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Analysis of Financial Stability

By C.A.E. Goodhart[♣] and D.P. Tsomocos[♥][1]

A. Institutional Structure

On the macro-economic policy side of Central Banking a remarkable consensus has been emerging over the last two decades. This covers both the applicable theoretical framework for analysing the transmission mechanism of monetary policy and also the appropriate institutional structure for the Central Bank to deploy its macro-economic policies. The consensus about the latter structure generally involves a high degree of operational independence (from Government); the de facto selection of price stability as the primary objective, (except in those countries on a pegged, or fixed exchange rate, or in a currency union); and the choice of a short term interest rate, selected on pre-announced dates within the context of a forward-looking forecasting structure, as the main instrument. When some country strays from this consensus, for example when Poland or Venezuela seeks to curtail its Central Bank's operational independence, or when a (French?) politician casts doubt on the primacy of the price stability objective, you can almost hear the sharp intake of breath amongst the world-wide 'club' of central banks and at its focal point at the Bank for International Settlements (BIS) in Basel.

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There is no such consensus on the appropriate theoretical framework for the analysis of financial stability. Indeed some would claim that there is no proper theoretical framework for this function in being at all. We shall turn to this issue later, in Section B. But first we want to turn to the great diversity of institutional structures that exist for Central Banks on the stability/prudential/systemic stability wing. On this, see in particular, Mayes and Wood, The Structure of Financial Regulation, (2007), especially their 'Introduction', and also Masciandaro and Quintyn, Independence, Accountability and Governance of Financial Supervisory Authorities, (2007).

The earliest banks, that eventually became transformed into Central Banks, such as the Riksbank, Bank of England, Banque de France, were initially established to provide certain banking and financial services to the Government, notably including the provision of funding during war-time. In return they received certain competitive and governance advantages that quickly enabled them to become the largest commercial bank in their own country. As a result of their central role they had both a complementary relationship, (especially with the smaller country banks), and also a competitive relationship, (especially with the larger joint-stock banks), (see Goodhart, 1988, Cameron, 1967, 1972, etc.).

On the complementary side, it was more efficient to centralise reserve holdings of specie with the Governments' (central) bank, (with the other commercial banks using claims on the Central Bank, notes and deposits, as reserves instead). By the same token it was far simpler to settle payments' imbalances between banks by an exchange of claims on the CB than by carting gold bullion around the country. Moreover, a commercial banker which held balances with a CB and had a long-

standing customer relationship with it would be more likely to obtain loans from the CB, when there were (temporary) liquidity problems.

Nevertheless the CB was also a direct rival for the other main commercial banks during the 19th century, especially for the large, diversified joint stock banks that developed in the second half of the century. There are many examples of quite bitter rivalry. It was only slowly and quite reluctantly that the CB shed its commercial role towards the end of the 19th century. Given this commercial rivalry, the idea that the CB should have direct supervisory oversight of the commercial banks, and be able to inspect their books and to review their management practices would have been unacceptable to commercial bankers at the turn of the last century.[2]

Essentially the way that the CBs tried to keep oversight over the stability of the banking system was to keep watch over the quality of the commercial bills in money markets, since it was such bills that the CB would be requested to discount in a crisis. Indeed many CBs have strict limits on the nature and quality of assets that they can buy, or rediscount, or use as collateral for their Lender of Last Resort (LOLR) functions; (this was a major reason why the Bundesbank arranged for the establishment of the Likobank in 1974, since their own capacity to undertake LOLR operations was so constrained by legal limitations). The aim of CBs to ensure that the quality of available money market assets was good enough to enable them to inject liquidity into the banking system, (in case of need), without running into unacceptable danger of loss themselves. This was one of the foundations of the 'real bills' doctrine. This doctrine provided a unifying basis both for the prudential/systemic and the

[2] Also see Grossman (2006).

macro-economic policy aspects of CB policy.[3] If the (self-liquifying) characteristics of the commercial bills were good enough, being based on real trade activities, (whereby the final sale of products would raise more than enough funds to repay the debt), then both the quality and, it was assumed, the volume of such debt was sustainable, and could safely be the basis for CB market actions, including LOLR (see Bagehot, Lombard Street).

For such reasons, much early CB prudential oversight focussed on the nature and quality of bank assets, primarily in (commercial) bill markets, but also in loan and bond markets, and not on a direct examination of the books, or management practices, of the other commercial banks. For example, in the UK, prior to the Fringe Bank crisis in 1973/74, prudential oversight in the Bank of England was the province of the Discount Office, a small section within the Cashier's Department, run by a Principal with a couple of Deputies. They focussed their attention on the Accepting Houses, whose role then included the acceptance of commercial bills (turning them into two-name bills), and on the Discount Houses, which acted as a buffer between the commercial banks on the one hand and the CB on the other. The discount houses borrowed from the commercial banks, and used the funds to invest in bills and short-dated bonds. If the commercial banks ran into liquidity shortages, they would withdraw their funds from the discount houses, which would then in turn rediscount assets with the Bank of England. The discount houses were initially fostered by the Bank, and used by the commercial banks, precisely because the historical rivalry between the two made direct dealings between them problematical. When that faded into the dim, historical past, (in the 1990s), so did the discount houses.

[3] Though, as well known now, the 'real bills' doctrine is a misleading guide for macro-policy purposes, and has been blamed for leading the Fed astray in the Great Depression in the USA, 1929-33, see Meltzer (2003), Friedman and Schwartz (1963), and Timberlake (2007).

The Bank of England's Discount Office was meant to gather general market intelligence about the standing and reputation about banking and credit institutions, but had no right of onsite inspection with the commercial banks. In so far as there was any authority in the UK that could examine banks' books, it lay in the hands of the Department (Board) of Trade, (but was rarely utilised). The Chairmen of the big London Clearing Banks did come into the Bank to discuss their accounts and general position with the Governor, but only on an informal non-statutory basis.

In the United States, (prudential) oversight of the national banks, as contrasted with State chartered banks, had been allocated to the Office of the Comptroller of the Currency, (a part of the Treasury Department), in 1864, as part of the National Banking Act, well before the foundation of the Federal Reserve System in 1913; State banks were regulated and supervised by the respective State banking authorities.

> "[T]he Federal Reserve Act granted both the OCC and the Federal Reserve authority to supervise member banks [i.e. members of the Federal Reserve System]. This overlap of authority was resolved in 1917 with the OCC supervising national banks and the Federal Reserve supervising state member banks. However, state banks remained simultaneously subject to state supervision…..
>
> The Glass-Steagall Act [of 1933] also created the FDIC with the authority to resolve failed banks, but left the authority to close banks with their respective regulators – state, Federal Reserve, OCC – or the bank's directors. This had the effect of creating a resolution process for banks that was entirely separate from the bankruptcy process that applied to other corporations (and individuals)." [Also see Bliss and Kaufman, 2006, on this latter.]
>
> "…..Congress passed the Bank Holding Company Act in 1956 permitting formation of multi-bank holding companies (subject to state/interstate laws) and allowing some non-banking activities to take place under the holding company, though, outside the subsidiary banks. The Bank Holding Company Act gave the Federal Reserve supervisory authority for bank holding companies, but not for the constituent banks unless they were already subject to Federal Reserve oversight as state member banks. The Bank Holding Company Act was amended in 1970 to permit one-bank holding companies;

> that is, holding companies that control a single bank along with one or more non-bank subsidiaries."
>
> "The Financial Modernization Act of 1999 (Gramm-Leach-Bliley) removed a number of restrictions on banking activity that had been imposed under Glass-Steagall. Gramm-Leach-Bliley also permitted combining banking, securities and insurance subsidiaries under a single newly-defined financial holding company structure. The Act gave the Federal Reserve the power to authorize formation of financial holding companies, and to serve as 'umbrella regulator'. However, Gramm-Leach-Bliley further entrenched the separate functional regulators who regulate insurance, securities broker/dealers and commercial banks within the financial holding company. The Federal Reserve's powers as umbrella regulator are mitigated by requirements to defer to functional regulators in numerous ways. The Federal Reserve has considerable powers once a threat to the deposit insurance fund or more broadly a systemic concern has developed, but considerably less power to coordinate processes aimed at early detection and distress avoidance." Bliss, (2007, pp 135/6)

The structure of US financial supervision is, as a consequence, a complex muddle, involving problems of co-ordination and inter-agency rivalry. But attempts to rationalise it have failed; each of the agencies involved defends it own turf with some passion.

World War I not only destroyed much of the pre-war international financial system, centred on the (international, commercial) Bill on London, but also left the European combatant countries with a huge over-hang of government debt. Since such government debt, denominated in domestic currency, is (supposedly) default free, the banks in such countries had more than a sufficiency of 'high quality' assets which the CB could rediscount without loss. The problems that arose in the 'Great Depression were of insolvency, arising out of credit risk, rather than of illiquidity. This had to be handled by governments rather than by CBs; CBs can create liquidity; they cannot create capital.

The banking crises in Europe in the inter-war period were handled in different ways in the different countries involved. In many cases this adverse experience led to the establishment of separate institutions entrusted with responsibility for bank examination and oversight. In some countries this body, and the responsibility, was allocated to, and embedded within the CB, (e.g. Italy[4], Spain, Ireland and, in so far as it was done at all, in the Netherlands (Mooij and Prast, 2003)). In several other countries the responsible prudential institution was, or became, totally separate (e.g. Canada, Germany[5], Denmark[6], Norway, Sweden and Switzerland[7]). In yet other countries, there was a (formally) separate institution, but the relevant Commission or Supervisory body had such strong links with the CB (in management, personnel, and location), that the separation was more formal than real (Belgium[8], France).

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[4] See Cope, (1938). A financial Inspectorate was created by the Law of 1926 and reaffirmed by the Laws of 1936 and 1937. This was housed in the Banca d'Italia and its head was the Governor. But especially after the laws of 1936 and 1937 overriding control of key decisions rested with (Fascist) Ministers.

[5] "When the stability of the banking system was at stake during the Great Depression of the 1930s, the power of the Reichsbank to intervene in the management of this crisis was constrained by high levels of foreign debt and a system of fixed exchange rates. Consequently, the government had to intervene, acquiring substantial shareholdings in the problem banks. In 1961, the government founded the Federal Banking Supervisory Office as an independent institution responsible to the Minister of Finance, establishing the separation of monetary and banking supervision functions." Kahn and Santos (2007), p. 190. Also see Dark (1938).

Dark notes that the Banking Act of 1934 led to a system of regulatory/supervisory control, 'through a Supervisory Board (Aufsichtsamt für das Kreditwesen) and a Banking Commissioner (Reichskommisar für das Kreditwesen)', p. 199. Initially this was 'established at the Reichsbank', p. 218, and headed by the President of the Reichsbank Directorate, but in 1938 this role reverted to the Ministry of Finance, see Grossman, (2006).

[6] See Cope (1938). In the Nordic countries, Denmark, Norway and Sweden, an Inspectorate of Banks was set up, quite early in the 20th century, separate from the Central Bank.

[7] See Allen, (1938). He wrote, pp 369-370, "The Banking Commission itself, while a state-created organisation, is not a government department, and is claimed to be free of 'red tape' and to constitute a supple instrument of control. The state itself, and incidentally the central bank (although this latter point is not emphasised in the official literature), avoid responsibility. This, at least, is the published opinion of the legislators, but one cannot see how the state can avoid responsibility in a sphere in which it has undertaken to legislate."

[8] See Witheridge, (1938). The key reform of the Law of September 1935 establishing the Commission Bancaire. "It is intended that the Commission shall work in close co-operation with the

In so far as there was any common denominator to the choice between having a completely separate banking inspectorate and one housed in the central bank, it may have depended on the degree of distrust of the centralisation of power. In countries with a tradition of a separation of powers, (Switzerland, the Nordic countries, Canada), the Inspectorate was separate. In more unitary, centralised (and bigger) countries, the prudential authority became part of the central bank; indeed in fascist countries it became eventually transferred into the Ministry of Finance, see also Grossman (2006).

So there was no common historical tradition of the CB acting as banking supervisor. Moreover, in the next 35 years, from about 1935 until about 1970, the need for the exercise of bank supervision fell into abeyance. A key feature of these decades was the absence of banking crises, as evidenced by Figure 1, taken from Bordo et al. (2001). In the aftermath of the Great Depression, interest rates became low and stable, and bankers more cautious. The onset of World War II led to a further expansion of government debt, much of which was held in the banking sector. The need to make room for such debt, and the rise of socialist (command and control) ideology, led to the imposition of direct credit controls. Such controls, in the context of post-war rebuilding and balance of payments problems, generally directed such limited credits to the private sector to the largest, long-established, manufacturing and export sectors. This was not, in general, an efficient way to allocate scarce capital,

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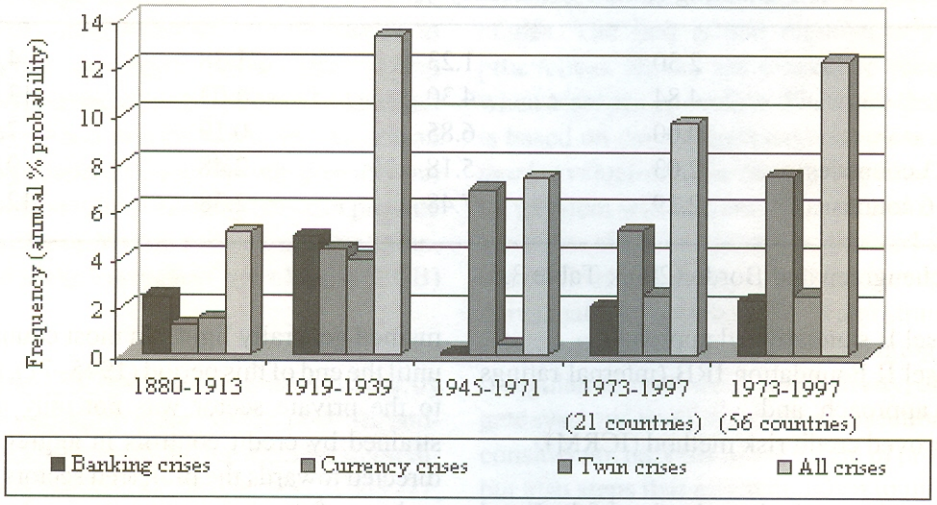
National Bank…", p. 102, and "their remuneration is… paid in the first instance by the National Bank,", p. 197.

but it did have the merit that banks subject to such direct controls bore little credit risk, and were predominantly safe (somewhat akin to nationalised utilities).

Figure 1
Crisis Frequency



Such, somewhat artificial, stability came to an end in the late 1960s and 1970s. A restoration of faith in the operation of free markets, the liberalisation of direct controls and the continuing improvement of (international) communications, all led to conditions in which banks were able to choose differing strategies, some of them riskier. In international finance, the euro-dollar market emerged, and the ability of financial institutions to use this as a vehicle for avoiding exchange controls helped to lead to the breakdown of the Bretton Woods pegged exchange rate system. In national financial systems fringe banks (and non-bank financial institutions) emerged to exploit business opportunities that the main commercial banks were prevented from entering by direct credit controls. This disintermediation into uncontrolled, and sometimes less reputable, institutions led to inherent weakness, e.g. the British fringe bank crisis (1973/74). This in turn generated pressures to dismantle the prior direct

controls, freeing banks to decide on the disposition of their portfolios. But for the prior 35/40 years bankers had had relatively little experience or training in risk assessment. And with the macro-economic conjuncture becoming more volatile in the late 1960s and 1970s, it is no surprise that banks, and banking systems, similarly became more unstable.

As already noted, the institutional structure of banking supervision at this juncture was extremely diverse, with CBs sometimes playing no supervisory role and sometimes having full responsibility for bank supervision. But whatever their supervisory role, CBs must have a functional concern and an operational role in the maintenance of systemic stability of the banking and payments' system, and for the resolution of financial crisis, should such stability be threatened. This latter consideration implies that CBs will want, and need, to play a continuing role in designing the regulations (rules) under which the banks operate, even if the supervision of banks, (that is checking that the rules are actually observed and imposing sanctions when they are not), is conducted by a separate institution. The importance and relevance of so distinguishing between regulation and supervision is emphasised in Lastra (1996, Chapter 2, and 2006, Chapter 3).

The fact that payments are finally settled in transfers of a CB's own liabilities gives it a necessary role in overseeing a country's payments and settlements systems, both internally and externally (e.g. in FX markets, CLS, Target, Swift, etc.). Somewhat more arguably, this may also extend to a concern with the risk management and payment and settlement systems of the other major financial markets (for bonds, equities and, perhaps, commodities) within its purview. A CB has to be concerned

with stability in monetary systems, primarily overall price stability, but inevitably including financial market stability more widely. After all, a CB usually seeks to maintain price stability by (money) market operations, (to sustain some chosen level of interest rates), and such market operations will be impeded and less effective if such markets have become disturbed and subject to panics. Neither its (money) market operations nor its macro-economy policy objectives (price stability) will be achieved smoothly if financial institutions and markets are in a state of crisis.

Moreover there is no other institution, besides the CB, that can create liquidity quickly in a crisis, and injections of liquidity are frequently a prerequisite for crisis management. Alternatives have been tried. One such example is a consortium of commercial banks, acting together in their role as managers of a Clearing House, (see Timberlake, 1984). But historical experience, notably in the USA, showed that their ability to stem a crisis was limited and subject to commercial conflicts of interest. Another possibility is for the government to act on its own, and some such government action may indeed become necessary when (some of) the banks involved are (probably) insolvent. But such government action has its own disadvantages, of delay, of (potential) corruption and favouritism; and the intermediation in the process of a disinterested and professional CB is comparatively preferable.[9]

[9] Indeed, direct government intervention in banking has complicated the operation of regulation and supervision in numerous ways, whether such supervision is carried out by the CB or by a separate body. In many countries, e.g. India, the government is the owner of a large segment of the commercial banking system. In such cases the supervision of such banks may not be allocated to the bank supervisor, as was the case until recently in Brazil, or constrained in various other ways. For this, and other, reasons government ownership of banks has been (statistically significantly) related to (contagious) failure, (see Barth, Caprio and Levine, 2005).

Furthermore, government guaranties (explicit or implicit) of banks have been an important characteristic of banking in Germany and some other European countries. Thus the state guarantees that public sector banks in Germany have enjoyed – Sparkassen and Landesbanken – have only been phased out recently. Such guarantees distort banking markets, and their effect on relative competitiveness may weaken the rest of the banking system.

In a recent paper, his inaugural lecture, Buiter (2006) has suggested that, not only should the responsibility for banking supervision be hived off to a separate supervisory body, but also that that body be given sufficiently large overdraft facilities (with the CB) to undertake liquidity injections attendant on crisis management on its own. Our response to that is that the supervisory body would then become the de facto CB, and the other body setting (nominal) interest rates would just be a macro-economic committee (not a Bank of any kind). It is, perhaps, arguable that the macro-economic function of a CB should be separated from the banking and stability functions of a CB, and transferred to a Committee of 'wise men', of professional economists; this does seem to be the direction of current trends, but we doubt whether it is really possible, or desirable, to try to separate macro-economic stability issues from financial market (and institutional) stability matters.

That said, it is surely possible to separate operational oversight over banking supervision from responsibility for overall market and systemic stability, if only because this is what has happened in many countries. But when concern about banking, and financial, stability came to the fore again in the late 1960s and early 1970s, it often did so in an international context, for example with Bankhaus Herstatt and the euro-dollar market in 1974. There was no world-wide forum then established for bank supervisors to meet and discuss common problems, though within the EEC an autonomous initiative of supervisory officials had set up the Groupe de Contact in 1972. By contrast, the CBs did have an international forum in being, in the guise of the G-10 Governors' Committee at the Bank for International Settlements in Basel. In

1974/75 they co-opted the banking supervisors, whether CB based or not, into the new Basel Committee on Banking Supervision, but under overall CB direction.

With the international aspect of crisis management having become more important, the CBs became the dominant players in this field. Although there were no cases (that we can recall) of previously independent supervisory bodies being folded back into the CB, the 1970s and 1980s became decades during which CB responsibility for setting financial regulation, e.g. the Concordat and Basel I, and for operational control of crisis management became institutionalised and extended.

The high point, apogee, of this shift of regulatory/prudential functions towards CBs was reached about the end of the 1980s. This was marked by four events; these were:- the successful passage of Basel I in 1987/88; the adoption of a new regime of Inflation Targetry, together with operational independence, in New Zealand in 1988/89; the gradual blurring of the commercial dividing lines between commercial and investment banking and insurance, with the rise of universal banking; and finally the growing importance of financial/pension arrangements for a wealthier and longer-lived population.

Taking these four developments in reverse order:- First, the growing importance of finance/pensions to a growing swathe of the population enhanced its political salience. This meant that conduct of business/consumer protection issues would tend to loom even larger in (retail) regulatory/supervisory matters, (see Westrup, Chapter 9 in Masciandaro and Quintyn, 2007). CBs, with a primarily economic rather than legal/accounting tradition, and a comparatively small staff, were not well placed to do

this kind of work, and did not wish to take it on. Second, the blurring of commercial divisions again implied that CBs would have to extend their field of professional competence, (and perhaps the safety net), to a wider range of institutions (markets) than those with which they had been historically involved. Only in a few, mostly small countries such as Ireland and Singapore, was responsibility for supervision of the full range of financial institutions vested in the CB.

Third, inflation targetry involved not only making price stability the primary objective, but also giving the CB operational independence (from government) to vary interest rates so as to achieve that end. For most CBs, who had become increasingly subservient (to governments) under the requirements of WWII and post-war socialism, this was a marked recovery of power. Moreover, the successful pursuit of price stability is much facilitated by the credibility of the CB, so that expectations of future inflation should remain anchored. But financial intermediation is a risky business, and there will always be shady and fraudulent fringes of the financial system; 'a fool and his money are soon parted'. Any regulatory/supervisory system that attempts to prevent all risk and any fraud will stifle enterprise and be impossibly heavy-handed. But the supervisor will take the blame for any crises/frauds as do occur. Frequently supervisory authorities will be simultaneously accused of being both too restrictive and also too lax to prevent failures. Being a supervisor, therefore, entails considerable reputational risk. A CB which is trying to maintain credibility, in order to assist its primary role of hitting an inflation target, might regard being also allocated a supervisory function as a poisoned chalice.

Moreover, the combination of operational independence, to achieve price stability, together with supervisory oversight over the whole financial system, might seem to concentrate excessive power in the hands of unelected CB officials. Would that be entirely consistent with democratic government? There is, perhaps, some tendency for governments to combine the award of operational independence to a CB with the removal of peripheral roles, such as banking supervision, debt management, etc., as occurred in the UK in 1997. This, it may be claimed, enhances CB focus on its main responsibility, and lessons potential conflicts of interest, (and incidentally will please the Ministry of Finance, which normally has an underlying rivalry with the CB). Putting the same issue around the other way, a CB that loses its macroeconomic monetary policy role, as the National Central Banks (NCBs) did within the European System of Central Banks (ESCB), will struggle much harder to retain its remaining supervisory functions; there are many current examples of this amongst the NCBs.

Finally, Basel I represented a high-water mark for the application of traditional CB methods for achieving international convergence on fairly simple, best-practice (capital adequacy) requirements. Thereafter additional bodies, both specialist supervisory authorities and governmental bodies, (international such as the EC and IMF as well as national), wanted to become involved in the process; moreover the procedures for assessing and estimating risks and regulatory requirements became much more complex. In effect a whole new technical profession of risk assessment and risk management has developed. The micro, financial skill base of this profession is quite different from the macro-economic monetary policy skill base of those undertaking the central function of a Monetary Policy Committee.

For all these various reasons, the tide which had been pushing additional regulatory/supervisory functions and responsibilities towards CBs in the 1970s and 1980s reversed and ebbed away in the 1990s. The direction was now clearly towards the establishment of specialist, universal, separate (from the CB) financial supervisory authorities, FSAs, as has occurred in Germany, Japan, Korea and the UK, following on from the Scandinavian countries where this had already taken place.

Yet this tide is not universal, nor overwhelming. There are a variety of countervailing considerations. First, for the reasons already adduced, a CB has to be involved in crisis management in its own bailiwick. If so, it must co-operate and co-ordinate with its FSA.[10] But will not such co-operation and co-ordination work best, (and crisis management be done most efficiently), if the two institutions are jointly run, with some degree of common management, possibly common location, and frequent exchange of personnel. Put another way, most CBs are still treated as being responsible for systemic stability. But exactly what can, and should, this mean if all responsibility for financial supervision is hived off to a separate institution? In our view the appropriate (institutional) functions of a CB, charged with maintaining systemic stability, in a country with a separate, fully-fledged FSA, are not yet clearly and firmly delineated.

Moreover, financial regulation does not have one single purpose, or objective, to be attained with one set of instruments. While the divisions of business line (between commercial banks, securities houses and (life) insurance companies) have become

[10] In the UK, after the transfer of supervisory responsibilities to the FSA, the co-ordination of crisis management is undertaken via a standing Tripartite Committee consisting of the Treasury, the Bank of England and the FSA. Both FSA and Bank are represented on the Basel Committee on Banking Regulation. General co-ordination is further enhanced by cross-membership on the governing boards of the two institutions.

utterly blurred, the separation between the objectives of consumer protection and conduct of business concerns, mostly in retail markets, on the one hand and systemic stability, crisis management, issues on the other remains. Inevitably conduct of business issues will be much more frequent in occurrence, and require many more staff, than for systemic stability. Also the skills of the staff dealing with such issues will diverge, involving lawyers and accountants for conduct of business, and (financial) economists for systemic stability. It is also arguable that conduct of business concerns will occur primarily in retail markets, and will tend to require more detailed rules and regulations, than systemic issues, which may occur more often in wholesale markets, and may be handled more expeditiously by the application of principles-based rules.

Bundling these two main functions together in a single, universal FSA could, perhaps, lead to the systemic function being swamped by the sheer number of those involved in the conduct of business function. Essentially economic issues pertaining to systemic stability could be decided by committees dominated by those with legal and accountancy training, (see Goodhart, Schoenmaker and Dasgupta, 2002). Yet the social welfare benefits of preventing, and successfully resolving, financial crises greatly outweigh the gains from better customer protection by all accounts. There is, therefore, a prima facie case at least for a 'twin peaks' approach, whereby the conduct-of-business regulatory/supervisory function is separated from the systemic stability role (see Taylor 1995, 1996, and Taylor and Fleming, 1999). This is now done in Australia and the Netherlands. Clearly no CB would want to be involved in the conduct of business specialist exercise. In practice, the body given responsibility for systemic stability issues has been located outside the CB both in Australia, where

it is held in a separate institution (APRA) and in the Netherlands, [where it has been embedded in the Ministry of Finance [check]]. Nevertheless there could certainly be a case for reducing the distance between the CB and the specialist systemic body, if not for reinserting it altogether within the CB.

For all these various reasons, the question of the appropriate institutional structure of financial regulation and supervision remains in a state of flux. Unlike the general consensus about the way in which monetary macro-economic policy should be run, with an operationally independent CB aiming primarily for price stability, there is no such consensus, either in theory or in practice, for the appropriate institutional setting for maintaining financial stability. There was a tide towards establishing separate, universal FSAs in the 1990s, but that tide was not all encompassing; the Federal Reserve System successfully beat off its encroachment in the USA. There is considerable discussion of the (prior) determinants of the various alternative institutional structures, and of what might work best, (see Masciandaro and Quintyn 2007, and the bibliography therein), but little in the way of general conclusions. This is a field in which there remains much to play for.

B. Is there a Theoretical Basis for the Conduct of Financial Stability?

In the ECB Financial Stability Review (December, 2005, p. 131) it is stated bluntly that, "Financial stability assessment as currently practiced by central banks and international organisations probably compares with the way monetary policy assessment was practiced by central banks three or four decades ago – before there was a widely accepted, rigorous framework."[11] It should be no surprise that the analysis of financial stability issues lags behind that of monetary policy. The former is just that much more difficult to model. In particular, financial (in)stability is generated by the probability of default (PD) and bankruptcy. In contrast, most mainstream macro and monetary analysis makes the assumption that no economic agent ever defaults. This latter assumption enormously simplifies modelling and allows for the use of representative agents, whereas a considered treatment of PD must face heterogeneity, i.e. some agents follow a riskier strategy with a higher PD than others.

Given the inherent implausibility of a world without default, it is quite remarkable how much such current mainstream models can achieve in monetary and macro-economic analysis and policy prescription; Woodford's, Money and Interest (2003) is an icon in this respect. Whether, or not, such monetary policy analysis would retain all its validity in a more realistic setting, it is just not possible to approach an analysis of financial stability without addressing bankruptcy, PD, and the heterogeneity of agents, both banks and their clients, head on.

[11] Also see Kahn and Santos, (2007), and the literature review therein.

There are two main approaches to a theoretical assessment of the probability of default in the literature. The first was initiated by Diamond and Dybvig (1983), and has been extended most notably by Allen and Gale, (see Understanding Financial Crises, 2007, and the references therein). In this model the uncertainty is generated by lack of knowledge about when depositors may need to withdraw their money from the bank. This risk is exacerbated by the illiquidity of (some of) the banks' assets. Although the ultimate return from such illiquid assets is, (in most of these exercises), assumed to be known and certain, there is a friction in these models whereby early redemption of such illiquid assets can only be done at a cost, so much so that the commercial bank may then not be able to honour its pledge to redeem all its deposits (plus stated interest) at par. Because of the sequential repayment convention, (first come, first served), when the probability of failure to repay rises above some small probability, a run ensues, and the bank(s) default.

In this approach, insolvency derives from illiquidity. It is certainly true that at a time when financial institutions are under strain, and need to raise extra cash, there can be severe stress in asset markets, and asset prices can fall sharply, (Cifuentes, et al. (2005), Shin (2005a and b). This is an externality whereby pressure to realise assets in one segment of the financial system can impact on every other agent by lowering asset prices and thereby weakening their balance sheet strength.

However, it is exactly such fluctuations in the demand for money (liquidity) that central banks are meant to offset and to meet. Recall that the Federal Reserve System was founded, in 1913, to provide an 'elastic currency', as noted in Lastra, 2006, pp 34/35. A central bank has two core purposes, to maintain not only price stability but

also the systemic stability of the banking and payments' systems. In a separate paper on 'The Optimal Monetary Instrument' (2007), we demonstrate that, when the central bank pegs interest rates in the short run, (rather than the monetary base), thereby allowing the money stock to fluctuate endogenously in response to such shocks in the demand for money, their damaging effect on the system, (in terms of interest rates, profits and default rates), falls to a small fraction of the effect when the monetary base is fixed.

Indeed, in most examples of this genre of literature there is no central bank in the model. It is conspicuous by its absence. We would argue that, in most normal circumstances, an efficiently managed central bank should be able to counteract this kind of crisis. There is, however, one set of conditions, when the domestic agents need foreign currency liquidity, when the central bank's ability to help may be strictly limited, (by the extent of its foreign currency reserves). Thus, we would agree that the Diamond/Dybvig and Allen/Gale analysis is applicable to the problems of those developing countries whose borrowing (and financial system) is largely denominated in foreign currencies (e.g. US dollars).

There is, however, one particular advantage that this genre of crisis literature possesses. This is that in such models generally either all depositors run and then default becomes certain, or nobody runs and the bank(s) remain solvent. Thus there is little need to model the probability of default, (PD). This contrasts with the main other branch of the literature, and most practical concerns, where default arises from declines in the value of bank assets, e.g. arising from credit or market risk. The main uncertainty in this latter genre is about the value of bank assets, insolvency rather than

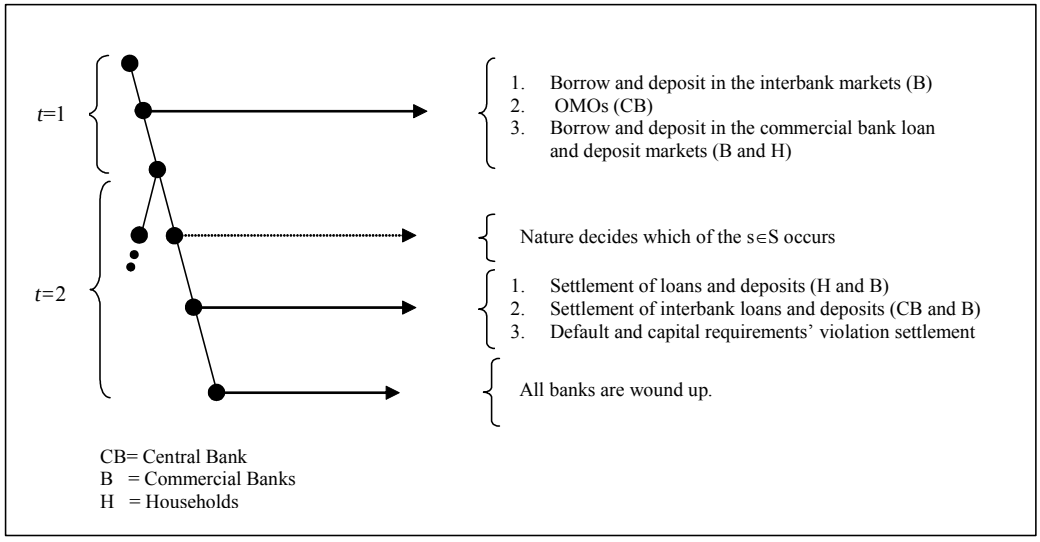
illiquidity. Of course these two, insolvency and illiquidity, go hand in hand, since depositors will flee, and potential lenders will refrain, from a bank perceived as potentially in trouble. So the first sign of potential insolvency is often actual illiquidity, a syndrome which causes problems for CBs.

A problem for modelling such causes of systemic crisis is that incorporating PD (and loss given default, LGD) into a theoretical model is hard to do since default is by definition a discontinuity. In our own view, as expressed in Goodhart et al. (2006) "A model of financial fragility", the best way to do so that has yet been devised was developed by Dubey et al. (2005) and Shubik and Wilson (1997). Shubik sees every agent as choosing a strategy, depending on his/her risk aversion, which will generate differing PDs, and losses given default (LGDs), depending on the state of the world. There have to be penalties for bankruptcy, which penalties may be non-pecuniary; otherwise no one would ever repay and no one would lend. The penalties cannot be extreme, or no one would borrow.

Indeed, the probability of default (PD) is a key concept in any analysis of financial fragility. It is, of course, central to the Basel II exercise. At the more formal level, modelling of default, following on from the approach pioneered by Martin Shubik and his co-authors, is the crucial element for the analysis of financial fragility that we have been developing. (See Tsomocos, 2003a, Tsomocos, 2003b; Goodhart et al., 2004, 2005, 2006a,b; Aspachs et al., 2007; Tsomocos and Zicchino, 2005).

Our model incorporates heterogeneous banks and capital requirements in a general

equilibrium model[12] with incomplete markets, money and default. It extends over two periods and all uncertainty is resolved in the second period. Trade takes place in both periods in the goods market. In the first period agents also borrow from, or deposit money with banks, mainly to achieve a preferred time path for consumption. Banks also trade amongst themselves, to smooth out their individual portfolio positions. The Central Bank intervenes in the interbank market to change the money supply and thereby set the interest rate. Capital adequacy requirements (CARs) on banks are set by a regulator, who may, or may not, also be the Central Bank. Penalties on violations of CARs, and on the default of any borrower, are in force in both periods. In order to achieve formal completeness for the model, banks are liquidated at the end of the second period and their profits and assets distributed to shareholders. Figure 2 makes the time line of the model explicit.



In the first period trades by all agents take place against a background of uncertainty

[12] For an extensive description of this variant of the model see Appendix A and Goodhart et al. (2005).

about the economic conditions (the state of nature) that will prevail in the second period. Agents are, however, assumed to have rational expectations, and to know the likelihood of good or bad states occurring when they make their choices in period one. In period two the actual economic conjuncture is revealed and all uncertainty is resolved.

The model incorporates a number of distinct, i.e. heterogeneous, commercial banks, each characterised by a unique risk/return preference and different initial capital. Since each bank is, and is perceived as being, different, it follows that there is not a single market for either bank loans or bank deposits. In addition, we introduce limited access to consumer credit markets, with each household assigned (by history and custom) to borrow from a predetermined bank. This feature allows for different interest rates across the commercial banking sector. In sum, multiple credit and deposit markets lead to different loan rates among various banks and to endogenous credit spreads between loan and deposit rates.

Individual non-bank agents are also assumed to differ in their risk attitudes and hence in their preferences for default. We model the incentive for avoiding default by penalising agents and banks proportionately to the size of default. Banks that violate their capital adequacy constraint are also penalised in proportion to the shortfall of capital. Both banks and households are allowed to default on their financial obligations, but not on commodity deliveries.

Our specification of the banking sector involves three banks, and can, in principle, be applied to the banking system of any country, or region. Banks γ and δ can represent

any two of these individual banks, or groups of banks, whereas bank τ represents the aggregation of the remaining banks. We have done calibration exercises in which banks γ and δ were be chosen specifically to represent two actual UK banks (Goodhart, Sunirand and Tsomocos, 2005).

All banks in the model, $b \varepsilon B = \{\gamma,\delta,\tau\}$, are assumed to operate under a perfectly competitive environment (i.e. they take all interest rates as exogenously given when making their optimal portfolio decisions). The structure of their balance sheets is given below;

Assets	**Liabilities**
Loans to agents	Deposits from Mr. Φ
Interbank deposits	Interbank borrowing
Market book	**Equity**
	Others

We assume that all banks endogenise their decisions in the loan, deposit and interbank markets.[13] The remaining variables are treated as exogenous.[14] We further assume that banks can default on their financial obligations, subject to default penalties set by the regulator. Thus, by varying the penalties imposed on default from 0 to infinity, we can model 100% default, no default or an equilibrium level of default between 0 and

[13]The modelling of the banking sector follows Shubik and Tsomocos (1992) and Tsomocos (2003a and b).

[14]As explained in Goodhart, Sunirand and Tsomocos (2005), we cannot endogenise banks' decisions on market book or equity. Since the model has two states in the second period and one unconstrained asset, (i.e. the interbank market investment), adding another unconstrained asset would make the markets complete.

100%.[15] At first sight, this `continuous' default rate approach may seem problematic since in reality banks either repay in full at the due date or are forced to close down. However, we interpret a bank's default rate in our model as a *probability* that such bank *chooses* to shut down, and hence in the short run to default *completely* on its financial obligations. Therefore, a bank's decision to increase its default rates is isomorphic to its decision to adopt a riskier position in pursuit of higher expected profitability.[16] With a large number of agents, as in a competitive equilibrium, conditions where everyone defaults on, say, 5% of their liabilities are equivalent to those where 5% of agents default on all their debts. This, however, is not the case when there are only a few agents in a concentrated field. If there are, say, only two agents in the field, and their failures are independent of each other, then in 0.25% of all cases there will be 100% default, in 9.75% of cases 50% default, and in 90% of cases no default, which is clearly vastly different from a 5% default rate amongst a large number of agents.

In most countries banking is a concentrated service industry. Moreover, reputational effects and cross-default clauses, amongst other things, mean that banks cannot default partially and remain open. If they cannot meet their payment obligations, (except under force majeure as in 9/11), they have to close their doors. Except when such closed banks are tiny, such closure does not however, in almost all cases, then turn into permanent liquidation. Effectively almost all banks are restructured, in some

[15]This modelling of default follows Shubik and Wilson (1977).

[16]For more on this issue, see Tsomocos and Zicchino (2005).

countries via a `bridge bank' arrangement[17], in others by what is effectively nationalisation, and shortly re-open, with the extent of short-fall of assets distributed amongst the various creditors, (the `haircut' in the American phrase), the shareholders and taxpayers depending on the deposit insurance arrangements, bank bankruptcy laws and political pressures. In this latter sense, even though the banking system is concentrated, and banks have to close when they cannot meet due payments, it is perfectly valid to assess strategies as bringing about possible conditions in which a bank defaults by, say, 5% to all depositors, because that would be the effective loss of funds, or haircut, in the event of a bad state of the world.

Finally, as in Bhattacharya et al. (2003), we make the simplifying assumption that banks' default rates in the deposit and interbank markets are the same, i.e. that banks are restricted to repay all their creditors in the same proportion.

Banks can also violate their capital adequacy requirement, subject to capital requirement violation penalties set by the regulator. In principle, each bank's *effective* capital to asset ratios may not be binding, (i.e. their values may be above the regulator's requirement), in which case they are not subject to any capital requirement penalty. However, in our calibration exercises, we assume that each bank wants to keep a buffer above the required minimum, so that there is a non-pecuniary loss of reputation as capital declines; in this sense the ratios are *always* binding. Put differently, we assume that banks' self-imposed ideal capital holdings are always above the actual values of all banks' capital to asset ratios. Given this assumption, we can rule out corner equilibria and therefore focus our analysis entirely on well-defined

[17] This is only legally possible in a few countries, such as the USA. In many others liquidation is the only option foreseen in the bankruptcy laws. Given the social costs involved in the latter, governments (and supervisory authorities may be tempted to exhibit undue forbearance.

interior solutions whereby banks violate their enhanced capital requirements. We assume that penalties are linear as capital declines from its ideal level.[18]

We have used this model for simulation (Goodhart, Sunirand and Tsomocos, 2004), calibration (Goodhart, Sunirand and Tsomocos, 2005), and to develop a quantified metric of financial stability, (Aspachs, Goodhart, et al. 2006 and 2007). We certainly would not claim that financial stability, and PD, must be modelled in this manner; indeed like any model it has numerous deficiencies, on some of which we are continuing to work, in particular on the attempt to model liquidity within this framework. But we do believe that any serious model of financial fragility has to include and be centred around measures of PD, and that our own approach makes a start in that direction, a start which we hope others will soon overtake.

One reason for developing models of this kind is that they could be used to overcome one of the main weaknesses of the current methodologies for assessing systemic stability. Such methodologies are often based on stress, or scenario, tests. In such tests, a scenario is assumed wherein some bad state occurs, and the banks are then asked what that might do to their profitability and capital adequacy. But this usually measures only a first round effect. If such bad outcomes did happen, the banks would often respond to these first round effects by reducing their loan extension and becoming themselves more conservative. This would have second round effects on asset prices, risk premia, and real economic activity, usually then amplifying the original first-round effect. While it is possible, in principle, to iterate through various

[18]In practice, there will be some non-linearity as capital falls below its required minimum, but this is just too complex to model at this stage.

rounds of effect in collaboration with the (main) commercial banks, in practice this is virtually never done. Instead, using a (centralised) model, such as ours, does enable one to estimate the equilibrium outcome; that is one of its main purposes. Of course our model depends on several variables that are difficult to observe, such as the degree of risk aversion and the risk strategies being adopted by both banks and their borrowers. But these are key fundamental elements in the determination of systemic stability. As all sensible CB officials know, it is just when (over) confidence during periods of boom and expansion leads banks and their borrowers to accept (or ignore) more risk in pursuit of higher returns that the seeds of the next crisis are sown. It happens all the time.

C. Conclusions

It is rare to recognize that one is living in a golden age. It is usually only by contrast to a miserable present that the past seems, often mistakenly, golden. Yet much of the world, including Europe, North America, and most of Asia, has been living in such a golden age in the last 15 years with low, and stable, inflation and steady growth. Much of this, though how much remains debatable, is due to improved macro-monetary policies, themselves a function of the new consensus of how such policies should be conducted. As the other papers in this symposium demonstrate, the consensus is not total, and there remains much to debate. But the range of agreement on the macro-monetary side is far greater than the remaining areas of disagreement.

The same cannot be said about the second core purpose of CBs, of maintaining systemic stability. The practical record remains patchy. There have been many more

banking crises, than in the quiet years of 1935-65. Many cases of potential bank failures, e.g. in China and Japan, have been pushed under the rug by throwing tax-payers' money at the problem. Difficulties in achieving good outcomes have been partly responsible for experimentation in the organisation and structure of the regulatory/supervisory system. As recorded in Section A such experimentation has not, at any rate so far, resulted in any consensus on the best approach for this purpose. The procedures for doing so are further complicated by the fact that banking and finance are becoming increasingly international in structure, whereas regulation/supervision has to be based on a specific legal structure, which is inherently national in coverage (as emphasized in Lastra, 2006); likewise crisis management depends primarily on national fiscal purses.

The agreement on the appropriate macro-monetary policies is based on an underlying consensus on the basic theoretical framework. There is no such consensus and no such framework, (and little enough basic theory), that relates to systemic stability. This is partly because such theoretical analysis is more difficult and complex, than that underlying macro-monetary policies. We have argued here that any serious theory of systemic (in)stability has to focus on PD, yet PD is assumed away entirely (by the transversality condition) in the macro consensus model.[19] We end by presenting a (somewhat potted) version of our own attempt to take default seriously. It is at best a start, mais c'est le premier pas qui coute.

[19] Thus several critical macro-economists regard this consensus model as suitable only for 'fair weather' policy-making.

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Appendix

The model by Goodhart, Sunirand and Tsomocos (2005)

The model has three heterogeneous banks, $b \in B = \{\gamma, \delta, \tau\}$, four private sector agents, $h \in H = \{\alpha, \beta, \theta, \phi\}$, a Central Bank and a regulator. The time horizon extends over two periods, $t \in T = \{1, 2\}$ and two possible states in the second period, $s \in S = \{i, ii\}$. State i is a normal/good state and occurs with probability p while state ii represents an extreme/crisis event.

Individual bank borrowers are assigned during the two periods, by history or by informational constraint, to borrow from a single bank: agents $\alpha, \beta,$ and θ borrow from banks $\gamma, \delta,$ and τ, respectively. The remaining agent, ϕ, represents the pool of depositors in this economy who supply funds to every bank. This limited participation assumption implies multiple active markets for deposits (by separate bank) and for loans (by borrower and bank). In addition, we assume a single, undifferentiated, interbank market where deficit banks borrow from surplus banks, and wherein the Central Bank conducts open market operations (OMOs).

At $t = 1,$ loan, deposit and interbank markets open. Banks decide how much to lend/borrow in each market, expecting any one of the two possible future scenarios to occur. The Central Bank conducts OMOs in the interbank market. At $t = 2$ all financial contracts are settled, subject to any defaults and/or capital requirements' violations, which are then penalised. At the end of the second period all banks are wound up.

The interbank net borrowers' (banks γ and τ) optimisation problems

Bank $b \in \{\gamma, \tau\}$ maximises its payoff, which is a quadratic function of expected profits in the second period minus non-pecuniary penalties that it has to incur if it defaults on its deposit and interbank obligations. It also suffers a capital violation penalty proportional to its capital requirement violation. Formally, the optimisation problem of bank $b \in \{\gamma, \tau\}$ is as follows:

$$\max_{\bar{m}^b, \mu^b, \mu_d^b, v_s^b, s \in S} \Pi^b = \sum_{s \in S} p_s [\pi_s^b - c_s^b (\pi_s^b)^2] - \sum_{s \in S} p_s \begin{bmatrix} \lambda_{ks}^b \max[0, \bar{k}^b - k_s^b] + \\ \lambda_s^b [\mu^b - v_s^b \mu^b] + \lambda_s^b [\mu_d^b - v_s^b \mu_d^b] \end{bmatrix} (1)$$

subject to

$$\overline{m}^b + A^b = \frac{\mu^b}{(1+\rho)} + \frac{\mu_d^b}{(1+r_d^b)} + e_0^b + Others^b \qquad (2)$$

$$v_s^b \mu^b + v_s^b \mu_d^b + Others^b + e_0^b \leq v_{sb}^{h^b}(1+r^b)\overline{m}^b + (1+r^A)A^b,\ s \in S \qquad (3)$$

where,

$\pi_s^b = \Delta(3)$

$e_s^b = e_0^b + \pi_s^b, s \in S \qquad (4)$

$$k_s^b = \frac{e_s^b}{\overline{\omega} v_{sb}^{h^b}(1+r^b)\overline{m}^b + \tilde{\omega}(1+r^A)A^A}, s \in S \qquad (5)$$

(4)

and

$\Delta(x) \equiv$ the difference between RHS and LHS of inequality (x)

$p_s \equiv$ probability that state $s \in S$ will occur,

$c_s^b \equiv$ coefficient of risk aversion in the utility function of bank $b \in B$,

$\lambda_{ks}^b \equiv$ capital requirements' violation penalties imposed on bank $b \in B$ in state $s \in S$,

$\overline{k}^b \equiv$ capital adequacy requirement for bank $b \in B$,

$\lambda_s^b \equiv$ default penalties on bank $b \in B$,

$\mu^b \equiv$ amount of money that bank $b \in \{\gamma, \tau\}$ owes in the interbank market,

$\mu_d^b \equiv$ amount of money that bank $b \in B$ owes in the deposit market,

$v_s^b \equiv$ repayment rates of bank $b \in B$ to all its creditors in state $s \in S$,

$\overline{m}^b \equiv$ amount of credit that bank $b \in B$ extends in the loan market,

$A^b \equiv$ the value of market book held by bank $b \in B$,

$e_s^b \equiv$ amount of capital that bank $b \in B$ holds in state $s \in \{0\} \cup S$,

$Others^b \equiv$ the `others' item in the balance sheet of bank $b \in B$,

$r^b \equiv$ lending rate offered by bank $b \in B$,

$r_d^b \equiv$ deposit rate offered by bank $b \in B$,

$\rho \equiv$ interbank rate,

$r^A \equiv$ the rate of return on market book,

$v_{sb}^{h^b} \equiv$ repayment rates of agent $h^b \in H^b = \{\alpha^\gamma, \beta^\delta, \theta^\tau\}$ to his nature-selected bank $b \in B$ in the consumer loan market,

$\overline{\omega} \equiv$ risk weight on consumer loans, and

$\widetilde{\omega} \equiv$ risk weight on market book.

Equation (2) implies that, at $t = 1,$ the assets of bank $b \in \{\gamma, \tau\}$, which consist of its credit extension and market book investment, must be equal to its liabilities obtained from interbank and deposit borrowing and its initial equity endowment, where ` $Others^b$ ' represents the residual. Equations (3) and (4) then show that, dependent on which of the $s \in S$ actually occurs, the profit that bank b incurs in the second period is equal to the difference between the amount of money that it receives from its asset investment and the amount that it has to repay on its liabilities, adjusted appropriately for default in each market. As shown in equation (4), the profit earned is then added to its initial capital, which in turn becomes its capital in the second period. Finally, equation (5) implies that the capital to asset ratio of bank b in state $s \in S$ is equal to its capital in state s divided by its risk-weighted assets in the corresponding state.

The interbank net lender's (bank δ) optimisation problem

Bank δ , unlike the other two banks, is a net lender in the interbank market. Thus it suffers only a default penalty in the deposit market. Formally, bank δ 's optimisation problem is as follows:

$$\max_{\overline{m}^\delta, d^\delta, \mu_d^\delta, v_s^\delta, s\in S} \Pi^\delta = \sum_{s\in S} p_s[\pi_s^\delta - c_s^\delta(\pi_s^\delta)^2] - \sum_{s\in S} p_s\left[\lambda_{ks}^\delta \max[0, \overline{k}^\delta - k_s^\delta] + \lambda_s^\delta[\mu_d^\delta - v_s^\delta \mu_d^\delta]\right] \quad (6)$$

subject to

$$A^\delta + d^\delta + \overline{m}^\delta = e_0^\delta + \frac{\mu_d^\delta}{(1 + r_d^\delta)} + Others^\delta$$

$$v_s^\delta \mu_d^\delta + Others^\delta + e_0^\delta \leq v_{s\delta}^{\beta^\delta} \overline{m}^\delta (1 + r^\delta) + A^\delta (1 + r^A) + \widetilde{R}_s d^\delta (1 + \rho)$$

where,

$$\pi_s^b = \Delta(7) \qquad (9)$$

$$e_s^\delta = e_0^\delta + \pi_s^\delta, s \in S \qquad (10)$$

$$k_s^b = \frac{e_s^\delta}{\overline{\omega} v_{sb}^{h^\delta}(1+r^\delta)\overline{m}^\delta + \omega \tilde{R}_s d^\delta(1+\rho) + \tilde{\omega}(1+r^A)A^\delta}, s \in S \qquad (11)$$

and

$d^\delta \equiv$ bank δ 's investment in the interbank market,

$\tilde{R}_s \equiv$ the rate of repayment that bank δ expects to get from its interbank investment, and

$\omega \equiv$ risk weight on interbank investment.

The budget set of bank δ is similar to those of the other two banks except that it invests in, instead of borrows from, the interbank market. Moreover, its risk-weighted assets in the second period, as shown in equation (11), also includes bank δ 's expected return on its interbank investment.

Central Bank and Regulator

The Central Bank conducts monetary policy by engaging in open market operations in the interbank market. It can either set its base money (M) as its monetary policy instrument, allowing the interbank rate to be determined endogenously, or it can fix the interbank rate and let its base money adjust endogenously to clear the interbank market.

The regulator sets capital adequacy requirements for all banks $(\overline{k}^b)$ and imposes penalties on their failure to meet such requirements (λ_{ks}^b) and on default on their financial obligations in the deposit and interbank markets (λ_s^b). Finally, the regulator sets the risk weights on consumer loan, interbank and market book investment $(\overline{\omega}, \omega, \tilde{\omega})$.

Household sector

Each household borrower, $h^b = \{\alpha^\gamma, \beta^\delta, \theta^\tau\}$, demands consumer loans from his nature-selected bank and chooses whether to default on his loans in state $s \in S$. The remaining agent, ϕ , supplies his deposits to each bank b. As mentioned, we do not explicitly model the optimisation problems of households but assume the following reduced-form equations.

Household borrowers' demand for Loans

Because of the limited participation assumption in every consumer loan market, each household's demand for loans is a negative function of the lending rate offered by his nature-selected bank. In addition, his demand for loans also depends positively on the expected GDP in the subsequent period. So we implicitly assume that household borrowers rationally anticipate GDP in both states of the next period, which then determines their expected future income, and adjust their loan demand in the initial period accordingly in order to smooth their consumption over time. The money demand function manifests the standard Hicksian elements whereby it responds positively to current and expected income and negatively to interest rates. In particular, household h^b 's loan demand from his nature-selected bank b , $\forall h^b \in H^b$, and $b \in B$ is as follows:

$$\ln(\mu^{h^b}) = a_{h^b,1} + a_{h^b,2} \ln[p(GDP_i) + (1-p)GDP_{ii}] + a_{h^b,3} r^b \quad (12)$$

where,

$\mu^{h^b} \equiv$ amount of money that agent $h^b \in H^b$ chooses to owe in the loan market of bank $b \in B$, and

$GDP_s \equiv$ Gross Domestic Product in state $s \in S$ of the second period .

Deposit Supply

Unlike the loan markets, we do not assume limited participation in the deposit markets. This implies that ϕ can choose to diversify his deposits with every bank. Thus, Mr. ϕ 's deposit supply with bank b depends not only on the deposit rate

offered by b but also on the rates offered by the other banks. Moreover, since banks can default on their deposit obligations, the expected rate of return on deposit investment of ϕ with each bank has to be adjusted appropriately for each bank's corresponding expected default rate . Finally, ϕ 's deposit supply is a positive function of the expected GDP. In symbols, ϕ 's deposit supply function with bank b is as follows:

$$\ln(d_b^{\phi}) = z_{b,1} + z_{b,2}\ln[p(GDP_i) + (1-p)GDP_{ii}] + z_{b,3}[r_d^b(pv_i^b + (1-p)v_{ii}^b)] + z_{b,4}\sum_{b\neq b\in B}[r_d^b(pv_i^b + (1-p)v_{ii}^b)] \quad (13)$$

where,

$d_b^{\phi} \equiv$ amount of money that agent ϕ chooses to deposit with bank $b \in B$.

Households' Loan Repayment Rates

We assume that each household's repayment rate on his loan obligation to his nature-selected bank in state $s \in S$ is a positive function of the corresponding GDP level as well as the *aggregate* credit supply in the economy. The latter variable captures the effect of `credit crunch' in the economy whereby a fall in the overall credit supply in the economy aggravates the default probability of every household.[20] Specifically, the functional form of the repayment rate of household h^b, $\forall h^b \in H^b$, to his nature-selected bank $b \in B$, in state $s \in S$ is as follows:

$$\ln(v_{sb}^{h^b}) = g_{h^b,s,1} + g_{h^b,s,2}\ln(GDP_s) + g_{h^b,s,3}[\ln(\overline{m}^{\gamma}) + \ln(\overline{m}^{\delta}) + \ln(\overline{m}^{\tau})] \quad (14)$$

GDP

As can be seen from equations (eq11) to (eq13), we have assumed that households' actions depend on their expected GDP in the second period. So, in this section we endogenise GDP in both states of the second period. We assume that GDP in each state is a positive function of the aggregate credit supply available in the *previous*

[20]Higher interest rates, given that households are liquidity constrained, ultimately increase their debt obligations in the future. Hence, defaults rise.

period. Since the Modigliani-Miller proposition does not hold in our model[21], higher credit extension as a result of loosening monetary policy, or any other shocks, generates a positive real balance effect that raises consumption demand and ultimately GDP. In particular, the following functional form for GDP in state $s \in S$ of the second period (GDP_s) holds .

$$\ln(GDP_s) = u_{s,1} + u_{s,2}[\ln(\overline{m}^{\gamma}) + \ln(\overline{m}^{\delta}) + \ln(\overline{m}^{\tau})] + u_{s,3}[\ln(e_s^{\gamma}) + \ln(e_s^{\delta}) + \ln(e_s^{\tau})] \quad (15)$$

Market Clearing Conditions

There are seven active markets in the model (three consumer loan, three deposit and one interbank markets). Each of these markets determines an interest rate that equilibrates demand and supply in equilibrium.[22]

$$1 + r^b = \frac{\mu^{h^b}}{\overline{m}^b},\ h^b \in H^b, \forall b \in B \quad \text{(i.e. bank } b\text{'s loan market clears)} \quad (16)$$

$$1 + r_d^b = \frac{\mu_d^b}{d_b^{\phi}}, \forall b \in B \quad \text{(i.e. bank } b\text{'s deposit market clears)} \quad (17)$$

$$1 + \rho = \frac{\mu^{\gamma} + \mu^{\tau}}{M + d^{\delta}} \quad \text{(i.e. interbank market clears)} \quad (18)$$

We note that these interest rates, i.e. $r^b, r_d^b,$ and $\rho,\quad b \in B$, are the *ex ante* nominal interest rates that incorporate default premium since default is permitted in equilibrium. Their effective (*ex post*) interest rates have to be suitably adjusted to account for default in their corresponding markets.[23]

Equilibrium

The equilibrium in this economy is characterised by a vector of all choice variables of

[21]See Goodhart et al. (2003) for an extensive discussion.

[22]The interest rate formation mechanism is identical to the offer-for-sale mechanism in Dubey and Shubik (1978). The denominator of each of the expressions (15-17) represents the supply side whereas the numerator divided by $(1 + r),\quad r \in \{r^b, r_d^b, \rho\},\quad b \in B$ corresponds to the demand. Note that this interest rate formation mechanism is well-defined both in, and out of, equilibrium.

[23]For more on the method of calculating the *ex post* interest rates, see Shubik and Tsomocos (1992).

active agents such that banks maximise their payoff function subject to their budget constraints, all markets clear (i.e. conditions 16, 17, and 18 are satisfied), bank δ is correct in its expectation about the repayment rates that it gets from its interbank investment, and, finally, loan demand, deposit supply, repayments rates, and GDP in both states s satisfy the reduced form equations (12)-(15).