The Instability of the Banking Sector and Macrodynamics: Theory and Empirics

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References: see also www.newschool.edu/nssr/cem
W. Semmler (with A. Greiner): „Global Environment, Growth and Natural Resources“, Oxford University Press, 2008
W. Semmler, „Asset Prices, Booms and Recessions“, Springer 2011

=> Optimal control models: Pontryagin´s Max Principle, Dynamic Programming; Solves Models with Thresholds and Mutiple Regimes:

This paper is on the banking sector and macrodynamics:
• I. Introduction
• II. A Model of the banking sector: Local Instability und multiple regimes
• III. Empirics: Multi-Regime VAR (MRVAR)
• IV. Conclusions
I. Introduction: A More General Note

An important driving factor for growth and macro fluctuations is the credit and banking system: It accelerates booms but also amplifies busts. Many historical studies have shown when imbalances have developed through booms (Reinhard/Rogoff, 2009, Gorton, 2010) then:

=> Sudden adverse shocks to firms, households, foreign exchange, stock market, sovereign debt end up in the banking sector

=> Banking sector amplifies the shocks
-- earlier work: loan losses, bank runs, currency runs (Asia 1997/8)
-- recent work: adverse shocks to asset prices and impact on banks
-- may generate local instability, thresholds and multiple regimes

We study here the recent US boom-bust cycle and the role of the banking sector in the 2007/8 meltdown; Literature:

=> Important earlier work on instability of credit:
   -- Kindleberger (2002), Instability of credit

=> Financial accelerator for firms (asset prices and credit market):
   -- Bernanke, Gertler and Gilchrist (1999)

=> Financial accelerator for financial intermediaries (asset prices and credit market):
I. Introduction:
Shadow banking system, transfer of risk through Complex Securities

Securitization of debt: Complex securities (rise of CDS, MBS, CDOs)
I. Introduction:
Incentives for risk transfer: bonus payments

Bonus payments as % of revenues
I. Introduction:
Role of Complex Securities

Modeled (Semmler and Bernard, 2009): Non robustness with respect to delinquency rates, interest rates, default risk and default correlations, recovery rates
I. Introduction: Housing and Asset Prices

The recent meltdown:

• Collapse of the housing market:

• Collapse of asset prices:
I. Introduction: Credit

Credit volume  
(Woodford 2010)

Credit spreads  
(Hall 2009)
I. Introduction: Output and Employment
I. Introduction: Collapse of Banks

Collapse of the banking sector (and credit):

![Bar chart showing the number of bank failures from 2001 to 2010.](chart.png)
1. Introduction: Theory, Financial Accelerator

=> Central Role of Asset Prices in Credit Market:

1. Financial Accelerator for firms: In DSGE models; net worth dependent credit cost:
   → hard to match the size of the risk premium
   → locally mean reverting (locally stable)
   → empirics tested through one-Regime VAR

2. Financial Accelerator for Banking Sector (Financial Intermediaries):
   → Recent literature: Adrian and Shin (2009, 2010), Hall (2010), and Brunnermeier et al (2009, 2010)
I. Introduction: Instability

Mechanism of local instability for financial intermediaries; see Brunnermeier et al.

→ Show local instability (not mean reverting)
→ Show an amplification mechanism (externalities, contagion and fire sales of assets)

The Unstable Mechanism -- Vicious cycle of amplification for financial intermediaries
II. The Model: Financial Intermediaries

Balance sheets (Brunnermeier et al 2010)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_t k_t$</td>
<td>$d_t$</td>
</tr>
<tr>
<td>$n_t = p_t k_t - d_t$</td>
<td></td>
</tr>
<tr>
<td>total assets</td>
<td>$\alpha(p_t k_t - d_t) + (1 - \alpha)(p_t k_t - d_t)$</td>
</tr>
</tbody>
</table>

=> A model of wealth management with borrowing:
- Bonus payments (unconstrained and constrained)
- We can allow for time varying risk premia and credit spread
- Undertakes risk transfer to secondary risk market (CDOs....)
- Externality effects, contagion, fire sales of assets
II. The Model: Financial Intermediaries

With dynamic decisions on investments \{g_t\}, and bonuses, \{c_t\}:

\[
V(k, d) = \max_{c_t, g_t} \int_0^\infty e^{-rt}U(c_t)\,dt
\]

\[
\text{s.t.}
\]

\[
dp_t = \mu_t p_t \,dt + \sigma_t p_t \,dZ_t
\]

\[
dk_t = (\varphi(i_t/k_t) - \delta)k_t \,dt + \sigma_t k_t \,dZ_t
\]

\[
d\omega_t = (rd_t - (ak_t - i_t - c_t)) \,dt
\]

Which can be summarized in terms of leverage dynamics:

\[
\omega = -(d_t/k_t)
\]

\[
V(\omega_t) = \max_{\tilde{c}_t, g_t} \int_0^\infty e^{-rt}U(\tilde{c}_t)\,dt
\]

\[
d\omega_t = ((g_t - r + \sigma^2)\omega_t + a - \tau(g_t)) \,dt - \tilde{c}_t + \sigma_t \omega_t \,dZ_t
\]
II. The Model: Dynamic Programming as Solution Method

(see Grüne and Semmler, JEDC 2004)

Dyn Program

\[ V(x) = \max_u \int_0^\infty e^{-rt} f(x, u) dt \]
\[ \text{s.t.} \quad \dot{x} = g(x, u), x(0) = x_0. \]

Discrete approximation

\[ V_h(x) = \max_{u \in U} J_h(x, u), \quad J_h(x, u) = h \sum_{i=0}^{\infty} (1 - \theta h) f(x_h(i), u_i) \]

Discrete dynamic state equations

\[ x_h(0) = x, \quad x_h(i + 1) = x_h(i) + hg(x_h(i), u_i) \]

Value function (Discrete time Bellman equation)

\[ V_h(x) = \max_{u \in U} \{ hf(x, u) + (1 - \theta h) V_h(x_h(1)) \} \]
II. The Model: DP as Solution Method

Using the operator

\[ T_h(V_h)(x) = \max_{u \in U} \{ h f(x, u_o) + (1 - \theta h) V_h(x_h(1)) \} \]

Approximation on a grid

\[ T_h(V_h)(x) = \max_{u \in U} \{ h f(x, u_o) + (1 - \theta h) V_h(x_h(1)) \} \]

with iteration

\[ V^\Gamma_h(x^i) = T_h(V^\Gamma_h)(x^i) \]

Error estimation and grid refinement

\[ \eta_l := \max_{k \in c_l} | T_h(V^\Gamma_h)(k) - V^\Gamma_h(k) | \]

Applicable to:
non differentiable value function
multiple equilibria, regimes
different domains of attraction
II. The Model: DP as Solution Method

Examples

2dim example (Investment model: K,I)

3dim example (growth with CO2 emission, K,M,T)
II. The Model: Extensions--Asset Prices

1. Asset prices

\[ dp_t = (\mu_t + z_t) p_t dt + \sigma_t p_t dZ_t \]

- \( z_t \) follows some sentiment (opinion dynamics)
- Externalities: fire sales of assets and deterioration of the Banks` balance sheets
- Banks have less collateral for borrowing, face greater repo rates, Ted spread etc.
- Less demand for capital and asset prices fall more
  - Downward spiral through endogenous risk…
  - Outside funds to the rescue: households, external funds, public funds
II. The Model: Extensions—Bonuses

*Basil III*

2. Bonus payments (unconstrained/constrained):

- Large bonuses: $0.01 < \tilde{c}_t < 0.8$

- Small bonuses: $0.01 < \tilde{c}_t < 0.1$
II. The Model: Extensions—Bonuses
for large and small bonuses
II. The Model: Extensions—Risk premium.

3. Risk premium, estimated through FFT (using BAA bonds)

\[
V(\omega_t) = \max_{\tilde{c}_t, g_t} \int_0^\infty e^{-rt} U(\tilde{c}_t) dt
\]

\[
d\omega_t = \left( (g_t - r(x_t) + \sigma^2) \omega_t + a - \tau(g_t) \right) dt - \tilde{c}_t + \sigma_t \omega_t dZ_t
\]

\[
dx_t = 1 dt
\]

Estimate:

\[
x_t = \sum_{i=1}^n \left( a_i \sin \left( \frac{2\pi}{\tau_i} (t - t_0) \right) + b_i \cos \left( \frac{2\pi}{\tau_i} (t - t_0) \right) \right)
\]
II. The Model: Extensions – Risk premium

3. Risk premium, estimated (by using BAA-AAA spread); Trajectories with time varying premium (small bonuses)
III. Empirics: Financial Stress Index (FSI: FRB Staff, Hubrich and Tetlow 2010)
III. Empirics: Financial Stress Index (FSI)

We take a financial stress variable (not only leveraging and net worth): Kansas City FED Financial Stress Index (KCFSI): measures mainly increasing asymmetry, heterogeneity and spreads (using principle component analysis)

- TED spread (libor/T-bill)
- 2 year swap spread (flexible and fixed rates)
- BAA/AAA spread
- AAA/10yearTB spread
- Consumer ABS/5 year T-bill
- Correlation between stock and bond returns (measure of flight to quality)
- VIX (volatility measure)
- Cross dispersion of bank stock returns

=> Recent IMF Data: FSI from 1980-2011 for US. EU, Adv Countries and Emerging Market Countries, includes bank related FS variables

=> FSI is somewhat correlated with balance sheets of financial intermediaries: here aggregate debt ratio
III. Empirics: Financial stress, growth rates, and leverage

Leverage = V/E

Figure 6: Financial stress index (KCFSI, lower graph) plotted against growth rates of industrial production (3 month moving average, upper graph)
III. Empirics: One Regime VAR versus Multiple Regime VAR (MRVAR)

• Usually done through a typically “one-regime” in DSGE (local linearization and VAR):
  
• For monetary policy shocks, see Smets and Wouters (2007), Christiano et al. (2005)

• For financial accelerator for firms: Christensen and Dib (2005), Gilchrist et al. (2009, 2010), Adrian and Shin (2010), Hall (2009)

2. We evaluate the dynamic with a multi-regime model and estimate regime (business cycle) dependent effects:

• Build our model on the tradition of non-linear modeling where “timing” and size of the shocks matter

• Undertake response analysis with a two-regime model, which can be viewed as piece-wise linear analysis

• We show that shocks to the Financial Stress have different effects in recessions (below average growth rates) as compared to booms (above average growth rates)

• Effects are depending on the size of the shocks
III. Empirics: Regime Change Models and “Multiple Regime“ (MR) Model

Business Cycle Analysis and Regimes:

- Neftci (1982): Regime switching model in terms of time
- Hamilton (1989, 1994, 2002,): Regime switching model in terms of state (Markov Switching VAR, MSVAR)
- Granger and Teräsvirta (1996): Smooth transition regression model (STR model)

Regime dependence of impulse-responses:

- Potter (1994), univariate impulse-response,
- Koop, Pesaran and Potter (1996), multivariate impulse response
III. Empirics: Steps in Estimating a MRVAR

   --- Multi-regime autoregression (TAR, MRVAR)

\[
y_t = c_i + \sum_{j=1}^{p_i} A_{ij} y_{t-j} + \varepsilon_{it}, \quad \text{if } \tau_{i-1} < r_{t-d} \leq \tau_i, \quad \varepsilon_{it} \sim NID(0, \Sigma_i), \quad i = 1, \ldots, M.
\]

\(r_{t-d}\) is the value of the threshold variable observed at time \(t - d\)

threshold levels \(-\infty = \tau_0 < \tau_1 < \cdots < \tau_M = \infty\)

Rather than estimating (best-fitting) threshold, we pre-define it according to the type of analysis we would like to conduct

Advantages:

(iii) Piecewise linearization around “interesting locations”

(iv) Straightforward linear least-squares estimation
III. Empirics: Steps in Estimating a MRVAR

2. Selection Criterion:

Model selection

We use the AIC for model selection, which is given by:

$$AIC(M, p_1, \ldots, P_M) = \sum_{j=1}^{M} \left[ T_j \ln |\hat{\Sigma}_j| + 2n \left( np_j + \frac{n+3}{2} \right) \right]$$

where $M$ is the number of regimes; $p_j$ is the autoregressive order of Regime $j$; $T_j$ reflects the number of observations associated with Regime $j$; $\hat{\Sigma}_j$ is the estimated residual covariance matrix for Regime $j$; and $n$ denotes the number of variables in vector $y_t$. 
III. Empirics: Steps in Estimating a MRVAR

3. Comparison of (one-regime) VAR and (multi-regime) VAR: two-regime VAR in KCFSI and Output

- Variables: $\Delta \log$ KCFSI and $\Delta \log$ Industrial Production (Monthly production index),
- For FSI, see also St. Louis Fed, Adrian/Shin (2010), Mishkin/Watson (2010), Hubrich/Tetlow (2010)
- Sample period: 1990.2 - 2010.6
- For two-regime MRVAR: **Threshold** predefined as sample mean of output growth rate: 0.165%; Regime 1: below mean, Regime 2: above mean
- Model selection: AIC (see Chan et al., 2004) suggests: AIC favors the **two regime** MRVAR ($p_1=4$, $p_2=3$, AIC= -1084.9 ) over the **one-regime** VAR ($p=4$, AIC=-842.1)
III. Empirics: Linear VAR and Impulse-Response

Cumulative responses from the Linear VAR (1 std shock)
III. Empirics: MRVAR Impulse-Response for high and low growth states  
(probability of regime change)  
Cumulative responses for the MRVAR (initial condition: mean of high and mean low growth states)
III. Empirics: MRVAR Impulse-Response for high and low growth states (probability of regime change, size of shocks)

Cumulative responses for the MRVAR: positive shock to KCFSI
III. Empirics: MRVAR Impulse-Response for high and low growth states-monetary policy

(probability of regime change, size of shocks)
Cumulative responses for the MRVAR: negative shock to KCFSI
IV. Conclusions: MR in Banking-Macro Linkage

We here have studied the Banking–Macro Link in a model where we observe local instability and empirically evaluate this:

• **Locale instability** is evaluated **not through** local linearizations but by a global method (DP)

• **Empirical Evaluation** undertaken by MRVAR: Impulse-responses were we can observe: asymmetry in impulse-responses, regime and size dependent effects of shocks:
  - **Financial Stress Index and output** (1990:2-2010:6)
  - **Credit Spread and output** (BAA-10yearTB, 1953.1-2009.2), see Ernst, Mittnik and Semmler (2010), JEDC

• **Other similar Banking-Macro work:**
  - There is modeling work on instability of the financial intermediaries, Brunnermeier et al. (2011a: model, 2011b: survey paper), Hubrich and Tetlow (2010)
IV. Conclusions: MR Studies Importance for Monetary Policy Evaluation

Quantitative Easing: QE1 and QE2

=> Unconventional monetary policy (affecting financial stability) is asymmetric: has different effects in booms as compared to recessions and its effects are size dependent-

⇒ Expansionary effect in a regime of low economic activity: reducing term spreads and risk spreads, though also increasing Tobin`s q (wealth effects), but more important in the long run through bond yield, improving banks balance sheets (net worth), relaxing constraints

=> Example: QE1 and QE2 of the years 2008/9 was to bring down financial risk (financial stress) and credit spread, had a strong impact on liquidity and short and long term lending, improved balance sheets of banks
IV. Conclusions: MR Studies Importance for Fiscal Policy and Economic Growth

MR Models and Fiscal Policy
The use of MRVAR to test regime dependence of fiscal policy (fiscal multiplier is regime dependent): see Mittnik and Semmler (2010), Fazzari and Morley (2010), Baum and Koester (2011, Bundesbank)

MR Models and Thresholds in Economic Growth:
The use of MR models in growth; there are stages of growth or growth regimes: see Durlauf and Johnson (1995), Evens, Konkopohja and Romer (1989), Greiner and Semmler (2005), Azariadis (2005), Semmler and Ofori (2007) , with empirical test using Kernel estimation and Markov chains
Here we have used MRVAR for empirical verification
IV. Conclusions: Financial Reform should establish a stable Banking-Macro Link

US: Measures taken to reduce instability
• 1. Complex securities, Hedge Fund regulation
• 2. Bonuses and incentive system
• 3. Capital requirements (Basil III)
• 4. Council on System Risk
• 5. Consumer protection agency


EU: Financial reform essential for success of Euro
• Fragmented banking and regulatory system
• Temporary ECB action of “unconventional monetary policy” - to bring financial risk and spread down
• ECB purchases of sovereign bonds…
• After the EU sovereign debt crisis, there is still a fragile banking system (sovereign bonds, private loans)
• EU wide reforms: 700 bill rescue funds, convergent policy