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On the Bottom-up Foundations of the Banking-Macro Nexus

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Abstract

The complexity of credit-money is conceived as the central issue in the banking-macro nexus, which the author considers as a structural as well as process component of the evolving economy. This nexus is significant for the stability as well as the fragility of the economic system, because it connects the monetary with the real domain of economic production and consumption. The evolution of credit rules shapes economic networks between households, firms, banks, governments and central banks in space and time. The properties and characteristics of this evolutionary process are discussed in three sections. First, the author looks into the origins of the theory of money and its role for contemporary monetary economics. Second, he briefly discusses current theoretical foundations of top-down as well as bottom-up approaches to the banking-macro nexus, such as dynamic stochastic general equilibrium and agent-based models. In the third part he suggests an evolutionary framework, building on a generic rule-based approach, to arrive at standards for bottom-up foundations in agent-based macroeconomic models with a banking sector.

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1 Introduction

Credit crunches and liquidity traps are highly complex economic phenomena, because their origin and nature lie in systemic characteristics concerning the evolving economy and not only the financial markets. Moreover, the provision and control of credit-money sustains the financial as well as the goods market by connecting them both; it thereby guarantees a continuity of economic operations. In the evolution of money we consider the innovation of banks as a significant institutional process in capitalist development capable of providing exactly this continuity – compare, for instance, Schumpeter (1954: 276–335) or Ferguson (2009). The complex logic of this process represents a very interesting but difficult economic topic, especially from the perspective of the actors. Uncertain economic actors incorporate roles of agenda setters and agenda receivers.

In this paper we focus on the complexity of credit-money to arrive at new standards for modelling the banking-macro nexus from the bottom up. Of course, such an endeavour needs to address a diversity of economic thought and analysis. The endogenous instability of capitalist modes of production has reached a new climax with the autonomous financialization of all economic realms during the twentieth century. Minsky (1986) communicated this climax in such a pointed way that, for the first time, a greater audience within the economic discipline recognized the importance of institutional factors for the (in)stability of the economy. His major research question, 'Why is our economy so unstable?' Minsky (1986: 109), should disappear step-by-step from the realm of what he called 'non-sense questions' in economic science. Within this context, Minsky pointed out that any satisfactory economic theory and analysis needs to recognize endogenous instability as a central characteristic of economic systems, leading us to out-of-equilibrium economics. By considering the systemic notion of economics we integrate concepts such as *self-organization*, *phase transition* or even *self-transformation*. This is something that Minsky might have learned as a graduate student of Schumpeter at Harvard; compare Knell (2012: 5). Minsky (1986: 279–282) considers banks as endogenous destabilizers in the monetary circuit. In 'The financial instability hypothesis', Minsky (1992) elaborates on this perspective through an integration of Schumpeterian and Keynesian economics. Knell (2012: 3) points out that '[h]is main contribution was to link financial market fragility and speculative investment

finance'. Obviously, the endogenous instability in the banking-macro nexus is affected by the dynamic change in bankers' and investors' cognitive, behavioural and social rules, since in good times investment agents are lured into taking higher risks, and in bad times they leave the markets. The central point in this paper deals with the complex (de)activation and synchronization of institutionalized rules in credit systems. Therefore, we look especially into the dynamics of corporate and household lending within credit rule populations, and synthesize them in prototypic bottom-up foundations for the banking-macro nexus. However, we refer to *bottom-up* instead of *micro* foundations as articulated in the new classical or new Keynesian macroeconomic frameworks; compare also Delli Gatti et al. (2011: 7–14) for this distinction. We highlight the dynamic institutional interplay of basic cognitive, behavioural and social rules via individual and social learning, instead of explaining rules just as static and therefore fixed properties of micro agents.

Banks institutionalize an evolutionary process of credit regimes via their lending capabilities, *creatively responding* to loan demands from firms and households. Hence, the evolution of lending standards is crucially significant for the contingent development of the economy's disequilibrium path, a notion highlighting the institutional nature of the monetary circuit. We thereby go back to Schumpeterian credit-driven innovation and, more generally, to the idea of endogenous money in Keynesian terms. Where it is well known that Schumpeter was not a great admirer of Keynes's *General Theory*, it is also accepted that both of them rejected the commodity-based approach of the *quantity theory of money*. We elaborate on this topic in particular in Section 2 of this paper, by providing insights on the *credit-centred* perspective of money from a history of economic thought perspective; see Stiglitz and Greenwald (2003) or Godley and Lavoie (2012) for analytical introductions into the new paradigm in monetary economics. Anyway, we are still confronted with the textbook model of monetary economics working with a different theoretical heritage of economic thought, in particular the quantity theory of money. From the perspective of scientific research paradigms (Kuhn 1962) or programmes (Lakatos 1980), we are able to identify two central agendas in the monetary economic realm, i.e. the *Cambridge approach* and the quantity theory of money. In this paper I shall argue that the former is not only more realistic from a scientific point of view but also that these two programmes are of different axiomatic natures. The latter is locked into *top-down* thinking and modelling, and

the former is at least open to a *bottom-up* configuration of monetary economic activities, if we stick to the original Keynesian interpretation and integrate it with Schumpeterian and other evolutionary economic conceptualizations. The paper thereby elaborates on the origins and fundamental differences between top-down and bottom-up approaches to the banking-macro nexus in Section 3.

Furthermore, it is argued that despite the first outstanding methodological considerations (Delli Gatti et al. 2011) for an integrative framework to model and simulate the economy from the bottom up, not much work has been done on the formulation of proper methodological standards for bottom-up foundations in agent-based monetary macroeconomic models. In this paper we elaborate on such a standard with regards to the institutional process of credit-money, and provide a theoretical framework for the evolution of generic credit-rules, building, in general, upon Dopfer and Potts (2008). Generic rule-based approaches, as articulated in Dopfer and Potts (2008) or Ostrom (2005), may serve as methodological blueprints for agent-based modelling in general. The power of such approaches is shown by a naturalistic and social embeddedness of knowledge, linking smoothly to bounded rationality and organizational complexity (Simon 1991), interactive learning and endogenous network evolution (Kirman 1997); or, more recently, to nested cognition and institutional change (Kawamura 2009), for instance. However, in this paper we briefly introduce rule-based evolutionary economic thought and suggest an empirically founded application in the realm of credit-money.

In Section 4, we discuss the specific characteristics (cognition, behaviour, socialization) for the banks' bottom-up foundations as given by *bank lending rules*, i.e., in particular, credit supply depending on factors such as risk perception, industry or firm-specific outlook or competition from other banks, in the case of enterprises, for instance. We also consider their co-evolution with firms' and households' *demand-for-loan rules* as central for the endogenous creation of money. The latter credit demand is affected by factors such as fixed investment, debt restructuring, internal financing or the price of loans from other banks or non-banks, for instance, again, in the case of enterprises. The rules are empirically founded through the *Bank Lending Survey* of the European Central Bank (http://www.ecb.europa.eu/stats/money/surveys/lend/html/index.en.html). We provide basic credit-rule heuristics for particular integration of this qualitative survey data in future agent-based monetary macroeconomic models.

2 The complexity of credit-money: A history of economic thought

Monetary theory deals with the relation between money supply and demand. Money is defined through its functions as a medium of exchange, store of value and unit of account; compare Stiglitz and Greenwald (2003: 4–6). The first two functions deal with money as a means of payment – as a transaction or exchange medium – and the circumstances that money can be held for future consumption or investment: a store of value. Money represents a unit of account when it emerges in balance sheets (Godley and Lavoie 2012: 8), which involves all commercial operations. Furthermore, money is pragmatically defined through its statistical properties for monetary policy. Here, we deal with money aggregates (Bofinger 2001: 5) $M1$ (currency in circulation), $M2$ ($M1 +$ bank deposits) and $M3$ ($M2 +$ repurchase agreements $+$ market funds $+$ debt securities), which serve as operative aggregation measures for the central banks.

The most divisive problem in monetary theory deals with the explanation of money demand. In the history of economic thought, three basic attempts have been made to articulate the demand for money: the *quantity theory of money*, the *Cambridge* or Keynesian approach and the *inventory* or *transactions* approach. We concentrate on the differences between the first two; for the latter's original elaboration, compare Baumol (1952) and Tobin (1956). All of them are related to the equation of exchange, first stated by Irving Fisher. The quantity theory attained its popular status through Friedman (1956), with the introduction of an additional basic relation between money-to-hold and wealth. In general, the quantity theory proposes c.p. a substantial and direct proportional relation between a quantitative money supply and the price level of the economy in the long run. The Cambridge approach emphasizes that money is not immediately spent for goods, but certain ratios of income are held or invested according to one's liquidity preference. Keynes thus introduced socio-psychological constants ('propensities' towards certain economic actions) on a macroeconomic level, which allowed him to replace the strict proportionality of the quantity theory of money by a more flexible framework – at least for short-run dynamics. In summary, following Bofinger (2001: 20), the quantity theory shows that 'demand for money is a demand for real balances and depends proportionately on real GDP. Its main assumption is a stable velocity of money. Keynesian approaches explain the role of the interest

rate as a determinant of money demand.' The Keynesian model introduces a speculative motive towards the theory of money demand. Keynes (2008: 126) [1936] emphasizes the incentive to buy interest-bearing assets (bonds) instead of consuming goods and services. In this way he reinforces the role of the interest rate within $M2$ and broader aggregates.

Otherwise, Hicks (1935) claimed that money needs to have a marginal utility as all other goods and services: 'People do choose to have money rather than other things, and therefore, in the relevant sense, money must have a marginal utility.' Hicks (1935: 3). Hicks argued that whenever there is a choice to make between alternatives that can be expressed in quantitative terms, we should apply the concept of marginal utility as for other commodities. Finally, Friedman's (1956) restatement of the quantity theory of money meets these claims for a marginal theory of money and introduces the argument of individual wealth of utility-maximizers as the decisive determinant for money demand. He thereby considers money as much a commodity as all other goods and services. Today, money is still considered within this mere quantity picture, mostly captured within Hicks's (1980) modern IS–LM (investment saving–liquidity preference money supply) model – see Blanchard (2000) or other macroeconomic textbooks. Modern quantitative approaches in monetary economics by 'new classicals' or 'new Keynesians' usually work with the mechanics of the quantity theory of money, providing the prototypes for the central banks. An overview of the theoretical and modelling foundations of current top-down approaches in monetary economics is given in Section 3.1.

The assumption that money is a commodity represents a key assumption within the standard model of money supply. This claim is scrutinized from several perspectives within the discipline, for instance by post-Keynesian approaches or Schumpeterian economists. Schumpeter (1954: 317–322) objected to the application of a demand and supply apparatus for a value theory of money, because money does not represent a commodity in his terms. Schumpeter associates trust and security with the emergence of bank notes. Bank money, understood as transferable deposit, was not a great novelty in the late seventeenth and eighteenth centuries, but the new practices and conducts associated with *were* novel – see Ferguson (2009). It is the credit form of money which rearranged its institutional features and functions. Credit-money constitutes a socioeconomic institution, capable of creating and destroying money, where we define institutions broadly as 'systems

of established and prevalent social rules that structure social interactions' Hodgson (2006: 2). Taking Schumpeter's arguments seriously, money cannot be simply understood as an object yielding marginal utility. In Schumpeter's (1970) *Das Wesen des Geldes*, published posthumously, he refers to the sociological role of money as a unit of account. Schumpeter considers the 'carriers of the social accounting process' as the households, the firms, the banks and the central bank. We thus consider the evolution of credit rules as an evolving social accounting system within the banking-macro nexus. Banks create and destroy money endogenously from a demand and supply perspective, where the borders between demand and supply get vaguer and vaguer. From the perspective of the quantity theory of money, money wants to be regarded as exogenous only. Post-Keynesian – compare Lavoie (1984) or Fontana (2003) – and institutional perspectives – compare Ferguson (2009) or Hall (2008) – suppose a more systemic, historical and therefore evolutionary approach to the theory of money and credit, which addresses the complexity of money in flow. This scepticism also originates from the exaggerated use of the general equilibrium framework, the efficient market hypothesis, the representative agent and the rational expectations approach in monetary theory and policy. Following Schumpeter, this is immediately clear since any innovation will need the disequilibrating force of a more or less daring credit. A general equilibrium framework – where the state of all markets is simultaneously determined by the set of exogenously given preference orders of all market participants – leaves no room for singular, credit-supported novelty. The missing property describing social and technical innovation (including the role of credit) from an empirical point of view leaves behind the most essential characteristics of industrialized economies in the last 300 years. These innovated advances observed in products, production processes and socioeconomic relationships (including credit) are the core of what is considered to be economic progress. Crisis is just the mirror image of progressive innovation, and it thus represents an innate property of capitalist development. All economic operations are executed under uncertainty, as Keynes (2008) [1936] also emphasized in a Knightian tradition. Time is irreversible. For Keynes to overcome the poverty of equilibrium analysis in the face of the Great Depression, the introduction of independent socio-psychological constants made errors by investors possible, but only on a short-run aggregate level. The challenge for a modern analysis is to go beyond (or, better, to go underneath) such an aggregate consideration

of error-driven, evolutionary credit dynamics; i.e., to provide theoretical as well as empirical arguments for the aggregate level of structural macro analysis. This notion follows Keynes's position, that money plays a part of its own. Then money needs to be considered as a social relation of credit, where accommodationists argue the idea of a social convention. In consequence, it expresses the value of a contract, rather than the value of a commodity, which in fact defines a fundamental economic difference.

Post-Keynesianism suggests that money supply gets endogenously determined by its demand for bank credits by other banks, firms and private households. Fontana (2003) explains that there are basically two major approaches to the theory of endogenous money: the accommodationist and the structuralist. Credit-money refers to the flow of money, and balance sheets refer to the stock of money. Accommodationists argue strongly in the tradition of Keynes, Kaldor and Robinson, as Fontana (2003) elaborates. Money is explained via the demand by entrepreneurs or investors. Structuralists criticize the accommodationist approach regarding its assumption of an infinite elasticity of credit supply. Further distinctions deal on the one hand with the liquidity preference of central banks, banks, firms and households and on the other hand with the role of private households in credit relations. Advocates of the structuralist approach argue that the behaviour of households on capital markets has changed fundamentally in the last decades. Today, money supply also depends on the demand for bank credit by households. The overall money supply is then influenced by a three-pillar system in an endogenous way: the liquidity preference of all participating parties, and corporate and household demand for loans. A common strategy of post-Keynesian theory and modelling concerns the concept of stock-flow consistency, as outlined in Godley and Lavoie (2012: 21): 'This sounds very much like Minskyan economics, and indeed it is, as Roe explicitly refers to the work of Minsky on financial fragility, showing that a stock-flow consistent framework is certainly an ideal method to analyse the merits and the possible consequences of Minsky's financial fragility hypothesis.'

Credit-money is encapsulated within a socioeconomic institution guiding accounting processes between creditors and debtors (Bezemer 2009). Today, the bank's central role is accompanied by a massive increase in its economic and political power; moreover, its decisions and actions may carry crucial ramifications for the global economy, as we have witnessed after the 2008 crash. Banks need

to be considered as crucial institutions today, since they may act as endogenous destabilizers by challenging the monetary authorities – compare Minsky (1986: 279). Minsky anticipated the game between central banks and banks as typically unfair, because '[t]he profit-seeking bankers almost always win their game with the authorities, but, in winning, the banking community destabilizes the economy; the true losers are those who are hurt by unemployment and inflation' Minsky (1986: 279). But how did the institutional innovation of credit change the bank's position? Schumpeter's (1954: 317–322) interest in the novelty of issuing money is connected with the rise of new analytical economic practices. He argues that in earlier times trade was always considered as perfect trade, so that commodities were exchanged exactly, without any residue. The monetary system has changed with the evolution of money to credit-money. The new possibilities enabled by credit changed the monetary system tremendously. The credit system therefore represents one of the most influential and powerful institutional networks in the global political economy.

Arena and Festré (1996: 117) argue that banks cannot be characterized as pure contractors or intermediaries, because of informational asymmetries between all the participating parties. The authors support the idea of Stiglitz and Weiss (1988) that banks appear as social accountants in the economy, instead of mere brokers. The consequential role of the bank is to synchronize informational asymmetries between firms, households and banks. The Schumpeterian story tells us that these functions characterize capitalist development, the evolution of business cycles and the evolution of institutions in a very dominant way. Arena and Festré (1996) focus on the monetary aspect of entrepreneurship, innovation and business cycles. They also argue that neoclassical economics considered the implications of capitalist development too narrowly by concentrating too much on factors of the real side of the economy, i.e. technology and structural change. The crucial point in their analysis faces Schumpeter's break with the Walrasian general equilibrium system. 'However, it is the finance side of Schumpeter's writings that demonstrates his break with Walras, especially in light of the history of economic dynamics and of monetary theory' Arena and Festré (1996: 117).

Banks are capable of creating money independently from certain custom deposits, so they do not merely exchange (understood as bilateral bank relations) money any more, they expand or restrict it depending on its demand. Here we

may also find the most crucial link between the real and the monetary sector of the economy. Money is not a mere commodity– only in the eyes of a theoretical metallist, as Schumpeter (1954) notes. The evolution of money also implies the evolution of the most dominant modern economic institutions. Hanappi (2009: 4) explains that money as credit becomes a process, because its value gets continuously judged through different social and cultural environments. Credit is about the trustworthiness of an economic system; with the rise of banks, this trustworthiness was institutionalized during the Middle Ages. Money changed dramatically, from a commodity-based, feudal, metallist structure to a financial social contract. Within this specific development lies a very deep evolutionary process of economic institutionalization, indicating that property and wealth were completely redefined. Though the banks' essential socioeconomic and political task has not changed over hundreds of years, they still evolve tremendously, as evidenced by the ever-increasing diversity of products and banking methods. Credit is the most essential feature for investments in future projects. Firms, households and governments have to rely on creditworthiness and creditability from an institutional perspective in general. Every economic step means a certain trade of trust versus money. Various, though still similar, manifestations of banks, money and credit have evolved throughout economic history – see Ferguson (2009) and Hanappi (2009). Therefore, banking underlies an evolutionary speciation process, where different lineages of credit rules have evolved in history. These lineages emerged in certain periods of economic evolution – the introduction of banknotes, the innovation of credit, the establishment of central banks – but also in the rather new developments of micro-credits in and macro-credits for developing countries.

However, monetary circuit theory was not only considered by Keynesians. Bertocco (2007) and Knell (2012) demonstrate the synergistic potential between Schumpeterian and Keynesian economics from a pure-theoretical perspective, expressed in the work of Minsky (1986, 1992). With regards to modelling, we highlight recent pioneering work in this respect in the next section of the paper. Of course, this aspect also deals with the influence of the Austrian as well as the German historical school on Schumpeter's vision of economics. Elsewhere, Steele (2001) discusses the main differences between Hayekian and Keynesian economics with an emphasis on their theories of money. We may also argue that the circuitist approach represents a synthesizing concept, though of course with

very different conclusions and implications for policy design. The quantity theory of money represents an economic doctrine which is objected to by economists with an institutional focus. This emphasis brings heterodox economists from several schools together, and may also help potential synthesis in the future. It is interesting to note that proponents of the quantity theory of money still emphasize a pure top-down modelling approach, whereas proponents of an endogenous theory of money have focused recently on bottom-up modelling.

3 Modelling approaches in monetary economics with respect to the credit channel

The history of economic thought perspective has shown that monetary economics is a highly contested terrain, including a variety of heuristic projections on the banking-macro nexus. But it has also shown that the bank needs to move into the centre of economic analysis, especially the institutional nature of credit-money. Both aspects are addressed within current top-down and bottom-up approaches, from different angles and with different implications.

3.1 Top-down approaches

Central banks are the focus of economic attention as agenda setters today. They increasingly fulfil and represent powerful roles within the global political economy. The economic power of nation states has decreased in recent decades, since financial complexity has grown to an immense extent. As a consequence, financial intermediation needs to be investigated more extensively, since in times of non-growth or recovery the interconnectedness between systemic institutions is crucial for real economic activity and political decision-making. The impact of monetary policy on the economy is investigated through the monetary policy transmission mechanism. Central banks argue that the policy rate manifests itself in wages, prices and output through four major transmission channels: the interest rate channel, the credit channel, the exchange rate channel and the wealth channel – compare Mishkin (1996). In general, the interest rate channel represents the quantity theory of money in its purest sense, because the cost of capital gets influenced by the

central bank's leverage on short-term interest rates. Nowadays, it is well known that arguments relying only on this perspective may not be satisfactory for the bigger picture, as also admitted by Bernanke and Gertler (1995). The credit channel works through the external finance premium representing the difference between firms' internal and external costs for capital, with consequences for investment operations. This channel also involves the goods and the labour markets, since households and firms have to rely on the provision of credits. Wage and price formation therefore follow a more complex evolution, because more stakeholders are involved in general. The exchange rate channel is dependent on currency fluctuations and on the degree of openness of the economy. The wealth channel is related to movements within the stock market and its asset price fluctuations.

Bernanke and Gertler (1995: 2) conceive the credit channel as an enhancement mechanism of standard monetary transmission, and identify two components of it: the balance sheet channel and the bank lending channel, where the latter accounts for the fact that 'monetary policy affects bank loan supply, which in turn affects aggregate economic activity', as considered by Diamond and Rajan (2006: 3). In this section we concentrate on the bank lending channel. However, in the neo-classical picture it is not quite well articulated how the game between central banks and commercial banks is played, referring again to Minsky (1986). It seems that banks are not considered as a source for crisis or instability; furthermore, there is not much discussion of the origins of crisis in this literature, but rather more on the consequences as well as the potential for combating it via monetary policy. The central bank acts as a hero in this outline. In times of crisis this game becomes crucial, because less-liquid financial institutions will have trouble refinancing. Diamond and Rajan (2006) make specific adjustments to the bank lending channel by arguing that banks may find different forms of financing once reserve requirements are eliminated. Nevertheless, there is evidence that monetary policy particularly affects the liquidity of those banks with worse balance sheets, and mainly small banks with initial low liquidity. Obviously, these effects seriously affect overall bank liquidity and, consequently, real economic activity in times of crisis or even recession. Diamond and Rajan (2006) focus on demand deposits as a crucial factor, with emphasis on capital flights or even bank runs in times of crisis. Hence, money and money-to-hold represents a complex and critical phenomenon with far-reaching consequences, as Kiyotaki and Moore (2012) argue.

Monetary economics and corresponding DSGE (dynamic stochastic general equilibrium) models work mostly with frictionless markets – see Christiano et al. (2005) or Smets and Wouters (2007). By focusing on the transmission mechanism of conventional monetary policy, they are unable to capture financial market disruptions. For that reason, recent studies have tried to produce a theory and implement models with financial frictions in order to discuss the reaction of unconventional monetary policy, i.e. credit policy. Gertler and Kiyotaki (2010: 566) identify three different credit policy options, also operated by the Federal Reserve Bank during the crisis: (1) discount window lending to banks secured by private credit, i.e. liquidity facilities; (2) lend directly in relatively high-grade credit markets, i.e. lending facilities; and (3) direct assistance to large financial institutions (TARP – Troubled Asset Relief Program), i.e. equity injections. In such a perspective, frictions need to be addressed seriously, as also indicated by Gertler and Karadi (2011). The authors note the problem that any deterioration in the balance sheets of financial intermediaries disrupts the flow of funds between lenders and borrowers. This process leads to a symptomatic rise in various credit spreads, as well as a significant tightening of lending standards (Gertler and Karadi 2011: 20). Therefore, a tightening raises the costs of borrowing and enhances the downturn on the real side of the economy, which reduces asset values throughout. Consequentially, an expansion of central bank credit might offset a disruption of private financial intermediation, as articulated by the contributions of Bernanke et al. (1999), with a focus on the financial accelerator, or Christiano et al. (2010), with a focus on risk shocks.

However, these contributions don't go into details about the rather 'new' endogeneity of risk, which reflects the ultimate reason for a more macroprudential regulation policy. Brunnermeier and Sannikov (2013) explain that securitization and derivative contracts might lead to better sharing or hedging of exogenous risk, though these vehicles also increase endogenous systemic risk, which can be viewed as one source of the subprime crisis. In this, the authors build on recent research on the agency and information sharing problem between financial intermediaries – see Brunnermeier and Sannikov (2011), Gorton (2009). The main conclusions of Brunnermeier and Sannikov (2013) can be summarized as: (1) the system reaction to shocks is highly non-linear; (2) in a 'normal regime' only unusually large shocks get much more amplified, in a 'crisis regime' even small shocks get amplified, lead-

ing to significant endogenous risk; (3) the system reaction to shocks is asymmetric; and (4) increased volatility in the crisis regime affects the expert's precautionary motive, also called the volatility paradox.

The argument sheds more light on the very painful reality central bankers need to face more and more: financial intermediation involves a tremendously complex process, especially the various aspects within the credit channel of monetary transmission. Furthermore, if we concentrate more on the European situation, apparent solutions from US monetary economists are not necessarily applicable. For instance, Eurozone countries, such as Greece, Italy, Portugal, Ireland and Spain, face an even more difficult situation, since they are not able to issue riskless government debt as the US can – the standard procedure by the 'Fed', as illustrated by most of the authors mentioned above. With regards to this issue, other political and institutional dimensions should be highlighted as well. Moreover, contagion effects are even more complex when we are not able to speak of an optimal currency area, as it is the case with the Eurozone. Hence, monetary unions face crucial problems if the real side of the economy is not structurally synchronized, and also demand political and fiscal integration, as many experts argue – see de Grauwe (2009). Also, the top-down approach to theory and modelling of the most prominent new-Keynesian macroeconomists and US central bankers also faces significant limits, since modern DSGE systems are not capable of including the emergence of discrete events. Crisis is always conceived as an exogenous phenomenon, also meaning that DSGE systems are not prepared for the modern globalized economy. Cumulative causation and interdependency characterize the contemporary problems of our economy. Others such as Mittnik and Semmler (2012) emphasize the notion of regime change within the banking-macro nexus. Different regimes face different systemic vulnerabilities, triggered by a variety of endogenous shocks. We are confident that the occurrence of regime changes can be investigated efficiently via bottom-up approaches, as discussed in the next section.

3.2   Bottom-up approaches

Interbanking is the central issue of financial intermediation; however, we have still not acquired much knowledge on the structure of interbank networks, nor, moreover, on firm–bank and household–bank networks. Here, the distribution

of institutional power plays a significant role; consider the aspect of shadow banking for instance (Pozsar et al. 2010). This notion – especially the aspects of interconnectedness, contagion and systemic risk – is investigated more and more now via bottom-up approaches, for reasons we provide below. DSGE systems don't feature evolutionary system characteristics such as adaptation/adoption, selection and retention, which shape the structuring processes of financial intermediation by the nature of the approach. The essence of population thinking, as well as the developmental aspect of evolution (Callebaut and Rasskin-Gutman 2009), open a variety of qualitative and quantitative aspects for an extensive research of this domain, such as institutional and organizational learning, niche construction and emergence. Hitherto, top-down approaches worked through the general equilibrium framework, where representative agents resemble the average economic actors within a homogeneous population of financial and non-financial firms. Empirical investigations, such as Schweitzer et al. (2009) and de Masi et al. (2011), show that the degree of heterogeneity and consequential complexity is much higher than assumed in DSGE systems. The theory of networks provides substantial support for such empirical observations of firm–bank and interbanking networks. Network theory as a stream within the science of complex systems has grown tremendously in recent decades. Nowadays, network scientists apply findings, particularly from biological and social networks, in the economic domain – see Barabási (2003) or Csermely (2009). The substantial advantage of network theory lies in the potential identification of weak links via clustering methods. Additionally, it allows the computation of the degree distribution of networks by indicating weights for systemic interconnectedness. Financial orders evolve in a nested way within top-level and bottom-level networks. They can be visualized with the tools of network theory, as scholars such as Schweitzer et al. (2009) have already shown. The authors argue that the global banking sector is highly interdependent, which makes the structure highly vulnerable to breakdowns of important nodes and weak links, as we have seen with the insolvency of Lehman Brothers in 2008. The global financial network incorporates a serious degree of systemic risk.

Certainly, spillovers to the real economic sector have far-reaching socioeconomic and political consequences during breakdowns of institutional networks of financial intermediaries triggered by liquidity traps, for instance. There is no doubt that studying the interconnectedness within banks and between banks and

firms is a highly promising approach to analysing the structural composition of the banking-macro nexus. Furthermore, we may also highlight the process component of changes within this structure, the evolutionary component. De Masi et al. (2011) investigated debt–credit relations between Japanese firms and banks with a network theory approach. The authors showed that the topology of the credit network is significant for its stability, fragility and vulnerability. They indicate crucial bank and firm nodes/links for the stabilization of the system as a whole. De Masi et al. (2011: 210) argue: 'In the presence of autocatalytic processes, even a small amount of individual heterogeneity invalidates any description of the behaviour of the system in terms of its "average" element: the real world is controlled as much by the tails of distributions as by means or averages. We need to free ourselves from average thinking'. This quote not only signals the importance of new statistical techniques engaged via network theory, but also emphasizes that self-organization, autocatalytic processes and selection pressures are highly non-linear phenomena which go beyond the analytical scope of standard methods. Obviously, intellectual exchange and dialogue between different economic approaches needs to be intensified. Network theory, agent-based modelling and computational socioeconomic simulation play key roles in such collaborative projects. However, there are three areas where such collaborative efforts need to be established for further synthesis and common frameworks, i.e. theory in general, modelling strategies and empirical foundations for heterogeneous interacting agents:

1. From a *theoretical perspective*, Delli Gatti et al. (2010, 2011), Stiglitz and Gallegati (2011) or Battiston et al. (2012a) argue in convincing terms for the application of bottom-up approaches in monetary economics. Obviously, emphasis is given to the credit system, where we find the interconnection between the real and the money market. Manifestos such as these are in favour of a serious paradigm shift in macroeconomic thought, building upon the Cambridge approach with a quantitative focus on systemic risk, interconnectivity, degree distributions and heterogeneity. Their theoretical agendas and the scientific tradition is basically connected to econophysics and (post-)Keynesian theoretical cornerstones. However, evolutionary economists highlighted a great deal of the agenda of this paradigm shift a long time ago, going back to the seminal contribution by Nelson and Winter (1982).

In this respect we speak about endogenous change, disequilibrium, heterogeneity, bounded rationality and fitness. As we will outline in the following section, we apply a political economy and institutional approach within evolutionary economics and focus more on qualitative aspects (instead of mere quantitative, therefore) for a general paradigm shift in economics. However, evolutionary economists have not contributed towards an evolutionary macroeconomics with a monetary system in theoretical terms. Nonetheless, it is the *crisis mode of evolutionary economics* which makes it into a crucial collaborative patron for the alleged paradigm shift. Central theoretical agendas for such evolutionary modelling strategies for macroeconomic policy have recently been crafted in Dosi (2012) or Hanappi (2013), for instance.

2. On behalf of actual *bottom-up macroeconomic models*, the evolutionary economic agenda lags totally behind econophysics. As a seminal exception we refer to the recent contribution by Dosi et al. (2010) emphasizing a Schumpeter–Keynes macroeconomic modelling framework. Otherwise, the central models are currently given in the publications of Cincotti et al. (2010) and Raberto et al. (2012), where the authors introduce the EURACE computational simulation, and Delli Gatti et al. (2011: 45–85), introducing the so-called BAM (bottom-up adaptive macroeconomics) model. We can speak of 'complete' macroeconomic models with regards to these models because they integrate all relevant economic markets (credit, goods and labour) with corresponding micro-foundations. For a highly topical comparison of recent econophysics trends in agent-based economics, see Bargigli and Tedeschi (2012). In the coming years we will see a growing number of innovative models in this realm, as new developments such as Seppecher (2012) indicate. Furthermore, most recent modelling contributions concentrate more specifically on systemic risk in the various credit networks: interbanking (Gai and Kapadia 2010; Tedeschi et al. 2012; Thurner and Poledna 2013); household–bank (Lengnick et al. 2012) as also contributed to this special issue; firm–bank (Bargigli and Gallegati 2013); and firm–bank–household (Delli Gatti et al. 2009; Battiston et al. 2012b).

3. With regards to the *empirical foundations of agent-based models*, we need to distinguish between quantitative and qualitative foundations. Additionally, Bianchi et al. (2007, 2008) highlight the important difference between calibration and validation of agent-based models, truly a crucial issue for the reception of bottom-up macroeconomic models in comparison to DSGE. According to quantitative empirical foundations we may recognize huge successes concerning the basic link between 'micromotives and macrobehavior', as stated by Schelling (1978), for instance. Aggregation is not the main problem any more in non-representative agent models. Rather, the problem lies deeply in the degree of realism of the empirical foundations for microbehaviour, a problem already central to Veblen (1898), Schumpeter (1911) or Hayek (1945); see Wäckerle (2014) for an extensive discussion of their heuristic projections on economic evolution. However, we currently tackle this problem by looking into the quantitative data of economic experiments on expectations, learning and rationality in general (Hommes 2011, 2013). Others, such as Kirman and Vignes (1991), have inspired a series of recent studies on real-life demand and supply in fish markets – compare Cirillo et al. (2012) or Tedeschi et al. (2012). The issue of dispersion is a crucial outcome of micro observations and emerging self-organization in such bargaining situations, where experience and knowledge of the rules play a significant role. Of course, the actual behaviour, the internal models and the final decisions are driven by qualitative features of social relations such as trust and power, which need to be incorporated somehow. Economies represent more than just networks between heterogeneous atoms, they consist of emotional, interacting human beings. One significant problem of a pure focus on quantitative data refers to the notion that such data does not contain process characteristics of socioeconomic change. In this paper we highlight this issue as a current shortcoming, and argue for additional integration of qualitative survey and interview data for bottom-up macroeconomic models. This concern is connected to the lack of a generic rule-based approach for the agent-based methodology, as indicated by Dopfer and Potts (2008) and Ostrom and Basurto (2011: 319). This very notion is also explicitly articulated in Delli Gatti et al. (2010: 119) with reference to the micro-meso-macro rule-based framework previously described in Dopfer et al. (2004). Basically,

generic rule-based approaches go far beyond the simple idea of ad hoc rules of thumb, because they use empirical material (compare Blind (2012) for instance) to describe and explain the emergence, durability and exit of rule structures in the economy, crucial for endogenous change via institutional mediation.

Let us briefly consider Delli Gatti et al. (2011: 31–33), which explicitly refers to this theoretical problem and also addresses the importance of survey studies as crucial for modelling strategies. The authors dedicate a chapter to 'Rules of Behavior'. In comparison to other rule-based approaches, such as Ostrom (2005) or Dopfer and Potts (2008), Delli Gatti et al. (2011: 31–33) do not address a broader categorization of rules with regards to individual, cultural and social properties. To this extent we cannot speak of a rule taxonomy, since rules of behaviour refer in this context just to 'rules due to different circumstances, i.e. different time periods, geographical areas, markets and so on' (Delli Gatti et al. 2011: 31). Furthermore, the authors state that 'Pushing heterogeneity to this limit, that is a continuum of different behavioral rules, makes the model – especially a multi-agent model – easily unmanageable' (Delli Gatti et al. 2011: 31). This is obviously the case if we stick to the arbitrariness of a multitude of ad hoc rules of thumb. For that very reason, a comprehensive and easily accessible rule taxonomy is necessary to sensitize modellers to the categorical differences in rules as internal models as well as actualized operations. After a sufficient articulation of a rule taxonomy on behalf of empirical material, we are able to talk about the endogenous change of such a rule system, i.e. the institutional dynamics and trajectories of rule evolution. Delli Gatti et al. (2011: 33–40) treat this issue in a separate chapter on 'Interaction', which considers the real engine of multi-agent models, constituting itself through the path-dependent development of an agent's actions due to encounters with other agents. Correspondingly, the authors highlight four criteria for agent interactions on theoretical grounds: direct vs indirect, space, market vs non-market, preferences-constraints-expectations. The main difference from the evolutionary framework lies in a full integration of institutions. Generic rules act as informal institutions and therefore as endogenous (de)stabilizers in agent populations once they build up *meso units* (Dopfer and Potts 2008: 22) or reach a significant platform size in a group of agents (Elsner 2010; Elsner and Heinrich 2009). This aspect reflects

a phenomenon which is not yet addressed in bottom-up macroeconomic models, but would improve their current status. For that very reason, the following section suggests a prototypic but empirically founded rule taxonomy, applied to the realm of bank lending and the demand for loans. This taxonomy may not yet allow for proper conclusions on rule trajectories and their endogenous change, but it provides the first step for actual implementations of institutional change in bottom-up models. Moreover, it can easily connect with the previously elaborated history of economic thought approach from an analytical perspective. Such collaborative efforts lead to significant methodological improvements of the common multi-agent approach and may therefore provide additional arguments to convince advocates of DSGE.

4   Evolutionary bottom-up foundations for the banking-macro nexus

The history of economic thought has always been shaped by grand theories in the humanities, social and natural sciences. First attempts at an appropriate theory of money were established in the early twentieth century, where economics also made a major turn towards a subjective marginal theory of value. Economic theory was constructed as a so-called hard science, building upon classical physics, especially on Newtonian mechanics – see Mirowski (2002: 7) or Dopfer (2005: 7). This legacy of classical mechanical thinking still dominates the theoretical grounds of the discipline, as we have shown in the top-down modelling section. However, crises accumulate endogenously and diffuse like a computer virus on a network, but in far more complex terms since human beings interact in institutional environments. These characteristics make traditional monetary policy (controlling money supply via interest rate targeting) into a speculative game from a classical-mechanical/top-down perspective.

Early evolutionary economists such as Veblen, Hayek, Marshall or Schumpeter have recognized that economists may learn a lot by looking into the theory of evolution– see Dopfer (2005), Hodgson (2004), Nelson and Winter (1982), Shionoya and Nishizawa (2009) or Witt (2003). Darwin's theory of evolution is a theory of speciation and development, a theory of variation, selection, retention and of modularity. Speciation processes occur endogenously from within the entities

and evolution can therefore be denoted as a theory of continuous change from the bottom up. Additionally, the idea of population thinking contributes to an open-system approach in a feasible way. The Schumpeterian and Cambridge approaches to the theory of money invite evolutionary ideas concerning the institutional dimension of credit-driven endogenous economic change in particular. Then the focus switches to social learning, diffusion and the transmission of values within the banking-macro nexus. Uncertainty and innovation drive this self-transformation process from the bottom up. Trust and power thereby gain more importance for economic operations, and particularly for economic policies. The notion of credit inhibits investment and consumption opportunities for economic actors, which make the system disequilibrating and vulnerable to critical mass processes; for the latter, compare Schelling (1978). For that reason, evolutionary bottom-up logic serves as a theoretical basis for investigating interconnectedness, contagion and systemic risk in firm–bank networks, for instance. Monetary policy is then perceived as a cumulative feedback process, where money demand and supply trickle around. Monetary rules are usually associated with the central bank's authority controlling the mechanics of credit expansion and contraction. The central bank's major goal is to guarantee price stability and then financial market stability. Today, most central banks follow predetermined rules (e.g. the Taylor rule) instead of discretionary policy to sustain their goals. Within this section we want to point out that credit rules are part of a larger ensemble within the channels of monetary policy transmission. Generic rule-based approaches within the realm of evolutionary institutional economics constitute a solid framework for this proposed endeavour and may give fruitful new perspectives for future research in monetary economics. Two basic role models for economic agents appear: rule-makers (leaders) and rule-users (followers). Such a rule-based micro-economic theory of heterogeneous *Homo sapiens oeconomicus* is developed in Dopfer (2004). Rule-making and rule-using constitute generic economic features, like innovation and stability. Dopfer and Potts (2008: 8–12) offer a taxonomy of generic rules, as given in Table 1. The taxonomy refers to the diffusion of rules from the subject to the object domain and vice versa on the *meso* level of the economy, shaping its evolving knowledge base. Such a generic rule-based approach can be applied to the theory and policy of money and credit. We thus want to highlight the multidimensional character of credit-money, indicating and investigating the evolving interdependencies between

Table 1: Generic rule taxonomy

Generic rules			
Subject rules		Object rules	
cognitive	*behavioural*	*social*	*technical*
e.g. mental models and schemata	e.g. behavioural heuristics, algorithms and norms	e.g. organization of enterprise or market	e.g. machines, instruments and techniques

Source: Dopfer and Potts (2008: 8)

the cognitive, behavioural and social aspects of monetary intermediation and its effects on real economic activity.

Current monetary economic models do not integrate the institutional role of credit rule evolution. These days, credit-money involves an economic category of creative destruction, consuming and producing at the limits. The creative as well as the destructive characteristics of money creation via credit are much underestimated on the intermediary level of monetary transmission, especially since Ponzi borrowing became an integral part of creditors' and debtors' monetary habits of thought; compare also Minsky (1992). The meso level offers a process dimension for appropriate *bottom-up foundations* in economic theory. These foundations highlight an institutional socioeconomic level instead of mere micro foundations of the rule carriers; a dimension of rule creation (agenda setting) and rule adoption (agenda receiving). Generic rules are distinguished from genetic rules, as the latter 'replicate biologically and the former communicate socially. Economic evolution is the evolution of generic rules relating to the economy, which are rules relating to operations on resources' Dopfer and Potts (2008: 6). According to Table 1, these rules are subject rules (cognitive and behavioural) and object rules (social and technical); together, they span a rule matrix, called [CBST] by the authors. Then, as argued by Dopfer and Potts (2008: 8), 'Economic evolution is the ongoing process of coordination and change in these economic generic rules.' The classification of these rules into subject and object can be expanded by the introduction of rule orders, formulated within an order vector [0 1 2] – constitutional, operational and mechanism rules. The Cartesian product of [CBST]

Table 2: Order of rules

0th order constitutive rules
Social, legal, political, cultural and other constituent rules that underpin generic rules for economic operations.
1st order operational rules
Generic rules originated, adopted and retained by carriers for operations.
2nd order mechanism rules
Rules for changing rules. The origination, adoption and retention of rules about origination, adoption and retention.

Source: Dopfer and Potts (2008: 9)

$\times$ [0 1 2] expresses the generic state of the economic system, also expressed by the coordination of its knowledge base. Generally, evolutionary economics seeks to investigate changes in this matrix and the interconnection between its rows and columns. The co-evolution and synchronization between subject and object rules is crucial for sustainable development of the economy. It is thus of utmost importance which hierarchical level of order is affected and which level can can be addressed in certain classes of model. The hierarchical order of rules is given by Dopfer and Potts (2008: 9) as shown in Table 2.

This framework offers an analytical interpretation of economic change on several layers, articulating distinct categories of change. Economic evolution is basically shaped by coordination and change of 1st order rules, since goods and services are produced through these rules or resources are exploited by these means. Nevertheless, evolutionary economics proposes expanding the realm of investigated rules into the dynamics of lower-order constitutive rules as well as higher-order mechanism rules. Hence, we are able to argue that 1st order rules are contingent on changes in lower or higher orders. Consequently, such a three-order approach allows for a full endogenous analysis of the economic system. The rule taxonomy provides a comprehensive categorization of what does and what may happen in an economy, but it needs active economic agents, or rule carriers, who transport or even operationalize them. Generic rules are empty and worthless to investigate without specifying their carriers: ideas and corresponding norms are neatly connected to

economic agents. This notion brings in the population and speciation approach of evolutionary thought, which is open to variety, diversity and heterogeneity of acting carriers. It is worth noting that rules can be operationalized by a multitude of subject and object carriers. Rules can be adopted by human economic agents, but can also be carried by a specific artefact or agency. Then the object transforms generic rule knowledge by its distinct incorporation or internalization. For instance, Dopfer and Potts (2008) argue that capital stock and physical commodities are economic object carriers and are also connected to specific rules. In principle, all sorts of carriers carry rules to perform transformations and transactions, but for a more detailed explanation of rule carriers see Dopfer and Potts (2008: 11). As already stated above, we will concentrate on the first step for a generic rule-based methodology for agent-based macroeconomic models for now, i.e. a rule taxonomy for banking. To this extent we briefly characterize the evolutionary process of a Schumpeterian rule trajectory, but need to keep a more in-depth specification of this process for further work. Basically, '[a] trajectory is the process unit of change . . . In evolutionary economics, a trajectory is also a path from one state of order to another, but this process results in generic structural change in the rules, populations and associations that compose the economy' Dopfer and Potts (2008: 11). An evolutionary trajectory is composed of a three-phase transitionary process:

Phase 1: Origination of a novel rule
Phase 2: Adoption of that rule into a population of carriers
Phase 3: Retention of that rule in a population of carriers
Dopfer and Potts (2008: 12)

The meso unit consists of a generic rule and a population of micro agents, and represents the result of a corresponding set of micro trajectories. This process is called a meso trajectory and represents a significant heuristic device for the actual implementation in a bottom-up process of social learning. For the realm of credit-money, we are concerned with specific credit rule populations (elaborated in the following) critical to certain path-dependent processes on the macro level, i.e. the investigation of the banking-macro nexus. From a theoretical perspective, a monetary meso unit consists of a credit rule population. The variety within the population of credit carriers is given by the actual and manifold 1st order operations of micro agents.

We suggest a prototypic generic credit rule taxonomy according to a qualitative empirical survey of credit supply and demand. Hence, focus is given to the banking sector as a population of financial intermediary rule carriers. However, this first experimental endeavour may easily serve as a schema for interconnections in credit rule populations. In order to analyse the composition of a credit rule population we use findings from the Bank Lending Survey (BLS) of the European Central Bank (ECB). The questionnaire gathers quarterly data on the setting of lending standards as well as the demand for loans. Senior loan officers are questioned on the reasons for changing a specific lending standard; see, in particular, Berg et al. (2005).

The BLS indicates the important role of the credit channel as an impact stream for monetary policy. It also shows that the credit channel delivers new insights into the complex multilateral relations of lending, borrowing and monetary policy. The BLS was launched in 2003 by the ECB. It encompasses a questionnaire on bank loan supply and demand within the Euro area. Between 90 and 110 banks respond to the survey quarterly, according to de Bondt et al. (2010). The BLS is a qualitative survey and documents changes and expectations in a bank's standard setting for credit tightening and easing from one quarter to the next. The particular set of questions on bank lending anticipates five possible choices for the setting of a credit standard: (1) tightened considerably, (2) tightened somewhat, (3) remained basically unchanged, (4) eased somewhat and (5) eased considerably. Furthermore, the BLS hints at a variety of potential credit reactions that the banks apply and might be anticipating. From a generic perspective, we are able to investigate the (de)activation, nestedness and synchronization of different signalling systems for credit operations between banks, their customers and among them. Thus, the BLS can be regarded as a proxy transcript for individual and social learning mechanisms of credit rules. However, the BLS deals with qualitative and, importantly, anonymous data, which means in particular that the sources do not have any incentive to deliver accurate and reliable responses. Of course, this aspect also drives the major critique from monetary economists. General concerns and the theoretical foundations of the BLS are provided by Berg et al. (2005). The authors elaborate on the empirical nexus between monetary transmission, credit and business cycles, highlighting the interconnectedness within monetary transmission. Lending cycles occur due to different activations and rhythms of credit rule domains. Berg et al. (2005) argue that these cycles serve as proxies for

business cycles. Therefore, the investigation of credit rules sheds more light on the versatile structure of credit expansion and contraction in the balance sheets of banks, households and small, medium and large enterprises. Furthermore, the authors also highlight the potential gains from this subjective study of credit standards. ECB studies such as Berg et al. (2005), Maddaloni and Peydrò (2010) or de Bondt et al. (2010) serve as first reference points for such an empirical endeavour. The BLS concentrates particularly on demand and supply of bank loans for enterprises and households. De Bondt et al. (2010: 8) further argue that 'cycles in bank lending standards are important in explaining aggregate economic activity.' In particular, the authors conclude that expected net tightening of credit standards leads loan growth to enterprises by four quarters, and to households by one quarter on average. These and other significant systemic characteristics of the credit system can be further re-evaluated and incorporated into a bank lending rule taxonomy, which will provide a systemic prototype for agent-based macroeconomic models of the banking-macro nexus. Credit demand and supply raises a complex network of rule-makers and rule-users (Dopfer 2004) in a non-exclusive way.

The significant message for modelling purposes is to focus on cognitive, behavioural and social rules from a qualitative perspective in monetary economics, instead of just technical rules from a quantitative perspective. Concerning the basic rule taxonomy in Table 1, the BLS generally looks into the domain of cognitive, behavioural and social rules, which cover the organization of the credit market as well as the diffusion of financial norms and competitive pressures. Maddaloni and Peydrò (2010) look into the empirical relation between central bank policies on credit setting from the BLS perspective, and particularly into the different effects of lending for short-term and long-term rates. Otherwise, de Bondt et al. (2010: 20) oppose the versatile factors of the BLS (for changes of the credit standard and in the demand for loans) within a credit supply and demand category for enterprises and households, in the questionnaire. We summarize these categories in the following credit rule populations.

1 Credit Supply Rule Population

(1a) corporate lending: The first group of questions concerns corporate lending and the changes in credit standards with regards to tightened, unchanged

or eased supply of loans. Factors affecting credit standards depend on *cost of funds and balance sheet constraints (A)*. Loan conditions change with regards to the *price for loans (A)* – category A in de Bondt et al. (2010: 20) for credit supply. A typical question might be 'Over the past three months, how have your bank's credit standards as applied to approval of loans or credit lines to enterprises changed?' for a particular backward-looking credit supply rule within this sub-population; see question 1 in Berg et al. (2005: 47). The question explores two dimensions, the degree of expansion and contraction (tightened, unchanged, eased) overall and in particular the degree for the specific sizes (SME or large) of enterprises and specific maturities (short or long term) of loans. Hence, the latter qualitative differentiation refers to a subcategory of this credit rule population and deals therefore also with *competitive pressure (A)* and *risk perception (C)* with regards to the factors. The loan conditions change respectively on behalf of *other standards (B)* – categories B and C in de Bondt et al. (2010: 20) for credit supply.

(1b) household lending: Changes in the respective population of credit rules for household lending depend on all the above-mentioned categories for factors as well as loan conditions. A typical question might be 'Please indicate how you expect your bank's credit standards as applied to the approval of loans to households to change over the next three months?' for a particular forward-looking credit supply rule within this sub-population; see question 16 in Berg et al. (2005: 54). In addition, this type of question also differentiates between expected changes in credit standards for house purchase or consumer credits and other lending.

2 Credit Demand Rule Population

(2a) corporate lending: On the demand side the survey asks for a decreased, unchanged or increased demand for loans depending on *financing needs (A)* in general for factors affecting credit demand – category A in de Bondt et al. (2010: 20). In particular, we may also differentiate between changes for the subcategories for enterprise sizes and the time horizon of maturities for loans. The latter refer to changes in *alternative sources of finance (B)* for credit demand. A typical question might be 'Over the past three months, how

has the demand for loans or credit lines to enterprises changed at your bank, apart from normal seasonal fluctuations?' for a particular backward-looking credit demand rule within this sub-population; see question 4 in Berg et al. (2005: 48).

(2b) household lending: Changes in the demand for loans for house purchase, consumer credit and other loans to households are affected by *financing needs (A)* and *the use of alternative finance (B)*. A typical question might be 'Please indicate how you expect demand for loans to households to change over the next three months at your bank (apart from normal seasonal fluctuations)?' for a particular forward-looking credit demand rule within this sub-population; see question 17 in Berg et al. (2005: 54).

If changes in credit standards were made or are expected by critical masses of senior loan officers, then we can speak of an institutionalization process in the respective rule population: *a credit meso unit emerges*. Basically, the data reaches back to 2003; to this extent, we can currently analyse short-term institutionalization in European bank lending with regards to crisis effects, for instance. The BLS delivers highly detailed qualitative data, suitable for crafting further analysis with a credit rule taxonomy. We are thereby able to detect and categorize credit rules more specifically with regards to the prior elaborated generic rule-based approach. Moreover, analysts of Basel II and forthcoming legal frameworks for banks may categorize these rules within the realm of 0th order constituent rules as given in Table 2 and categorize them with regards to Table 1.

In the following, we focus on corporate lending (1a and 2a) and highlight significant factors for 1st order rule populations corresponding to Table 2. These are factors for *generic rules originated, adopted and retained by carriers for operations*. In combination with the rule taxonomy from Table 1, we separate them into social/organizational, behavioural and cognitive rules. We receive loan covenants as factors for social 1st order rules or collateral requirements as factors for cognitive 1st order rules, for instance. With regards to 2nd order rules we may highlight the perception of risk with regards to general economic activity as 2nd order behavioural rules and the bank's margin on average or riskier loans as 2nd order cognitive rules. In this respect we summarize factors for corporate lending

Table 3: A prototype taxonomy for credit rule population (1a)

cognitive	*behavioural*	*social*
costs related to bank's capital position; risk on collateral demanded; bank's margin on loans; non-interest-rate charges; size of the loan or credit	expectations regarding general economic activity; industry or firm-specific outlook	bank's ability to access market financing; competition from other banks, non-banks and market financing

Table 4: A prototype taxonomy for credit rule population (2a)

cognitive	*social*
fixed investment; inventories and working capital; debt restructuring; internal financing; issuance of debt securities or equity	merger/acquisitions and corporate restructuring; loans from other banks or non-banks

(credit supply rule population 1a) in a prototype taxonomy, given in Table 3, leaving aside the categorization of rule orders at the moment.

We elaborate the same framework for corporate lending within the credit demand rule population (2a), shown in in Table 4. For instance, we deduct 1st order demand-for-loan rules depending on basic financing needs regarding mergers and acquisitions or corporate restructuring. With the help of an explicitly formalized credit rule taxonomy we can see that the realm of behavioural rules (especially the trending and imitation of agents' activities) is unfortunately not covered within the questions on the demand for loans in the BLS. However, these rule taxonomies, as articulated in Tables 3 and 4, may serve as basic heuristics for the bottom-up foundations in artificial credit market modules of agent-based macroeconomic models.

In order to meet the demands of agent-based modelling, it is important to know on the one hand which factors trigger cognitive, behavioural or social rules, since

agents must be implemented with individual as well as social learning algorithms. On the other hand, it is about the timing of events; agents listen to different signals in nested ways, meaning in particular that rule iterations and specific sequences need to be implemented. Agents may be equipped with, create and use sets of credit rules in certain schemas, as exemplified in Algorithm 1. Where the actual phenomenon of rule-creation in the realm of credit markets is very difficult to implement, it is worthwhile to model credit rule adoption within specified rule populations, as already articulated.

Algorithm 1 Prototypic 1st-order credit rule implementation

  1: **for** bank $i \leftarrow 1, n$ **do**
  2:     **if** (risk on collateral demanded changed over past 3 months) **then**
  3:         (tighten credit standard somewhat)
  4:     **end if**   ▷ cognitive subject rule in (1a)
  5:     **if** (industry or firm-specific outlook changed over past 3 months) **then**
  6:         (tighten credit standard somewhat)
  7:     **end if**   ▷ behavioural subject rule in (1a)
  8:     **if** (competition from other banks changed over past 3 months) **then**
  9:         (ease credit standard somewhat)
 10:     **end if**   ▷ social object rule in (1a)
 11:     **if** (fixed investment changed over past 3 months) **then**
 12:         (expect somewhat higher demand for loans)
 13:     **end if**   ▷ cognitive subject rule in (2a)
 14:     **if** (mergers/acquisitions and corporate restructuring changed over past 3 months) **then**
 15:         (expect somewhat lower demand for loans)
 16:     **end if**   ▷ social object rule in (2a)
 17: **end for**

The prototypic pseudo code in Algorithm 1 refers to some selected credit rules stated as if-conditions in a loop over the population of banks; these rules are backward-looking. Of course, it is also possible to derive forward-looking rules on behalf of the BLS, but for these purposes we need to apply a deeper empirical analysis going beyond the scope of this paper. Moreover, the data of the survey
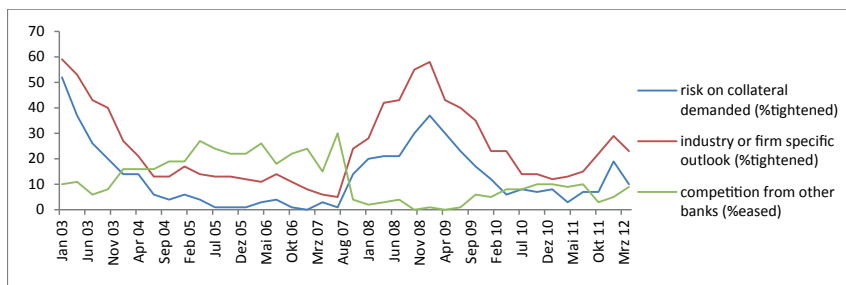
Figure 1: Credit standard changes in net percentage for exemplary (1a) rules

allows also for comparisons across countries of credit rule populations over Europe. However, the qualitative empirical material of the BLS does not contain any information on the factual movement of a given factor in a certain direction, which finally triggers the rule. We just know the magnitude of the rule activation due to a prior 'change' in the factor. For instance, with reference to Figure 1,[1] the survey data clarifies that in advance of the fall of Lehman Brothers all selected tightening rules were activated and the easing rule was deactivated almost synchronously by an increasing majority of European banks. In particular, it means that due to the risk on collateral demanded as well as the industry and firm-specific outlook, European banks have tightened somewhat their credit standards (credit-money contraction). Starting with August 2007, an increasing number of banks applied these rules while reaching a rule activation peak in December 2008. To this point in time, more than half of European banks have adopted the behavioural subject rule 'If industry or firm-specific outlook changed over the past 3 months then tighten credit standard somewhat', leading to a significant institutionalization process for European banking in this period. Of course, banks use and adopt a multitude of rules simultaneously.

Otherwise, Figure 2 indicates a decrease in demand for loans after the crisis due to the factors of fixed investment as well as mergers/acquisitions and corporate restructuring, leading to an endogenous drop in money demand from the perspective

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[1] Data Source for Figure 1 and 2: European Central Bank – Bank Lending Survey
https://www.ecb.int/stats/money/surveys/lend/html/index.en.html
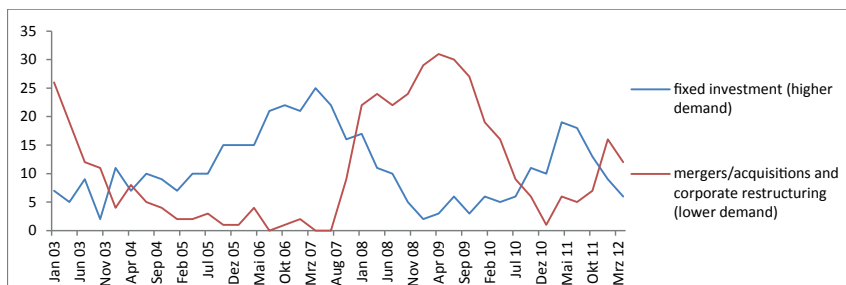
Figure 2: Percentage changes in loan net demand for exemplary (2a) rules

of corporate lending. For modelling purposes, the BLS data expressed in such a credit rule taxonomy may serve as a blueprint for rule (de)activation mechanisms in heterogeneous credit modules of agent-based macroeconomic models. In this paper we have focused on firm–bank relations (credit rule populations (1a) and (2a)) for didactic reasons, although the same schema can get applied to household–bank relations (credit rule populations (1b) and (2b)). As we mentioned above, it is important for agent-based models to have an empirical reference point for the timing of events and a concept for rule sequencing and perhaps also synchronization.

Once we have elaborated such a taxonomy and are able to compare the priorities of credit rules in their respective rule and carrier populations (*meso units*), we may apply the rule-based approach to compete with endogenous credit-driven innovation and money demand from the bottom up. Such institutional economic dynamics are based on the complex logic of rule variation, selection, retention and modularity, thereby shaping the nested character of individual and social learning. Credit tightening/easing as well as decreases/increases in credit demand are then considered under the umbrella of generic rule evolution, thereby relying on the ideas of bounded rationality (Simon 1991) and nested cognition (Kawamura 2009). These organizational aspects of bank lending also highlight the ontological category of a rule from an evolutionary computational perspective, i.e. generic credit rule speciation. Otherwise, the specific structural change of credit networks (Schweitzer et al. 2009; De Masi et al. 2011; Bargigli and Gallegati 2013) covers the developmental aspect of banks in credit rule environments, i.e. modularity of credit rule carrier institutions. Computational bottom-up simulation provides tools

to develop algorithms integrating downward and upward causation in particular between cognitive, behavioural and social credit rules. A proper evolutionary economic theory of credit rules looks into the co-evolution of these rule sets. Such an empirical investigation may guide the future architecture for a new family of evolutionary monetary macroeconomic models. A credit-focused rule-based approach is conceived as a promising methodological standardization for the institutional bottom-up foundations within further models of the banking-macro nexus.

5 Summary

This paper synthesizes a qualitative overview in terms of the history of ideas, the basic paradigmatic developments and the ontological demands towards realistic modelling strategies in evolutionary macroeconomics with an institutional approach. It is a central concern suggesting a pragmatic thread for thinking about and modelling the foundations of the banking-macro nexus. Top-down and bottom-up approaches face distinct agendas in economics, which go beyond the merely technical aspects. These are primarily related to certain trends in the history of economic thought, broadly the quantity theory of money and the Cambridge approach, and focus either on money supply and price level or on money demand and the motives or propensities of economic agents. Obviously, a credit-centred rule-based approach suggests further integration of the Schumpeterian aspect of credit-driven innovation with the post-Keynesian framework. Schumpeter never published a concise theory of money and finance comparable to the Keynesian approach. Minsky – as a graduate student of Schumpeter – took the opportunity to bring these grand scholars closer together through the business cycle aspects of investment and credit in the Keynesian 'General Theory' and the Schumpeterian 'Theory of Economic Development'; see Knell (2012). Perhaps Minsky's (1992) 'Financial Instability Hypothesis' was one of the first studies of the systemic problems in the banking-macro nexus within such frames. Obviously, phenomena relating to *emergence*, *diffusion* and *exit of rules* in the banking-macro nexus represent core issues for future enhancements in monetary economics. However, Minsky's legacy still remains in the realm of classical mechanics, although he emphasized

vehemently the inherent disequilibrating forces of the capitalist economy in the Schumpeterian tradition. As elaborated in this paper, the standard neoclassical methods of analysis – with their origin in classical mechanics – are not sufficient to grasp the versatile properties of endogenous change in complex economic systems. In contrast, the evolutionary approach hints exactly at this aspect. Today we are not obliged to discuss the potential of computational methods using evolutionary concepts in an appropriate bottom-up way for economic analysis. Many others have shown that the 'sciences of the artificial' are rewarding in such adventures, for example Simon (1991, 1996) or, more recently, Beinhocker (2007, 2011). In particular, formal computational methods can synthesize insights from the technical and instrumental knowledge of monetary transmission with heterogeneity and diversity in cognition, behaviour and socialization. The computational approach to economics allows for a meaningful use of rule taxonomies – it can capture the emergence, durability and exit of rule structures through individual and social learning in nested credit relations. These notions highlight the characteristics of proper bottom-up foundations. To this extent, the category of a *rule* also enables an appropriate scientific medium in which to craft more realistic models of monetary transmission. Again, we may refer to Herbert Simon when discussing how rules and heuristics serve as an empirical category for novel microfoundations – see Simon (1997). In this respect there is no doubt that the evolutionary economic agenda – with its emphasis on synthesizing empirical studies and formal modelling through the institutional approach – may contribute substantially to the realm of monetary economics.

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