Modelling the “Animal Spirits” of bank’s lending behaviour

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Presenter: Carl Chiarella
Co-authors: Corrado Di Guilmi, Tianhao Zhi

Finance Discipline Group
Business School
University of Technology, Sydney

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Passive Intermediary vs. Active Credit Creator

- In the traditional banking literature that attempts to address this real-financial interaction problem, the commercial bank is often modelled as a passive intermediary that channel funds from the ultimate borrower to the ultimate lender (Allen and Gale 2000; Bernanke et al, 1999; Fama, 1980).
  - In reality however, the role of banks goes beyond a passive intermediary that channels funds from lenders to borrowers.
  - In the presence of fractional banking system, it functions as an active credit creator.

- In other words, the banks behaviour is not a passive reflection of the conditions of the economy, but is in itself an important factor that influences the economy via credit creation.
Bank’s Lending Attitude

- Another important aspect, which is overlooked in the traditional banking literature, is the role of banks lending attitude (Asanuma, 2012).
  - An optimistic attitude in the banking sector collectively lowers the lending standard and prompt banks to collectively over-lend to a particular sector such as real estate.
  - It potentially leads to the development of a credit bubble.
  - A collectively pessimistic banking system not only hinders economic growth but also renders expansionary monetary policy ineffective.

- In the aftermath of the crisis, the money base has tripled due to three rounds of Quantitative Easing (QE).
- It has virtually no effect on the growth of broad money due to an inactive and pessimistic banking sector (Koo, 2011).
The Money Base and M2

Figure 1: The Effect of Quantitative Easing on Money Base and M2

Source: the Federal Reserve Data Release H.3 (Aggregate Reserves of Depository Institutions and the Monetary Base) and H.6 (Money Stock Measures)
Keynes’ “Animal Spirit” Argument

- Keynes (1936)
  - *most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits: of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities.*

- Two important characteristics of the animal spirit.
  - Self-reinforcing: an optimistic/pessimistic sentiment will bring forth a positive/negative outcome to the market, which further reinforces the optimistic/pessimistic sentiment.
  - Contagion: sentiment spreads and it eventually leads to herding amongst agents.

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Introduction

Literature Review

Current Literature that models the "animal spirit"

- Lux (1995) proposes a seminal work that examines the relationship between investors sentiment, asset price bubble and crash by applying the stochastic aggregation method;
- Franke (2010) applies the Lux model in the context of macroeconomic dynamics. He studies the interplay between the firm’s sentiment, inflation climate, and the interest rate;
- De Grauwe (2010) develops a DSGE model that is augmented by agents cognitive limitations;
Objective of the paper

- This paper examines the role of “animal spirits”, here represented as, in determining banks’ lending behaviour.
- The aim is to assess how the contagious waves of optimism and pessimism contributes to the boom-bust of the credit cycle.
  - It is via a modification of the bank’s balance sheet positions, and how it amplifies the business cycle in the real sector.
- Main Contributions
  - To the best of our knowledge, this paper represents the first attempt to model the banking behaviour as influenced by animal spirits.
  - We introduce the heterogeneity in the credit sector, which represent a novelty in this stream of aggregative dynamical model.
  - We stress the role of the mechanism of credit-creation by banks as a potentially destabilising factor.
The Baseline Model

The Balance Sheet of a Typical Commercial Bank

Table 1: A Simplified Balance Sheet of Commercial Bank

<table>
<thead>
<tr>
<th>Asset</th>
<th>Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>R (Reserve)</td>
<td>D (Deposit)</td>
</tr>
<tr>
<td>L (Loan)</td>
<td>CB (Central Bank Borrowing)</td>
</tr>
<tr>
<td>B (Bond)</td>
<td>IB (Interbank Borrowing)</td>
</tr>
<tr>
<td></td>
<td>E (Bank Equity)</td>
</tr>
</tbody>
</table>

Following Taylor (2004), we focus on the loan-to-reserve ratio \( (\lambda^s) \)

\[
L^s = \lambda^s T_c, \tag{1}
\]

Here \( L^s \) is the level of aggregate credit supply, \( \lambda^s \) is the loan-to-reserve ratio of banks, and \( T_c \) is the level of unborrowed reserves.

The \( \lambda^s \) reflects not only bank’s lending attitude, but also the amount of debt accumulation due to banks’ loan creation.
The average opinion index $x$

- We consider the following baseline model, where we categorize banks into two groups, i.e. the optimistic banks and the pessimistic banks.

- Formally, suppose that there are $2N$ banks in the economy, of which $n_+$ is the number of optimists and $n_-$ are the number of pessimists, thus $n_+ + n_- = 2N$.

- Following Lux (1995), we focus on the difference in the size of the two groups by defining the index $x$, where

$$x = (n_+ - n_-)/2N.$$  \hspace{1cm} (2)
The aggregate availability of credit $L^s$

- Recall that $L^s = \lambda^s T_c$, $T_c = 2NR$.

- Given that there are two groups of banks in our model, and each group has different loan-to-reserve ratios. We modify the equation to

$$L^s = R(n_+ \lambda_+ + n_- \lambda_-).$$  \hspace{1cm} (3)

- In the baseline model, we assume that the optimistic banks are active and the pessimistic banks are inactive ($\lambda_- = 0$). We have

$$L^s = Rn_+ \lambda_+ = RN(1 + x)\lambda_+ = (T_c/2)(1 + x)\lambda_+. \hspace{1cm} (4)$$
The dynamics of the average opinion index $x$

- We follow Lux (1995) to model the average opinion $x$. The change in $x$ depends on the size of each group multiplied by their transition probability:

$$\dot{x} = (1 - x)p_{+-} - (1 + x)p_{-+}. \quad (5)$$

- Here $p_{+-}$ is the transition probability that a pessimistic bank becomes an optimistic one, and likewise for $p_{-+}$.

- The Opinion Formation Index:

$$s(x, \lambda_+, d) = a_1 x + a_2 \lambda_+ + a_3 (y^d - y) + d. \quad (6)$$

- Here $a_1$, $a_2$, $a_3$ are three cognitive parameters; $d$ is a general financial condition index.

- The Switching Probability:

$$p_{+-} = v \cdot \exp(s), \quad (7)$$

$$p_{-+} = v \cdot \exp(-s). \quad (8)$$

- Hence:

$$\dot{x} = v[(1 - x) \exp(s) - (1 + x) \exp(-s)]. \quad (9)$$
The dynamics of $\lambda_+$

- We assume that the optimistic banks make decisions based on the average opinion $x$, as well as development in the real sector $\dot{y}$.
- The law of motion for $\lambda_+$ can be formulated as
  
  $$\dot{\lambda}_+ = \gamma_1 x + \gamma_2 \dot{y}. \quad (10)$$

- Here $\gamma_1$ and $\gamma_2$ are two action parameters, $\gamma_1$ is the speed of adjustment toward the average opinion and $\gamma_2$ is the speed of adjustment toward the change in output ($\dot{y}$).
The dynamic multiplier of output

Following Blanchard (1981), we assume that output moves according to a standard dynamic multiplier process,

except that the availability of credit $L^s$ determines the aggregate demand ($y^d$):

$$
\dot{y} = \sigma(y^d - y), \quad (11)
$$

$$
y^d = y^d_0 + kL^s, \quad (12)
$$

$$
L^s = (T_c/2)(1 + x)\lambda_+, \quad (13)
$$

Here $y$ is the output; $y^d$ is the aggregate demand; $y^d_0$ is the autonomous component of the aggregate demand.

Hence

$$
\dot{y} = \sigma(y^d_0 + k(T_c/2)(1 + x)\lambda_+ - y). \quad (14)
$$
The 3D Baseline Model

- Given the above assumptions, the 3D system with a real sector becomes

\[ \lambda_+ = \gamma_1 x + \gamma_2 \dot{y}, \quad (15) \]
\[ \dot{y} = \sigma (y_0^d + k(T_c/2)(1 + x)\lambda_+ - y), \quad (16) \]
\[ \dot{x} = v [(1 - x) \exp(s(.)) - (1 + x) \exp(-s(.))]. \quad (17) \]

- Here \( s(.) = a_1 x + a_2 \lambda_+ + a_3 (y^d - y) + d. \)
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The Baseline Model

The 3D Baseline Model

Figure 2: The feedback loop

- Self-reinforcing herding effect
  - \(x > 0\) (optimism)
    - \(x\) increases
    - \(x < 0\) (pessimism)
      - \(x\) decreases
- \(s\) increases
- Positive Feedback
- Loan-to-reserve ratio increases
- Credit supply \((L)\) increases
- \(y\) increases
- Output gap \((y - \bar{y})\) increases
- Output \((y)\) increases

Negative Feedback (due to accumulation of debt)
The local stability condition

By setting LHS = 0, we derive the equilibrium of the system: 
\[(\lambda^*_+, y^*_+, x^*_+) = (d/(-a_2), y_0^d + k(T_c/2)d/(-a_2), 0).\]

The Trace (Tr) and Determinant (Det) of the Jacobian at equilibrium are derived as:

\[
\begin{align*}
Tr &= \gamma_2 \sigma kT_c/2 - \sigma + 2(a_1 + a_3 k(T_c/2)(d/ - a_2) - 1), \\
Det &= a\sigma\gamma_1(a_2 + a_3 kT_c/2) - 2a_3\gamma_1 \sigma kT_c/2. 
\end{align*}
\]

According to the Routh-Hurwitz condition, two of the necessary (yet not sufficient) conditions for the stability of system (16-18) are:

- \(Tr(J) < 0\) and \(Det(J) < 0\). In order to satisfy these two conditions we need to have sufficiently small \(a_1\) and \(a_3\), as well as sufficiently large \(-a_2\).
Figure 3: A Representative Numerical Simulation: \(a_1 = 0.3\) (stable scenario) and \(a_1 = 1.5\) (unstable scenario), \(a_2 = -0.02, \ a_3 = 1.3, \ \sigma = 0.8, \ k = 0.1, \ T_c = 1, \ y_0^d = 10, \ d = 0.5, \ v = 0.4, \gamma_1 = 0.5, \ \gamma_2 = 2\)
The Dynamics of the Debt/GDP Ratio

\[ \text{Debt/GDP ratio} = \frac{L^s}{y} \]  

Figure 4: The dynamics of Debt/GDP ratio: \( a_1 = 0.6 \) (blue), \( a_1 = 1.1 \) (black), \( a_1 = 1.7 \) (red)
Sensitivity Analysis

Figure 5: The effect of congation on output: $a_1 = 0.3$ (red), $a_1 = 0.7$ (blue), $a_1 = 1.5$ (black)
Sensitivity Analysis

Figure 6: Bifurcation Diagram for $a_1$
Sensitivity Analysis

Figure 7: Bifurcation Diagram for $a_2$
Sensitivity Analysis

Figure 8: Bifurcation Diagram for $a_3$
Sensitivity Analysis

Figure 9: Bifurcation Diagram for $\gamma_1$
Sensitivity Analysis

Figure 10: Bifurcation Diagram for $\gamma_2$
Introducing Heterogeneous Lending Strategies

\[ \dot{\lambda}_+ = \gamma_1 (x + g(\cdot)) + \gamma_2 \dot{y} + \gamma_3 (\lambda_+ - \lambda_+), \]  
\[ \dot{\lambda}_- = \gamma_1 (x - g(\cdot)) + \gamma_2 \dot{y} + \gamma_3 (\lambda_- - \lambda_-), \]  
\[ \dot{y} = \sigma (y^d - y), \]  
\[ \dot{x} = v [(1 - x) \exp(s) - (1 + x) \exp(-s)]. \]  

Here

\[ y^d = y_0^d + k L^s = y_0^d + k (T_c/2)[(1 + x)\lambda_+ + (1 - x)\lambda_-], \]  
\[ g(\cdot) = \xi_0 \exp(-\xi_1 x^2), \]  
\[ s = a_1 x + a_2 + \lambda_+ + a_2 - \lambda_- + a_3 (y^d - y) + d. \]
Steady State and Local Stability Analysis

- By setting the $LHS = 0$, we derive that
  \[ a_2 + \left[ \frac{\gamma_1}{\gamma_3} (x + \xi_0 e^{-\xi_1 x^2}) + \lambda^- \right] + a_2 - \left[ \frac{\gamma_1}{\gamma_3} (x - \xi_0 e^{-\xi_1 x^2}) + \lambda^- \right] = \frac{1}{2} \ln \left[ \frac{1+x}{1-x} e^{-2(a_1 x + d)} \right]. \]
  
  Apparently this equation has no closed form solution.

- Therefore, we consider a special case where the average opinion is neutral at equilibrium ($x^* = 0$).

- The steady state of the system in this special case is given by

  \[ \lambda^*_+ = \lambda^- + \frac{\gamma_1}{\gamma_3} \xi_0, \]  
  \[ \lambda^*_- = \lambda^- - \frac{\gamma_1}{\gamma_3} \xi_0, \]  
  \[ y^* = y_{d*} = y_0 + k(T_c/2)[(\lambda^*_+ + \lambda^*_-)], \]  
  \[ x^* = 0. \]
Steady State and Local Stability Analysis

- To simplify, we exclude the real sector by setting $\gamma_2 = 0$, $\sigma = 0$, and $a_3 = 0$.
- The Jacobian of sub-dynamics without the real sector is derived as
  \[
  \begin{pmatrix}
  -\gamma_3 & 0 & \gamma_1 \\
  0 & -\gamma_3 & \gamma_1 \\
  2va_2+ & 2va_2- & 2v(a_1 - 1)
  \end{pmatrix}.
  \]
- The trace ($Tr(J)$), determinant ($Det(J)$), and the three principle minors ($J_i$) are derived as follows $^2$:
  \[
  Tr(J) = 2[v(a_1 - 1) - \gamma_3], \tag{32}
  \]
  \[
  Det(J) = 2v[\gamma_3^2(a_1 - 1) - \gamma_1 \gamma_3(-a_2+ - a_2-)], \tag{33}
  \]
  \[
  J_1 = -2v[\gamma_3(a_1 - 1) + \gamma_1 a_2-], \tag{34}
  \]
  \[
  J_2 = -2v[\gamma_3(a_1 - 1) + \gamma_1 a_2+], \tag{35}
  \]
  \[
  J_3 = \gamma_3^2. \tag{36}
  \]

$^2$According to the Routh-Hurwitz theorem, the necessary and sufficient condition for the stability of the 3D sub-dynamics is that $tr(J) < 0$, $J_1 + J_2 + J_3 > 0$, $det(J) < 0$, and $-tr(J)(J_1 + J_2 + J_3) + det(J) > 0$ (Chiarella and Flaschel 2000).
Figure 11: Introducing Heterogeneous Lending Strategies: $a_1 = 1.5$, $a_{2+} = -0.3$, $a_{2-} = -0.5$, $a_3 = 1.3$, $\sigma = 0.8$, $k = 0.1$, $T_c = 1$, $y_0^d = 11$, $d = 10$, $\nu = 0.4$, $\gamma_1 = 0.3$, $\gamma_2 = 0.4$, $\xi_0 = 0.2$, $\xi_1 = 3$
Sensitivity Analysis

Figure 12: Bifurcation Diagram for $a_1$
Sensitivity Analysis

Figure 13: Bifurcation Diagram for $\xi_0$
Sensitivity Analysis

Figure 14: Bifurcation Diagram for $\xi_1$
Conclusion

- This paper provides a simple model that aims to examine how the contagious waves of optimism and pessimism contributes to the boom-bust of the credit cycle.
  - It emphasises on the importance of bank’s balance sheet position and its role in credit creation.

- The result is still preliminary, yet it reveals the crucial role of bank’s herding behaviour in creating boom-bust cycle and destabilizing the real economy.
Limitations

- For the sake of parsimony, our assumption about bankers' behaviour is simple.
- We have yet to take into account other important variables such as interest rate and asset price.
- Third, we need a more detailed picture of the macroeconomy that incorporates inflation, unemployment, and so on.
- This can be done by incorporating our model into the recently emerging DSGD-type model developed by Charpe et al (2012).
- The loan-to-reserve ratio takes into account of the unborrowed reserves only.
- It is possible to extend the model by incorporating an interbank market, where banks can lend and borrow reserves to each other.


