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

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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

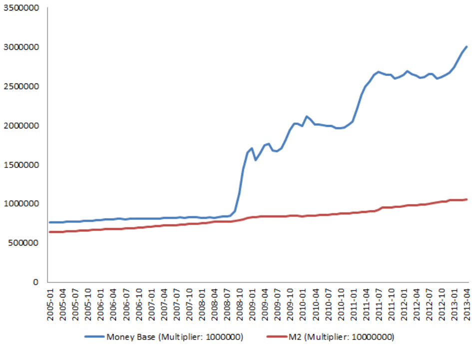

Figure 1: The Effect of Quantitative Easing on Money Base and M2[1]

[1] *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.
- Empirical evidence on herding in financial markets and financial institutions: (Bikhchandani and Sharma 2000; Haiss, 2005; Nagawaka and Uchida, 2007; Liu, 2012).

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;
  - Charpe et al (2012) further extends Franke (2010) and proposes a Dynamic Stochastic General Disequilibrium (DSGD) Model of Real-Financial interaction;
  - De Grauwe (2010) develops a DSGE model that is augmented by agents cognitive limitations;
  - Asanuma (2012) examines how banks lending attitude affects economic growth in an agent-based setting.

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 Balance Sheet of a Typical Commercial Bank

Asset	**Liability**
R (Reserve)	D (Deposit)
L (Loan)	CB (Central Bank Borrowing)
B (Bond)	IB (Interbank Borrowing)
	E (Bank Equity)

Table 1: A Simplified Balance Sheet of Commercial Bank

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

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

- Here L^s is the level of aggregate credit supply, λ^s is the loan-to-reserve ratio of banks, and T_c is the level of unborrowed reserves.
- The λ^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

$$x = (n_+ - n_-)/2N. \tag{2}$$

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

$$L^s = R(n_+\lambda_+ + n_-\lambda_-). \quad (3)$$

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

$$L^s = Rn_+\lambda_+ = RN(1+x)\lambda_+ = (T_c/2)(1+x)\lambda_+. \quad (4)$$

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:

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

- Here p_{+-} is the transition probability that a pessimistic bank becomes an optimistic one, and likewise for p_{-+}.
- The Opinion Formation Index:

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

- Here a_1, a_2, a_3 are three cognitive parameters; d is a general financial condition index.
- The Switching Probability:

$$p_{+-} = v \cdot exp(s), \tag{7}$$
$$p_{-+} = v \cdot exp(-s). \tag{8}$$

- Hence:

$$\dot{x} = v[(1 - x)\exp(s) - (1 + x)\exp(-s)]. \tag{9}$$

The dynamics of λ_+

- 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 λ_+ can be formulated as

$$\dot{\lambda_+} = \gamma_1 x + \gamma_2 \dot{y}. \tag{10}$$

- Here γ_1 and γ_2 are two action parameters, γ_1 is the speed of adjustment toward the average opinion and γ_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):

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

$$y^d = y_0^d + kL^s, \quad (12)$$

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

- Here y is the output; y^d is the aggregate demand; y_0^d is the autonomous component of the aggregate demand.
  - Hence

$$\dot{y} = \sigma(y_0^d + k(T_c/2)(1+x)\lambda_+ - y). \quad (14)$$

The 3D Baseline Model

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

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

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

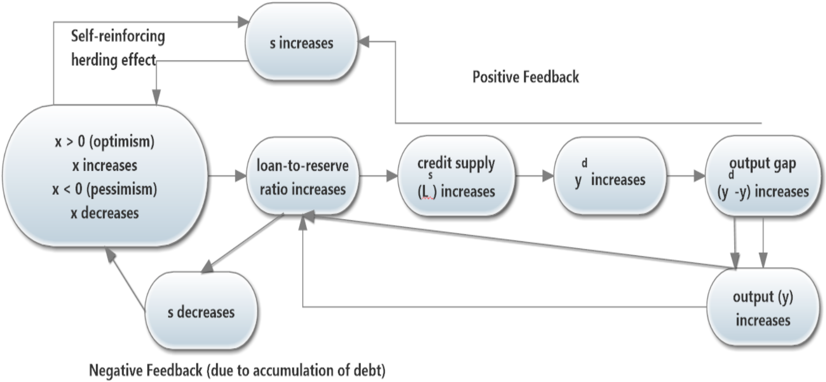

Figure 2: The feedback loop

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:

$$Tr = \gamma_2 \sigma k T_c/2 - \sigma + 2(a_1 + a_3 k(T_c/2)(d/-a_2) - 1), \quad (18)$$

$$Det = a\sigma\gamma_1(a_2 + a_3 k T_c/2) - 2a_3\gamma_1\sigma k T_c/2. \quad (19)$$

- 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 $-a_2$.

A Representative Numerical Simulation

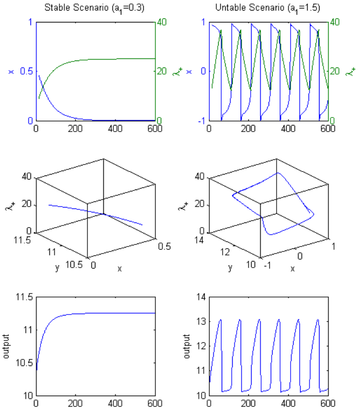

Figure 3: A Representative Numerical Simulation: $a_1 = 0.3$ (stable scenario) and 1.5 (unstable scenario), $a_2 = -0.02$, $a_3 = 1.3$, $\sigma = 0.8$, $k = 0.1$, $T_c = 1$, $y_0^d = 10$, $d = 0.5$, $v = 0.4$, $\gamma_1 = 0.5$, $\gamma_2 = 2$

The Dynamics of the Debt/GDP Ratio

$$Debt/GDP\ ratio = L^s/y \tag{20}$$

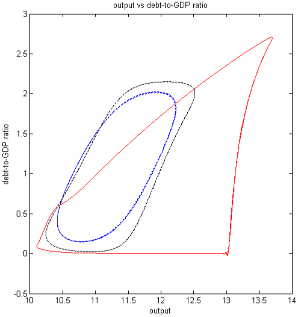

Figure 4: The dynamics of Debt/GDP ratio: $a_1 = 0.6$ (blue), $a_1 = 1.1$ (black), $a_1 = 1.7$ (red)

Sensitivity Analysis

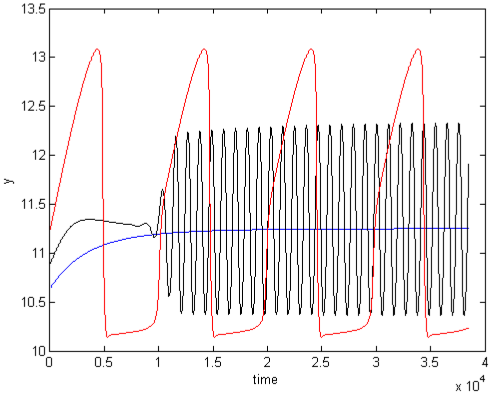

Figure 5: The effect of congation on output: $a_1 = 0.3$ (red),$a_1 = 0.7$ (blue),$a_1 = 1.5$ (black)

Sensitivity Analysis

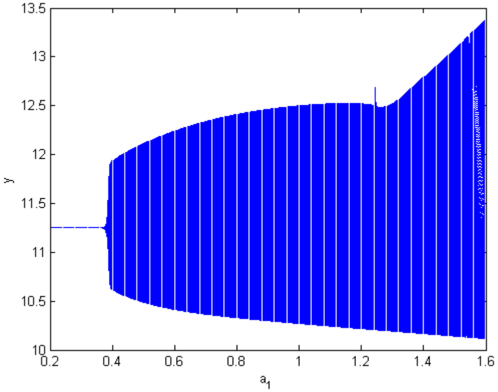

Figure 6: Bifurcation Diagram for a_1

Sensitivity Analysis

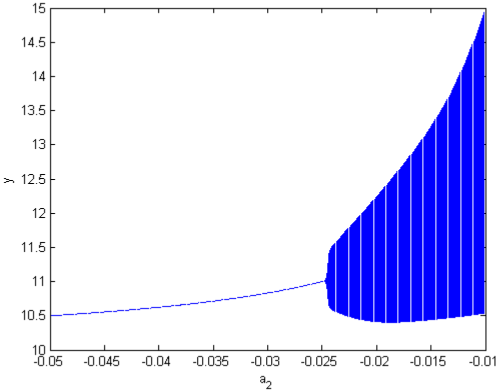

Figure 7: Bifurcation Diagram for a_2

Sensitivity Analysis

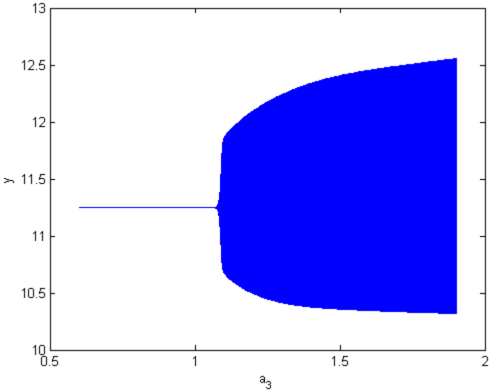

Figure 8: Bifurcation Diagram for a_3

Sensitivity Analysis

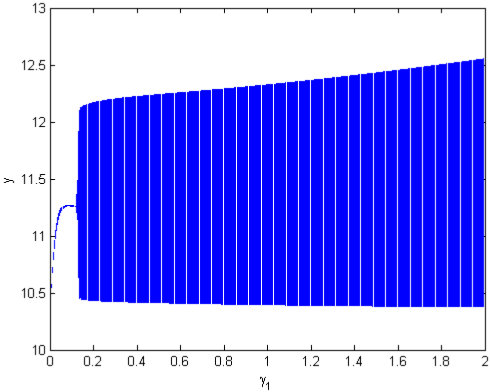

Figure 9: Bifurcation Diagram for γ_1

Sensitivity Analysis

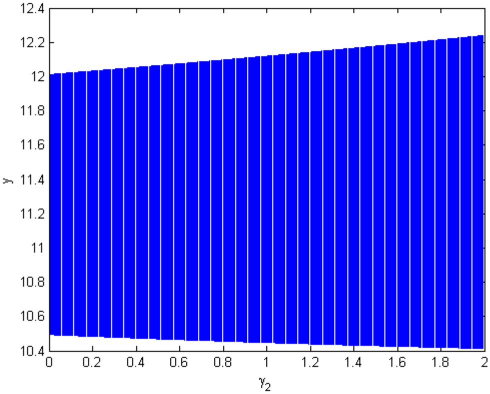

Figure 10: Bifurcation Diagram for γ_2

- Introducing Heterogeneous Lending Strategies

$$\dot{\lambda}_+ = \gamma_1(x + g(.)) + \gamma_2\dot{y} + \gamma_3(\bar{\lambda}_+ - \lambda_+), \tag{21}$$
$$\dot{\lambda}_- = \gamma_1(x - g(.)) + \gamma_2\dot{y} + \gamma_3(\bar{\lambda}_- - \lambda_-), \tag{22}$$
$$\dot{y} = \sigma(y^d - y), \tag{23}$$
$$\dot{x} = v[(1-x)\exp(s) - (1+x)\exp(-s)]. \tag{24}$$

- Here

$$y^d = y_0^d + kL^s = y_0^d + k(T_c/2)[(1+x)\lambda_+ + (1-x)\lambda_-], \tag{25}$$
$$g(.) = \xi_0 exp(-\xi_1 x^2), \tag{26}$$
$$s = a_1 x + a_{2+}\lambda_+ + a_{2-}\lambda_- + a_3(y^d - y) + d. \tag{27}$$

Steady State and Local Stability Analysis

- By setting the $LHS = 0$, we derive that $a_{2+}[\frac{\gamma_1}{\gamma_3}(x+\xi_0 e^{-\xi_1 x^2})+\bar{\lambda_+}]+a_{2-}[\frac{\gamma_1}{\gamma_3}(x-\xi_0 e^{-\xi_1 x^2})+\bar{\lambda_-}] = \frac{1}{2}ln[\frac{1+x}{1-x}e^{-2(a_1 x+d)}]$.
  - Apparently this equation has no closed form solution.
- Therefore, we consider a special case where the average opinion is neutral at equilibrium ($x^\star = 0$).
- The steady state of the system in this special case is given by

$$\lambda_+^\star = \bar{\lambda_+} + \frac{\gamma_1}{\gamma_3}\xi_0, \quad (28)$$

$$\lambda_-^\star = \bar{\lambda_-} - \frac{\gamma_1}{\gamma_3}\xi_0, \quad (29)$$

$$y^\star = y^{d\star} = y_0^d + k(T_c/2)[(\lambda_+^\star + \lambda_-^\star)], \quad (30)$$

$$x^\star = 0. \quad (31)$$

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]:

$$\begin{aligned} Tr(J) &= 2[v(a_1 - 1) - \gamma_3], && (32) \\ Det(J) &= 2v[\gamma_3^2(a_1 - 1) - \gamma_1\gamma_3(-a_{2+} - a_{2-})], && (33) \\ J_1 &= -2v[\gamma_3(a_1 - 1) + \gamma_1 a_{2-}], && (34) \\ J_2 &= -2v[\gamma_3(a_1 - 1) + \gamma_1 a_{2+}], && (35) \\ J_3 &= \gamma_3^2. && (36) \end{aligned}$$

[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).

Representative Simulation

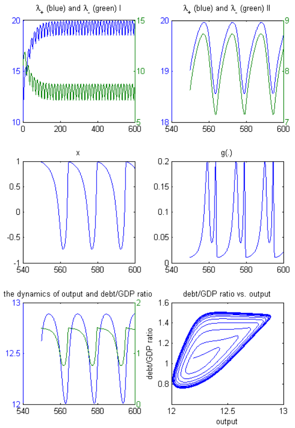

Figure 11: Introducing Heterogeneous Lending Strategies: $a_1 = 1.5$, $a_{2+} = -0.3$, $a_{2-} = -0.5$, $a_3 = 1.3$, $\sigma = 0.8$, $k = 0.1$, $T_c = 1$, $y_0^d = 11$, $d = 10$, $v = 0.4$, $\gamma_1 = 0.3$, $\gamma_2 = 0.4$, $\xi_0 = 0.2$, $\xi_1 = 3$

Sensitivity Analysis

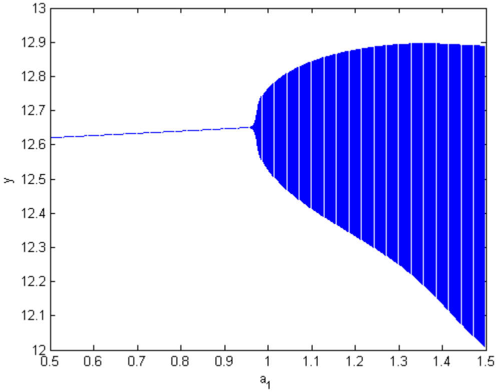

Figure 12: Bifurcation Diagram for a_1

Sensitivity Analysis

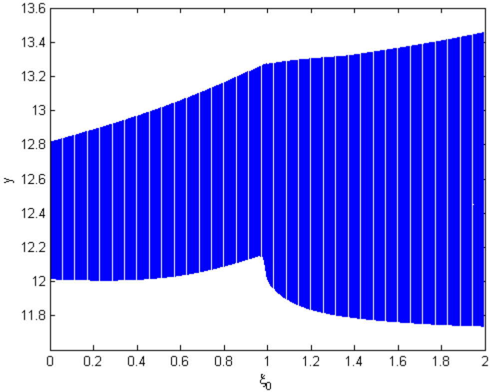

Figure 13: Bifurcation Diagram for ξ_0

Sensitivity Analysis

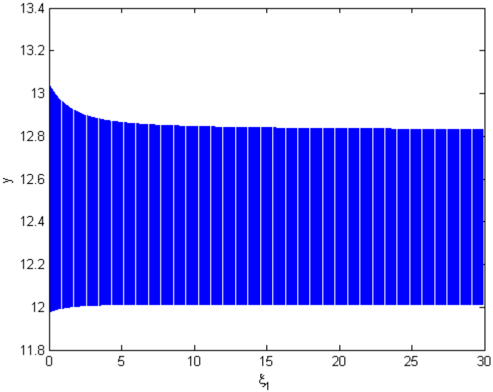

Figure 14: Bifurcation Diagram for ξ_1

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.

- Allen F., Gale D. (2000). Financial contagion. *Journal of Political Economy* **108** (1),1-33.
- Asanuma, D. (2012). Lending attitude as a financial accelerator in a credit network economy. *Journal of Economic Interaction and Coordination*, 1-17. doi: 10.1007/s11403-012-0102-9
- Bernanke, B., Gertler, M., Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics*, North-Holland, Amsterdam.
- Bikhchandani S., Sharma, S. (2000). Herd behaviour in financial markets: a review *IMF Working Paper* **WP/00/48**.
- Blanchard, O. (1981). Output, the stock market, and interest rates. *American Economic Review* **71** (1),132-143.
- Charpe, M., Flaschel, P., Hartmann, F., Veneziani, R. (2012). Keynesian DSGD(isequilibrium) Modelling: A Basic Model of Real-Financial Market Interactions with Heterogeneous Opinion Dynamics. *Paper presented at the POLHIA, 'Rethinking Economic Policies in a Landscape of Heterogeneous Agents'*, Milan, Italy.

Chiarella, C., Flashel, P., and Franke, R. (2005). Foundations for a Disequilibrium Theory of the Business Cycle. Cambridge University Press, Cambridge.

Fama, E.F. (1980). Banking in the theory of finance. *Journal of Monetary Economics* **6** (1),39-57.

Franke, R (2012). Microfounded Animal Spirits in the New Macroeconomic Consensus. *Studies in Nonlinear Dynamics & Econometrics* **16** (4), 1-41.

Grauwe, P. d. (2010). Animal Spirits and Monetary Policy. *Economic Theory*.

Haiss, P. R. (2005). Banks, Herding and Regulation: a Review and Synthesis. *Paper presented at the Workshop on Informational Herding Behavior*, Copenhagen, Denmark.

Keynes, J. M. (1936). The General Theory of Employment, Interest, and Money. Macmillan, London.

Kindleberger, C. P. (1989). Manias, Panics, and Crashes: A History of Financial Crises. Macmillan, London.

Koo, R. C. (2011). The world in balance sheet recession: causes, cure, and politics. *real-world economics review* **58**, 19-37.

Liu, C. (2012). Herding Behavior in Bank Lending: Evidence from U.S. Commercial Banks. *European Finance Association (EFA) working paper*, Queen's School of Business. Queen's University.

Lux, T. (1995). Herd behaviour, bubbles and crashes *Economic Journal* **105** (431).

Nakagawa, R., Uchida, H. (2007). Herd Behavior by Japanese Banks After Financial Deregulation in the 1980s *Paper presented at the CJEB*, Columbia University

Rethel, L., Sinclair, T. J. (2012). The Problem with Banks. London, New York: Zed Books.

Taylor, L. (2004). Reconstructing Macroeconomics. Cambridge, Massachusetts: Harvard University Press.