

## D TOWARDS MACRO-FINANCIAL MODELS WITH REALISTIC CHARACTERISATIONS OF FINANCIAL INSTABILITY

*The global financial crisis has revealed important deficiencies of the standard macroeconomic models in capturing financial instabilities. Realistic characterisations of such instabilities include bank defaults, financial market illiquidity, extreme events, and related non-linearities. None of these feature in the macroeconomic models regularly used for forecasting and monetary policy analysis and only recently has more emphasis been given to better developing the role of financial sectors in these models. This gap is of particular concern given the ongoing efforts to establish serious macro-prudential oversight and regulation to counter systemic risks. The aim of this special feature is to provide an overview of the recent upsurge in research papers trying to integrate more developed financial sectors in standard macroeconomic models and to compare this work with what is needed for the support of macro-prudential policies. One conclusion is that very significant further research efforts are needed, including attempts using modelling approaches that deviate from the currently dominating macroeconomic paradigm. It is of great importance that the academic and policy-oriented research communities join forces in working towards this objective.*

### INTRODUCTION

Mainstream macroeconomic models developed before the global financial crisis did not attempt to model the way in which the financial sector operates and interacts with the real economy. This, certainly from today's perspective, might seem surprising. While recent contributions are slowly starting to bridge the gaps, the road ahead is still long. The aim of this special feature is to review progress made so far and to highlight important aspects of financial instability that need to be accounted for before the macro-financial models can become truly useful policy tools and fill the gaps in central banks' analytical toolkits, in particular for the currently developed new macro-prudential supervisory policy function.<sup>1</sup>

The basis for the common neglect of financial markets in macroeconomics was the prevalent, if implicit, assumption of market completeness and the seminal Modigliani-Miller theorem.<sup>2</sup> The former implied that a representative agent set-up could be solved and used to back out prices of all financial assets, while the latter asserted that the value of the firm should be independent of how it finances itself. This was sometimes interpreted as suggesting that the dynamics of variables such as leverage – i.e. the ratio of debt to equity – should be of no consequence to asset valuations and aggregate fluctuations.

Such results rested on strong assumptions. Markets were assumed to be efficient and complete and there was no room for imperfect or asymmetric information, bankruptcy costs or distortionary taxation. Incidents of financial instability made the perfect information assumption look untenable. This accounted for the large impact of the contributions of Bernanke-Gertler<sup>3</sup> and, thereafter, Kiyotaki-Moore<sup>4</sup> and Bernanke-Gertler-Gilchrist.<sup>5</sup> They demonstrated how asymmetric information and moral hazard could amplify business cycles and showed that the existence of collateralised borrowing could amplify shock propagation.

1 Jean-Claude Trichet, in his speech opening the ECB-CEPR-CFS conference on macro-prudential regulation as an approach to contain systemic risk (27 September 2010), mentioned the introduction of developed financial sectors and non-linearities to capture realistic characterisations of widespread financial instability in macro models as one of the three key areas that require future work. The remaining two areas are an increased understanding of how regulation contains risk and affects the growth potential of economies, and the systemic importance of non-bank financial intermediaries. As one contribution to filling these gaps, the European System of Central Banks (ESCB) has launched a macro-prudential research network called MaRs. Various special features in the June 2010 and December 2009 FSRs have illustrated what macro-prudential policy analysis involves.

2 F. Modigliani and M. Miller, "The cost of capital, corporation finance and the theory of investment", *American Economic Review*, Vol. 48(3), June 1958.

3 B. Bernanke and M. Gertler, "Agency Costs, Net Worth, and Business Fluctuations", *American Economic Review*, Vol. 79(1), March 1989.

4 N. Kiyotaki and J. Moore, "Credit Cycles", *Journal of Political Economy*, Vol. 105, No 2, April 1997.

5 B. Bernanke, M. Gertler and S. Gilchrist, "The financial accelerator in a quantitative business cycle framework", in J. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, Elsevier, 1999.

While seminal, these papers did not intend to capture typical financial instability, such as bank defaults, illiquidity, feedback effects, extreme events and related non-linearities. This led to an emergence of *new* contributions which, while partly building upon earlier developments, focused more closely on certain aspects of macro-financial transmission. This special feature analyses the new contributions from a macro-prudential oversight perspective and therefore with a special focus on realistic financial instability.

To facilitate an overview of that work and to lay the ground for a discussion of modelling deficiencies, the approach taken is to focus on three areas whose importance was highlighted during the crisis, but less so in the early literature.

First, arguably, a large part of the recent turbulence played out in the banking sector. This meant that the models omitting banks would be incapable of addressing these events, but it also suggested that financial frictions occur along more margins than previously allowed for – e.g. they could be caused by asymmetric information involving the banker. Equally, the growth of wholesale financial markets meant that the highly leveraged institutions operating in them assumed an important role in the supply of credit to the real economy (occasionally supplanting more traditional banking activities).<sup>6</sup> Consequently, the first criterion used by this special feature to organise the surveyed papers relates to the market segment where the friction takes place, as well as its form (focusing, where appropriate, on implications for financial instability).

Second, the high leverage ratios combined with increased maturity mismatches in banks' balance sheets paved the way for "liquidity spirals", which acted as crucial amplification mechanisms during the recent turmoil.<sup>7</sup> Liquidity spirals have the potential to exacerbate small equity losses, especially when: (i) the financial institutions hit by the shock are highly leveraged, (ii) their balance sheet maturity mismatch is large and (iii) the amount of funds they are able to "lever"

on the market (i.e. the "margin requirement") is sensitive to asset prices. Accordingly, the shock propagation mechanism or, more broadly, the way in which systemic risk materialises is the second dimension used to organise the surveyed papers, with a focus on related non-linearities.

Third, in many cases the interplay between leverage and asset prices results in externalities and leads to inefficient equilibria. This implies that policy interventions have the potential to improve welfare. However, financial crisis prevention and crisis management policies have not been analysed or even considered by the pre-crisis literature. This lacuna is particularly striking in the context of the planned overhaul of financial regulation (e.g. Basel III) and in the light of the widespread use of unconventional policy measures (some taking the form of direct lending in credit markets). Given the importance of these questions for the design of macro-prudential policies, the third aspect of the new models which this special feature highlights is the implied externality (if any) and its implications for policy – both crisis management and prevention.

#### GENERAL EQUILIBRIUM MODELS OF FINANCIAL INTERMEDIATION: RECENT TRENDS

Banks are institutions which intermediate between savers and borrowers. Many recent contributions distinguish themselves by emphasising that these interactions are subject to frictions and lead to amplified economic volatility.<sup>8</sup> However, few papers capture relevant features of financial instability such as bank defaults or extreme events. Most recent contributions model imperfections as *collateral constraints* à la Kiyotaki-Moore and, ultimately, as some sort of debt-deflation mechanism.

6 See, for example, T. Adrian and H. S. Shin, "Money, Liquidity, and Monetary Policy", *American Economic Review: Papers and Proceedings*, Vol. 99(2), 2009.

7 M. Brunnermeier, "Deciphering the 2007-08 Liquidity and Credit Crunch", *Journal of Economic Perspectives*, Vol. 23(1), 2009, pp. 77-100.

8 For a discussion of the dual nature of financial frictions, see ECB, "Financial development: concepts and measures", *Financial Integration in Europe*, April 2008.

The table classifies some of the papers focused on in this special feature by friction type, propagation mechanism and inefficiency.

#### RETAIL VERSUS WHOLESALE MARKETS

The recent crisis had two prominent features. First, as already mentioned, a large part of the turbulence played out in the banking sector. Second, it followed the rapid development of the market-based banking sector and the surge in this sector's leverage. Adrian-Shin<sup>9</sup> show that broker-dealers' (i.e. investment banks') leverage has been highly pro-cyclical and increased about threefold during the six-year expansion that preceded the crisis. These developments occurred alongside the growth in importance of broker-dealers in the supply of credit to the real economy.

Most of the recent literature attempts to account for the first feature by exploring the effects of banks being financially constrained, as opposed to the real sector. For example, Meh-Moran<sup>10</sup> present a benchmark dynamic stochastic general equilibrium (DSGE) model where the standard moral hazard problem between entrepreneurs and banks is supplemented with another moral hazard problem between banks and households.<sup>11</sup> The incentive constraints in the model ensure that entrepreneurs choose "good" projects and banks decide to monitor. As a result, the capital position of banks affects their ability to attract loanable funds and influences the business cycle through a bank capital transmission channel. Hirakata et al.<sup>12</sup> adopt a similar "double friction", but using Bernanke-Gertler's original costly state verification framework.

One major caveat to the above models is that they focus on the financing conditions of a traditional banking sector and the relationship between commercial banks and depositors, while the recent financial crisis originated in the wholesale financial market. Gertler-Kiyotaki's<sup>13</sup> contribution is the first attempt to incorporate the interbank market within DSGE models. The authors assume a moral hazard problem à la Kiyotaki-Moore, which constrains banks' borrowing both from households (deposits) and from other banks (interbank loans). The borrowing constraint

entails a relationship between banks' leverage and banks' franchise value. This dependence is at the core of liquidity spirals.

#### LIQUIDITY SPIRALS AND THE DEBT-DEFLATION MECHANISM

For many observers, one of the main vectors of contagion and propagation during the recent crisis was the liquidity shortage in the financial sector and the two liquidity spirals that compounded it. For example, Brunnermeier makes the distinction between the loss spiral and the margin/haircut spiral.<sup>14</sup>

The *loss spiral* resembles the traditional debt-deflation mechanism, with the difference that it occurs in the highly leveraged banking sector, as opposed to the real sector. Building upon previous works on the debt-deflation mechanism, the recent literature has modelled the loss spiral by introducing ad hoc borrowing constraints into otherwise standard frameworks. While such constraints may be motivated by different financial frictions, their form differs marginally across models. For example, Jermann-Quadrini<sup>15</sup> consider an incentive problem, which implies that the principal of a loan must not exceed a certain fraction of the borrower's equity. In contrast, Bianchi-Mendoza<sup>16</sup> consider a limited

9 T. Adrian and H. S. Shin, "Financial Intermediaries, Financial Stability, and Monetary Policy", *Federal Reserve Bank of New York Staff Report*, No 346, September 2008.

10 C. Meh and K. Moran, "The role of bank capital in the propagation of shocks", *Journal of Economic Dynamics and Control*, Vol. 34, Issue 3, 2010.

11 This double moral hazard framework builds upon B. Holmström and J. Tirole, "Financial intermediation, loanable funds, and the real sector", *Quarterly Journal of Economics*, Vol. 112(3), August 1997.

12 N. Hirakata, N. Sudo and K. Ueda, "Chained credit contracts and financial accelerators", *IMES Discussion Paper Series*, No 2009-E-30, 2009.

13 See M. Gertler and N. Kiyotaki, "Financial Intermediation and Credit Policy in Business Cycle Analysis", 2009, unpublished manuscript, available at <http://www.econ.nyu.edu/user/gertler/>.

14 M. Brunnermeier, "Financial Crises: Mechanisms, Prevention, and Management", in M. Dewatripont, X. Freixas and R. Portes (eds.), *Macroeconomic Stability and Financial Regulation: Key Issues for the G20*, CEPR, 2009.

15 U. Jermann and V. Quadrini, "Macroeconomic Effects of Financial Shocks", *NBER Working Paper*, No 15338, September 2009.

16 J. Bianchi and E. Mendoza, "Overborrowing, Financial Crises and 'Macro-prudential' Taxes", *NBER Working Paper*, No 16091, June 2010.

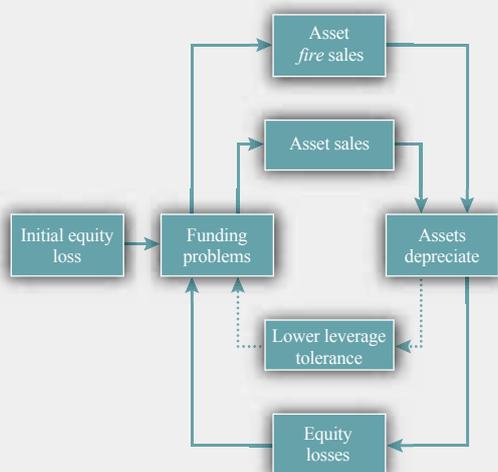
enforcement problem, which implies that the total repayment of the loan (i.e. principal plus interest) is constrained by the borrower's asset value. The general principle behind these various approaches is that the borrower's total debt-to-equity ratio must not exceed a certain constant and exogenously given threshold. In a nutshell, banks have to maintain a constant leverage ratio or margin.<sup>17</sup> Under this constraint, a mark-to-market equity depreciation reduces the bank's borrowing capacity and forces it to sell off long-term assets at short notice so as to keep its leverage ratio constant. Obviously, banks would do this only when the maturing short-term assets are insufficient to cover the payments of maturing short-term debts. In general, however, a bank's balance sheet exhibits such maturity mismatches. Mechanically, asset fire sales are all the more significant when borrowers are leveraged and their balance sheet maturity mismatch is important. Asset fire sales generate a market liquidity problem and a further depreciation in asset prices and marked-to-market equity.

This liquidity spiral, represented by the solid arrows in Chart D.1, corresponds to the standard debt-deflation mechanism. However, it is only

one part of the propagation mechanism as margin requirements and leverage have, in fact, been highly cyclical rather than constant. Variations in leverage have a huge impact on the price of assets, potentially contributing to economic bubbles and busts. Geanakoplos<sup>18</sup> refers to this phenomenon as the *leverage cycle*, while Brunnermeier<sup>19</sup> calls it the *margin spiral*. This second spiral works as follows. When asset prices fall and investment opportunities have lower returns, borrowers typically have less incentive to behave well (e.g. to exert effort in line with lenders' interests). To restore the right incentives, lenders then tend to tolerate lower leverage ratios (or higher margins) so as to force borrowers to "have more skin in the game". It follows that margin requirements in general increase as a bank's equity falls in value. The leverage cycle demultiplies the adjustments required after a mark-to-market of equity loss and the effects of the loss spiral (see the dotted arrows in Chart D.1).

Few papers so far have modelled the margin spiral. One notable exception is Brunnermeier-Sannikov.<sup>20</sup> They follow the recent trend in the literature, in that borrowing is limited owing to financial frictions in the form of moral hazard. However, their model also includes some important novel features. First, the borrower's incentive constraint requires a higher margin requirement in downturns, when equilibrium asset prices are depressed. Therefore negative macro shocks that reduce the collateral value of banks' assets trigger both the loss and margin spirals, causing long-lasting adverse feedback loops. Second, because their analysis is not restricted to local effects around a steady state and, therefore, breaks away from the certainty equivalence characteristics of the standard linearised DSGE model, Brunnermeier-Sannikov

Chart D.1 The two liquidity spirals



Source: ECB.

17 The leverage is the reciprocal of the margin, namely the ratio of the asset value to the cash needed to purchase it.

18 J. Geanakoplos, "The Leverage Cycle", in D. Acemoglu, K. Rogoff and M. Woodford (eds.), *NBER Macroeconomics Annual*, Vol. 24, 2009.

19 M. Brunnermeier, "Deciphering the 2007-08 Liquidity and Credit Crunch", op. cit., pp. 92-93.

20 M. Brunnermeier and Y. Sannikov, "A Macroeconomic Model with a Financial Sector", unpublished manuscript, 2010, available at <http://www.eu-financial-system.org/index.php?id=96>.

also account for the feedback effects of asset price volatility on asset prices. As asset price volatility increases, risk-averse households are inclined to hoard more cash and reduce their demand for assets. This accumulation of precautionary savings during downturns is responsible for asset price volatility and plays a crucial role in the dynamics of their model.

### POLICY IMPLICATIONS

Existing macroeconomic models are ill-equipped to assess the effects of the various extraordinary policy interventions that have taken place since the start of the financial crisis. Over the past three years, the research community has become aware that a greater understanding is needed of how *crisis management* policies and *crisis prevention* policies (inter)act at the aggregate level. Some efforts have been made in these two domains, from both a normative and a positive perspective.

In many cases the liquidity spirals described above result from externalities and lead to inefficient equilibria. A strand of the recent literature rationalises micro-prudential policies (such as some of the Basel III reforms) by their ability to prevent the build-up of financial imbalances and the occurrence of crises and thereby improve welfare. Mendoza,<sup>21</sup> Bianchi-Mendoza<sup>22</sup> and Brunnermeier-Sannikov,<sup>23</sup> for example, develop dynamic equilibrium models where private agents face an “occasionally binding” borrowing constraint. In the decentralised competitive equilibrium, private agents do not internalise the effects of their individual borrowing plans on the market price of assets and, therefore, on the value of their collateral and borrowing capacity. Compared with a constrained social planner who internalises these effects, they undervalue the benefits of an increase in self-financing “ex post” when the constraint binds. Typically, they accumulate too much debt. Since both the social planner and the private agents are forward-looking, these differences in valuation lead to differences in the private and social benefits of debt accumulation “ex ante” when the constraint is not binding (i.e. in good times). In this context, constrained-efficient allocations

imply less frequent and milder crises than the decentralised equilibrium because the social planner accumulates extra precautionary savings in good times that makes the constraint less likely to bind. These extra precautionary savings need not be large to reduce the probability and size of crises. The social planner can decentralise the constrained-efficient allocations as a competitive equilibrium by introducing an optimal schedule of state-contingent taxes on debt. By doing so, it can neutralise the adverse effects of the credit externality and increase social welfare. The tax is higher when the economy is building up leverage and becoming vulnerable to shocks, but before a crisis actually occurs, so as to induce private agents to value the accumulation of precautionary savings more than in a competitive equilibrium without taxes. In effect, a tax on debt of about 1% would suffice to reduce sharply the probability and severity of financial crises. Although a tax on debt is not featured in the Basel III reform package, Bianchi<sup>24</sup> shows that such a tax is equivalent to tighter capital or liquidity requirements. Overall, this research work therefore supports the recent proposal of the Basel Committee on Banking Supervision (Basel Committee) on counter-cyclical capital buffers.<sup>25</sup>

In parallel with this literature, some research efforts have been devoted to assessing crisis management policies. For example, Gertler-Kiyotaki<sup>26</sup> and Gertler-Karadi<sup>27</sup> focus

21 E. Mendoza, “Sudden Stops, Financial Crises and Leverage”, *American Economic Review*, forthcoming. See also O. Jeanne and A. Korinek, “Managing Credit Booms and Busts: A Pigouvian Taxation Approach”, unpublished manuscript, 2010, available at <http://www.eu-financial-system.org/index.php?id=96>.

22 J. Bianchi and E. Mendoza, op. cit.

23 M. Brunnermeier and Y. Sannikov, op. cit.

24 J. Bianchi, “Over-borrowing and Systemic Externalities in the Business Cycle”, *MPRA Paper*, No 16270, University Library of Munich, Germany, April 2009.

25 See Basel Committee on Banking Supervision, “Countercyclical capital buffer proposal – consultative document”, July 2010. Bengui uses a similar approach, with private agents facing a borrowing constraint, but focuses on the negative externalities of excess debt maturity mismatches. See J. Bengui, “Systemic Risk and Inefficient Debt Maturity”, unpublished manuscript, 2010, available at <http://www.eu-financial-system.org/index.php?id=96>.

26 Gertler-Kiyotaki, op. cit.

27 See M. Gertler and P. Karadi, “A model of Unconventional Monetary Policy”, *Journal of Monetary Economics*, forthcoming.

on unconventional monetary policies. To combat the crisis, monetary policy and fiscal authorities have employed various unconventional policy measures that involve some form of direct lending in credit markets, whereby central bank lending substitutes private bank lending. Gertler-Kiyotaki find that such policies moderate the contractions that follow adverse technology shocks, monetary shocks or banks' equity losses. They also describe how long it takes for the economy to endogenously "phase out" these unconventional policies. In effect, the exit timing depends on the ability of private banks to recapitalise and become unconstrained. As they build up their balance sheets, private banks can gradually absorb assets from the central bank's balance sheet and return to normal. The speed of exit is thus shown to be inversely related to the size of the central bank's intervention.

#### MISSING CHANNELS AND OPEN QUESTIONS

While some progress has been made in the contributions surveyed above, here we focus on relevant aspects of financial market activity still missing from current macroeconomic models.

Given the key role of the recent crisis in driving the research agenda, we use a taxonomy of financial market instability to organise the discussion. Financial instability is frequently categorised as either being "horizontal" or "vertical".<sup>28</sup> The former is related to any form of systemic risk within the financial system while the latter focuses on two-sided interactions between the economy and the financial system. As the previous analysis made clear, most recent papers abstract from modelling the interbank market and so essentially neglect "horizontal" factors. But crucially, even the interbank market only accounts for a small part of where horizontal risk can materialise and what macroeconomic models should capture. Naturally, abstracting from this high degree of interconnectedness makes it hard to analyse risks related to contagion, as well as the information-intensive relationships between unsecured interbank lending and potential liquidity shortages.<sup>29</sup> Perhaps more importantly, failing to account for the diversity

within the financial sector also makes it difficult to account for crucial aspects of the build-up and unravelling of the widespread imbalances that ultimately led to the crisis.

Further, while depositor insurance schemes have all but eliminated classic bank runs,<sup>30</sup> the recent near shutdown of the interbank market, with banks refusing to extend credit and hoarding liquidity, displayed many related features. Additionally, while the asymmetric impact of macro shocks on banks' balance sheets has received much scrutiny, their role in amplifying contagion risks is less well covered.

Other than contagion, another group of "horizontal" factors yet to be analysed within a DSGE framework is related to the functioning of over-the-counter derivatives markets. New derivatives contracts arguably allowed institutions to increase their leverage, potentially acting as automatic "destabilisers" and leading to inefficient allocations once risks crystallised.<sup>31</sup> Equally, the impact of asset price falls on traders' ability to provide liquidity – compromised via collateral effects – also appears to have played a role in the crisis but is conspicuous by its absence in DSGE set-ups.

Broadly, many of these "horizontal" instability factors reflect information imperfections which can cause adverse selection and moral hazard, and lead to rational herding behaviour.<sup>32</sup>

28 The analysis here builds on the discussion in ECB, "The concept of systemic risk", *Financial Stability Review*, December 2009, although the distinction between vertical and horizontal instability was first used in O. De Bandt and P. Hartmann, "Systemic risk: A survey", *ECB Working Paper Series*, No 35, November 2000.

29 For an overview of financial market contagion research, see ECB, "Financial market contagion", *Financial Stability Review*, December 2005.

30 For a seminal theoretical analysis see, for instance, D. Diamond and P. Dybvig, "Bank runs, deposit insurance and liquidity", *Journal of Political Economy*, Vol. 91, No 3, June 1983. It has also been pointed out that while deposit insurance might limit the risk of bank runs, it can also lead to reduced monitoring effort and encourage investment in riskier banks where the value of the implicit insurance scheme is larger.

31 The planned introduction of clearing houses for derivatives contracts aims to mitigate some of these risks.

32 See, for example, A. Banerjee, "A simple model of herd behavior", *Quarterly Journal of Economics*, Vol. 107, August 1992 and S. Bikhchandani, D. Hirshleifer and I. Welch, "A theory of fads, fashion, custom and cultural change in informational cascades", *Journal of Political Economy*, Vol. 100(5), October 1992.

It has been argued, for example, that adverse selection and the inability of banks to distinguish the quality of assets led them to hoard liquidity, which contributed to the sudden drop in lending in unsecured interbank markets.

The absence of many aspects of imperfect information from general equilibrium set-ups coupled with the occasional lack of descriptive realism – e.g. ignoring the impact of remuneration incentives – meant that the vital importance of financial contract information intensity and balance sheet structures was largely neglected. Since banks address information problems, their failure can accentuate these problems leading to inefficient allocations. This becomes crucial when trying to assess the costs of crises and devise adequate macro-prudential policies (and still has not been addressed in recent DSGE literatures).<sup>33</sup>

“Vertical” factors – i.e. financial real economy interactions – also deserve closer scrutiny in models. One such factor is the slow build-up of imbalances and their interplay with financial sector stability. Such imbalances can mean that risks are neglected in good times and lead to a situation in which small shocks make large financial crises possible.<sup>34</sup>

While leverage cycles have been analysed in the macro literature,<sup>35</sup> a feature that has received less attention – and is again related to imperfect information – is the potential impact of low interest rates on banks’ incentives to screen borrowers and on banks’ efforts to provide riskier loans in attempts to rebuild margins.<sup>36</sup> Equally, straddling macro and finance – and largely unaccounted for in the DSGE literature – is the impact of government bailouts on the riskiness of agents’ investment choices, as well as the role of existing micro-prudential regulation in exacerbating financial fluctuations.<sup>37</sup>

Finally, there are other issues – unrelated to “horizontal” or “vertical” instability – but still potentially relevant for modellers and policy-makers alike.<sup>38</sup> For example, all of the

DSGE models surveyed in this special feature are stable – i.e. in the absence of shocks they always converge back to equilibrium. This, though increasing tractability and ostensibly aligned with business-cycle analysis, ultimately eliminates hysteresis and most likely profoundly underestimates the welfare costs of financial instability.

Further, and related to the potential analysis of macro-prudential issues, the general equilibrium paradigm implies that markets always clear. This is especially questionable in times of financial distress, which are often associated with structural transformation and significant resource under-utilisation, as well as considerable ambiguity over loss size and “ownership” (e.g. following the bursting of asset price bubbles). Again this would tend to make the costs of crises much smaller in theoretical models than they may be in practice.

Finally, the models discussed largely ignore cross-sectional heterogeneity. This implies that asset price changes in the models have no redistributive effects, which could – to the extent that agents differ – act as economic “shocks”. And, clearly, these shocks would be exacerbated by financial innovation which permits greater risk-taking.

33 Because bank default destroys the specific knowledge banks have about borrowers, it shrinks the common pool of liquidity and may also have adverse implications for other institutions – particularly if the value of illiquid bank assets goes down. See, for example, D. Diamond and R. Rajan, “Liquidity shortages and banking crises”, *Journal of Finance*, Vol. 60(2), 2005 and V. Acharya and T. Yorulmazer, “Cash-in-the-market pricing and optimal resolution of bank failures”, *Review of Financial Studies*, Vol. 21(6), November 2008.

34 Empirically, banking crises appear more probable after lending booms rather than tranquil periods. See also P.-O. Gourinchas, R. Valdes and O. Landerretche, “Lending booms: Latin America and the world”, *Economia*, Vol. 1, No 2, 2001.

35 J. Geanakoplos, op. cit.

36 G. Dell’Arricia and R. Marquez, “Lending booms and lending standards”, *Journal of Finance*, Vol. 61, Issue 5, October 2006.

37 E. Farhi and J. Tirole, “Collective moral hazard, maturity mismatch and systemic bailouts”, *NBER Working Paper*, No 15138, July 2009.

38 Some of the arguments are taken from J. Stiglitz’s Adam Smith lecture, “Rethinking Macroeconomics – What went wrong and how to fix it”, delivered at the European Economic Association Congress, Glasgow, 24 August 2010.

Another under-researched facet relates to solution methods to deal with non-linearities – and in particular allowing for sudden switches from financial booms to deep recessions. Arguably, standard methods might insufficiently penalise inaccuracy under crisis situations. While these occur rarely, an argument can be made that small mistakes in times of financial instability can be very costly, suggesting overweighting accuracy in states of turmoil.<sup>39</sup>

Related issues include assessing the quantitative relevance of many of the channels discussed above, as well as the fit of models allowing for financial instability. As mentioned above, standard methods, such as comparing impulse responses to those of vector autoregressions or comparing model-implied moments to those of the data, might give too much weight to set-ups which do well in normal times but are inadequate in times of financial turmoil.

### CONCLUDING REMARKS

This special feature surveyed the recent literature on incorporating financial factors in DSGE models from a macro-prudential perspective, with a special focus on the realistic characterisation of financial instability. The literature has started reacting to the issues raised by the recent financial crisis, and the surveyed contributions go some way towards capturing several aspects of financial market activity. However, many areas and facets of financial instability still need to be accounted for.<sup>40</sup> These should focus on combining the notions of financial instability and systemic risk within macro-financial models and capturing more aspects of the two-way relationship between the financial system and the wider economy (e.g. deepening our understanding of the interaction between financial instability and economic performance). The relevant questions – certainly from the point of view of the new trend of establishing serious macro-prudential oversight and regulation to counter systemic risks – include the following. How does widespread financial instability affect the real economy? What are the main

transmission channels of financial instability at the aggregate level? What role is played by non-linearities, amplification and feedback effects, as well as oligopolistic market structures and herding? What level of descriptive realism is necessary for the macro-financial models to become viable tools in assessing the advantages and disadvantages of different macro-prudential policies and is useful in stress tests and simulations? Crucially, as mentioned in the overview, only the development of aggregate models with realistic characterisations of widespread financial instability will enable macro stress-testing models and other essential analytical tools for assessing systemic risk, as well as macro-prudential policies, to be further improved significantly. This may well require the development and use of modelling approaches outside the presently dominating macroeconomic paradigm. It is therefore of great importance that the academic and policy-oriented research communities join forces to address these discrepancies and find answers to the open questions.

<sup>39</sup> This is, of course, directly related to issues such as the adequacy of linearisation techniques, or even higher order, local solution methods for solving DSGE models with financial instability.

<sup>40</sup> C. Goodhart, C. Osorio and D. Tsomocos also stress this point: "... the appeal of DSGEs withered during the current financial crisis because they failed to provide a suitable framework for the analysis of financial (in)stability...". See "Analysis of Monetary Policy and Financial Stability: A New Paradigm", *CESifo Working Paper*, No 2885, December 2009.

## An overview of the post-crisis literature

Study	Character of the friction		Mechanisms and propagation		Externality	Inefficiency	
	Market segment where friction occurs	Type of friction	Mechanism	Materialisation of systemic risk		Policy implication	
						Crisis prevention	Crisis management
Bengui	banks-firms	cc	debt deflation; fire sales	excessive maturity mismatch	misperceived asset-debt loop	counter-cyclical tax; short-term debt	–
Bianchi-Mendoza	banks-firms	cc (occasionally binding)	debt deflation; fire sales; regime switching (i.e. effects amplified by non-linearity)	excessive leverage; instability; fire sales	misperceived asset-debt loop	counter-cyclical tax on leverage; capital requirements; liquidity requirements	–
Brunnermeier-Sannikov	generic borrowers-lenders	cc (occasionally binding)	debt deflation; fire sales; regime switching (i.e. effects amplified by non-linearity)	excessive leverage; endogenous amplification	misperceived asset-debt loop	minimum capitalisation; discourage securitisation	–
Gertler-Karadi	banks-households	csv (cash diversion)	debt deflation	fire sales; endogenous amplification	–	–	unconventional monetary policy
Gertler-Kiyotaki	wholesale financial market	csv (cash diversion)			–	–	unconventional monetary policy
Jeanne-Korinek	generic borrowers-lenders	cc (occasionally binding)		excessive leverage; instability; fire sales	misperceived asset-debt loop	counter-cyclical tax on leverage	–
Meh-Moran	banks-firms	csv; dmh	bank capital channel	endogenous amplifications	–	–	–

Notes: “cc” stands for collateral constraints; “csv” stands for costly state verification; “dmh” stands for double moral hazard; “efp” stands for external finance premium; “–” indicates none or not applicable.