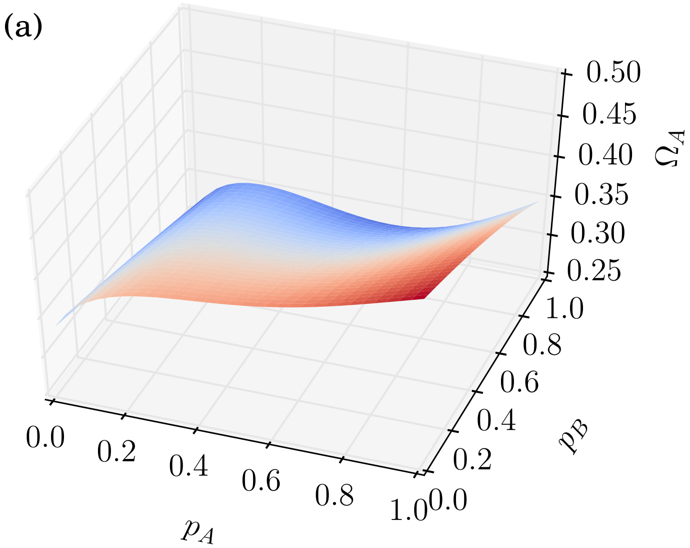
PDF of period 2 capital ratio



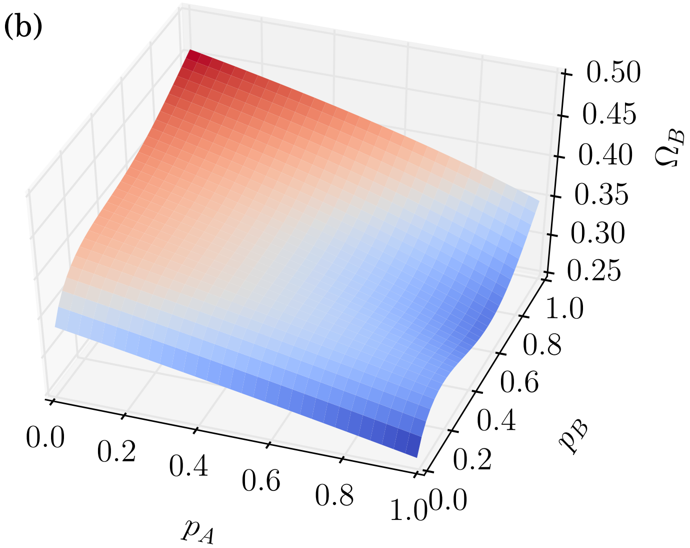
PDF of period 2 capital level



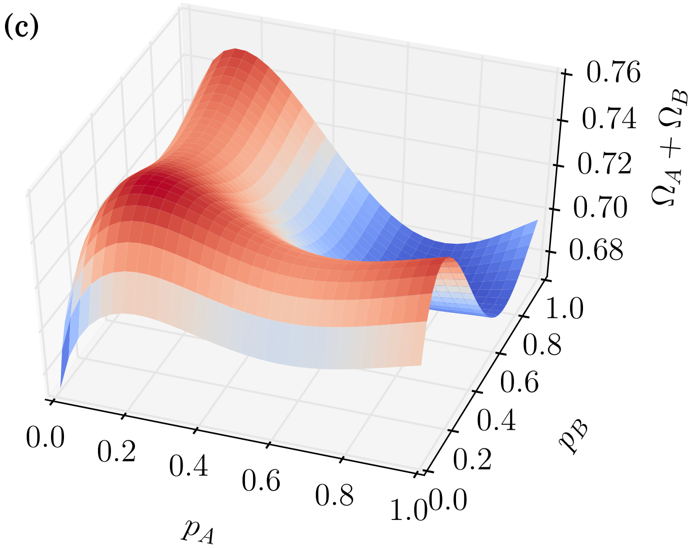
Bank A objective



Bank B objective



Joint objective



Conclusions

- Initial work on semi-structural model of financial crisis exposure
- Building on Vasicek one-factor model of credit portfolio risk
- Exploring risk versus return at time of crisis, looking ahead to ´post-crisis'
- Main result here: potential 'prisoner's dilemma'. Failure to co-ordinate leads to excessive foreclosure ('firesale externality').
- Further work: calibration to commercial property exposures
- Implication: potential for internalising systemic risks in individual bank risk curves . f