Analyzing the co-evolution of central-bank policies and heterogeneous credit demand in an agent-based artificial monetary union

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Abstract

We present a generic and scalable agent-based model of artificial economies within a monetary union. The monetary union includes per country a final goods sector with basic import and export functionalities and a banking sector. The model is stock-flow consistent and builds upon local decision heuristics of heterogeneous agents characterized by satisficing behavior. These agents are households (workers and capitalists), firms, banks as well as a rudimentary government, capital goods firm and central bank. The agents' interactions lead to the emergence of typical macroeconomic aggregate relations. The presented model features two significant differences in contrast to standard macroeconomic models. First, it is fully micro-founded by including well known propensities and behavioral rules on the individual agents' level. Second, this artificial economy is an evolving complex adaptive system that develops in paths of disequilibrium that originate from the respective interplay of individual and social histories of agents and institutions. Correspondingly the macroeconomic layer is not result of a priori made macroeconomic assumptions represented as top-level equations but rather the emergent outcome of interdependent dynamics. Thus, it is possible to study the impact of various policies on the individual level and the responses of heterogeneous firm, household and bank populations to economic and institutional changes on the aggregate and individual (macro and micro) level. In this particular paper we perform simulation experiments with heterogeneous bank lending. Banks employ different strategies in tightening and easing their credit standards of corporate lending. We follow a generic evolutionary rule-based approach and endow firms with different lending rules across the monetary union. Empirical evidence on this respective credit rule population and their observed dynamics is given by the Bank Lending Survey of the European Central Bank. To this extent we endogenize interest rate setting for loans not just on behalf of central bank actions, firm performance and financial exposure but moreover on the endogenous and heterogeneous credit demand rules. The paper aims to provide a deeper understanding on the co-evolutionary dynamics between various central bank policies and the heterogeneous as well as endogenous firm demand for credit. We aim to analyze effects on macroeconomic performance such as real GDP growth, price inflation, investment, aggregate demand and employment. Further simulation experiments shall deliver new insights on rule correspondence and (a)synchronization between commercial banks and the central bank.

1. Introduction

The recent economic crisis has shown that credit crunches have far-reaching consequences for the world economy when global interbank-markets freeze. A credit crunch or liquidity trap is a highly complex economic phenomenon, because its origin and nature lies in *systemic* characteristics covering the whole economy and not only the financial markets. Moreover the provision of credit-money sustains the financial as well as the goods market by connecting them both; thereby it guarantees the continuity of economic operations. On the other side intensive credit expansion may lead to economic bubbles and high inflation in the long run. This is the major reason why central banks have to balance their set of possible policies. Monetary policy involves huge feedbacks between all connected economic agents (states, banks, firms, households). The complex logic of money demand and supply makes the provision and control of credit-money to a very interesting but difficult economic topic, especially from the perspective of the actors. Uncertain economic agents incorporate roles of *agenda setters* and *agenda receivers*.

Central banks as agenda setters are in the focus of economic attention today. They increasingly fulfil and represent powerful roles within global political economy. The economic power of nation states has decreased in the last decades, since financial complexity has grown to immense extents. In 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. The impact of monetary policy on the economy is traditionally conceived along the *monetary policy transmission mechanism*. Central banks argue that the policy rate manifests itself in wages, prices and output along four major transmission channels, compare Mishkin (1996): The interest rate channel, the credit channel, the exchange rate channel and the wealth channel. In general the interest rate channel represents the quantity theory of money in its purest sense, because cost-of-capital gets influenced by the central bank's leverage on short-term interest rates. Nowadays we know that arguments relying just on this perspective may not be satisfactory for the greater picture, as admitted by Bernanke and Gertler (1995). The credit channel works along the external finance premium representing the difference between firm's internal and external costs for capital, consequential 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 respectively on the degree of openness of the economy, which is with regards to Eurozone development less important at the moment. The wealth channel is related to movements within the stock market and its asset price fluctuations.

In this paper we investigate the credit channel as an institutional structure that keeps the economy alive. Standard macroeconomic models such as dynamic stochastic general equilibrium models (DSGE) are basically not able to capture these dynamics since they don't incorporate frictions in the credit market, e.g. Christiano et al. (2005) or Smets and Wouters (2007). Where researchers try to include frictions in the aftermath of the crisis today (Christiano et al. 2010), we believe that the methology of DSGE does not fit the problem at hand, since it has been shown that systemic characteristics of endogenous dynamics play a

more significant role for emergent credit crunch, liquidity trap and even crisis. In contrast we refer to the agent-based modelling methdology that is able to introduce the credit channel as an institutional structure. Particularly we see the dynamics of credit demand rules within the corporate sector as crucial vehicles of change in a monetary union with different economic situations per country (e.g. purchasing power, inequality, employment). Moreover recent approaches using agent-based methdology have indicated that interdepencies with other economic sectors such as the goods and labor market are significant to include.

We use a macroeconomic multi-agent model (ABM) of an artificial monetary union that accounts for different types of boundedly rational behaviors of agents (households, firms, banks, governments) in a macroeconomic systems setting (Rengs and Wäckerle, 2014). The model belongs to a very small set of agent-based models in macroeconomics and political economy, which respond to a call in economics to give more attention to heterogeneity and complexity in financial- and macroeconomics (LeBaron and Tesfatsion, 2008; Farmer and Foley, 2009; Delli Gatti et al., 2010; Stiglitz and Gallegati, 2011). However, our model is to our knowledge one of the first that represents the institutional structure of a real monetary union with different economic situations in the specific artificial countries. In our model, households consume subsistence goods (serving basic “needs”) and additional, luxury goods (serving additional “wants”), depending on their class and budget. The consumption of the first is necessary, while behavior anomalies such as status and imitation, associated with specific consumer classes (“workers”, “wealthy workers” and “capitalists”) motivate people’s consumption of the luxury goods. Status or snob effects make firm and bank owners and upper working class members to switch the consumption of extra goods and search for new firms, thus forming an important driving factor of economic innovation.

The remainder of this paper is organized as follows. Section 2 introduces the basic ABM, including its general structure, the different agents, core parameters and unique features in comparison with similar model approaches. In section 3 we introduce bank lending and the evolution of credit rules as an institutional structure into the model. Furthermore we motivate the implementation of credit demand rules from a qualitative empirical perspective on behalf of the European Bank Lending Survey. Section 4 provides an outlook and characterization of planned simulation experiments.

2. The basic macro-evolutionary multi-agent model

The model we present encompasses a full macro-economy that evolves from bottom-up according to agent-based methodology (Tesfatsion and Judd, 2006; Gilbert, 2007), building upon the framework presented in Rengs and Wäckerle (2014). Its computational simulation follows a stock-flow structure that is consistent with the so-called balance sheet approach (Godley and Lavoie, 2012). It includes the following sectors: households, firms, banks, central bank and government. All sectors are disaggregated, except central bank and government, in the sense that they are composed of a multitude of agents and their interactive dynamic relations. Our model is close in spirit to recent models by Cincotti et al. (2010), Delli Gatti et al. (2011), Riccetti et al. (2013) and Chen et al. (2014). Moreover, in terms of scale and scope it is roughly comparable with the models by Seppecher (2012) with a focus on labor markets, Dosi et al. (2013) emphasizing capital goods, banking and innovation, and Lengnick (2013) with a simplified general purpose model.

Our model differs from these other approaches in a number of ways, notably distinct ownership and consumer classes with unique behavioral features and a detailed financial sector. In addition, the model can generate emergence of specialization patterns of firms in terms of the needs and wants servicing goods, while at the same time also specializing in the attraction of customers from different classes. In other words, a firm can for example initially produce goods that mainly serve basic needs, and over time shift to serving more want-related goods. This avoids the more common approach of starting with a fixed classification of firms or sectors with particular goods that permanently retain their character. Our approach is parsimonious (simplified) without sacrificing richness in explanatory power.

The approach considers the economy as a complex evolving system that organizes itself endogenously. This is reflected by notions like non-equilibrium dynamics, (in)stability, systemic risk and vulnerability. The recent financial crisis has once more shown that these are central to understanding crucial macroeconomic issues. To add realism to the model, economic agents are described as being heterogeneous and boundedly rational, where we follow the heuristic and algorithmic concept of satisficing decision rules and adaptive behavior (Simon, 1987; March, 1991; and Winter, 2000). Next, we treat the government, the central bank, markets and organizations (firms, banks) as formal institutions and social norms as informal institutions. The latter are described as dependent on agent networks and their dynamics. This steers consumption behavior taking the form of imitation (bandwagon effects) and status seeking behavior by different consumer classes. In the case of status seeking behavior, we consider Veblen effects (conspicuous consumption) and snob effects; both with a focus on luxury goods, where the first is about high-price and the second about rare goods. Because of the population structure of the different agent groups (especially consumers and firms) the model can generate so-called co-evolutionary institutional change (van den Bergh and Stagl, 2003; Hodgson, 2006; Dopfer and Potts, 2008; Wäckerle, 2014).

In what follows we introduce the various types of agents in the model, which include households, firms, the banking system (commercial and central bank), and the government. Figure 1 provides an idea of the main structure of the model, focusing on monetary flows in the economy.

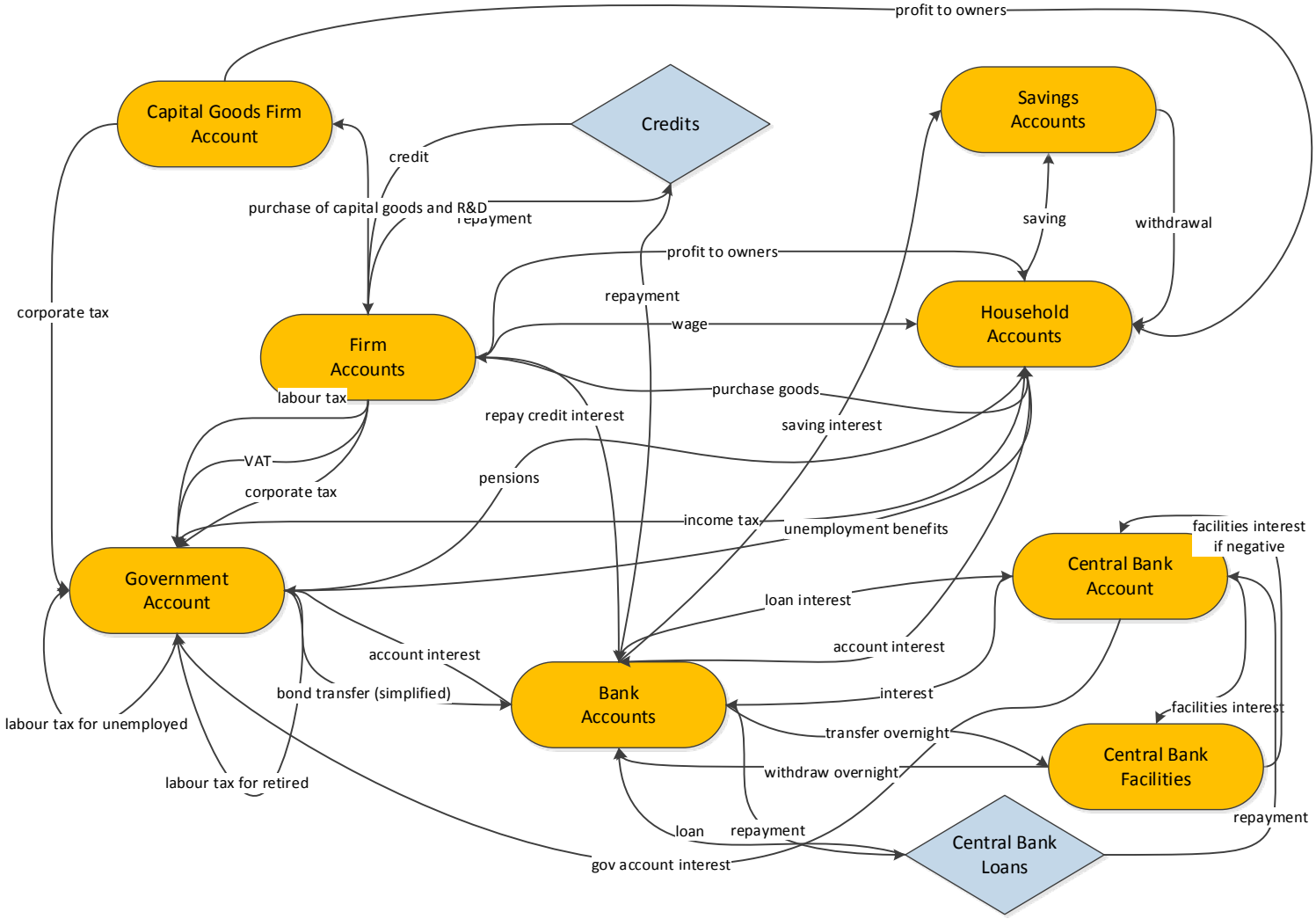

Figure 1: Monetary flows of a representative single artificial economy in the monetary union

Households

Households don't optimize their consumption behavior, but are instead assumed to be rather loyal or rigid in their choice of vendors, while also being open to new opportunities that arise. Their decisions (namely, which firms' products to buy) are linked to two differently motivational aspirations: need and want consumption. The tendency to buy from a specific firm then depends on the respective aspiration, the current product's relative price and firm reputation. The latter two are based on well-documented consumer behaviors: bandwagon, Veblen and snob effects. The consumption decision differs with respect to social class; capitalist households and wealthy workers have a higher saving rate than workers.

Households choose their seller in a boundedly rational way, by having a short list of preferred "vendors" at any given time (following Lengnick, 2013). They try to buy equal amounts from each firm on their list, as firms' stock and household budgets permit. Households actually employ two lists, one for needs and one for wants. Initially, each of these lists consists of *n* randomly chosen firms. During the simulation, households change the composition of these lists based on their preferences, slowly improving them in each round. As preferences are assumed to be different for needs and wants, these two lists will tend to comprise different firms. In the case of need consumption, households replace a firm that did not deliver – because of insufficient production or inventory – by another, randomly chosen one. In the want case, households do not immediately replace a firm that could not deliver, as it indicates a highly sought after good. Instead, they wait up to three months before randomly choosing a new one.

If a seller (firm) is considered for potential replacement and is perceived to be better (by some small but noticeable degree) in terms of price and firm reputation (implying a utility premium for a household consuming its good) than the one selected for potential elimination from the list, the replacement is effectuated. The rules employed in this comparison partially depend on prices and firm reputation (market shares), following the dynamics of imitation and status-seeking behavior (conspicuous consumption à la Veblen, 1899). In this respect we follow on the one hand Veblen's general suggestion of trickle-down effects in social structure (Trigg, 2001) due to working class consumers imitating capitalist class consumers. And on the other hand we are inspired by Leibenstein (1950), who specified consumption dynamics as resembling a bandwagon effect (imitation of other consumers) and contrasted it to the status-seeking Veblen effect (luxury consumption) and snob effect (consumption striving for rare goods – "exclusiveness"). We model Veblenian consumer dynamics in a similar manner as Kapeller and Schütz (2014), but with substantially more details about the differences in quantity and price effects as well as about underlying population dynamics.

It is worthwhile to cite Leibenstein (1950, p.205) in this context: "Any real market for semidurable or durable goods will most likely contain consumers that are subject to one or a combination of the effects discussed heretofore." Leibenstein concludes that there are four possible combinations dependent on price (normal price and Veblen effect) and firm reputation (bandwagon and snob effect). We extend his framework with need and want aspirations as well as social structure. This leads us to the following combinations of aspiration (want and need) and social structure (workers, wealthy workers, capitalists).

Household consumption behavior is highly heterogeneous and dependent on social class. Changes within social class identification are endogenously possible (capitalist may go bankrupt with their firm, wealthy workers may found a firm, etc.), but it cannot appear abruptly; meaning in particular that if there is a change in social class it happens with a lagged duration (set at three months).

Workers, wealthy workers, capitalists have different preferences and behaviors. Workers' need consumption has a high normal price effect (indicating a strong preference for the cheap over the expensive) and a low bandwagon effect. Workers imitate the behavior of all need consumers. Worker want aspirations have a low normal price effect (indicating a weak preference for the cheap over the expensive) and a high bandwagon effect (they imitate the capitalist want aspirations). Whereas wealthy workers follow the same bandwagon, they further consume on behalf of a weak Veblen effect (weakly prefer the expensive over the cheap). Finally capitalist (firm and bank owners) needs are triggered by an average snob effect (searching for rare goods – inverted imitation) and an average normal price effect. Capitalist wants work with the same bandwagon but additionally with an average Veblen effect (they prefer the expensive over the cheap).

As indicated before, households consume needs and wants with different motives, leading to different vendor choices. The amount of goods that are bought also differs with regards to needs and wants. Needs on the one hand are fixed amounts of consumption goods that every households needs to buy each period. Wants on the other hand are satisfied by buying goods up to the sum set aside for consumption in this period minus the costs for the needs. Whereas the period's consumption sum corresponds to a period's wage minus saving plus a small fraction of savings as long as a household is not indebted. Worker households set aside most of their wage for consumption, wealthy workers set aside a little bit less for consumption, while capitalist households again set aside a little bit less than wealthy workers.

Consumption behavior is thus not static but a co-evolving process between behaviors of consumers and social structure; i.e. a dynamic interplay between individual aspirations (need/want), status-seeking behavior, wealth and imitation dependent on emergent social structure driven by interactive evolution of populations of different classes of consumers.

Firms

A second group of agents are firms, which produce final goods using inputs of capital and labor. They employ a firm-specific production technology, with respect total factor productivity and emissions per output unit being heterogeneous among firms. Firms start with a number of differently scheduled credits (each with their own duration) emulating the reinvestment necessary to uphold the constant capital level to counter depreciation. They can apply for loans at banks operating in a credit market to increase or maintain production capacity. Goods-producing firms acquire capital from a single firm that produces capital goods. Physical capital is complementary to the production factor of labor. The capital goods firm is owned (as a crude proxy) equally by all households, who receive profit shares in relation to their wealth. Every month, a full production cycle up to delivery to final demand is achieved.

The initial firm population starts with randomly (using a uniform probability distribution) assigned workers, resulting in slightly heterogeneous firms in terms of numbers of workers. These are then assigned a matching physical capital stock, in accordance with labor productivity and start with homogenous production technology.

Every round each firm adjusts its production by monitoring the level of goods left in the inventory after sales. If sales exceed expectations, i.e. the inventory contains less than the targeted reserve stock (Godley and Lavoie, 2012), the firm decides to increase its output. The reserve stock is calculated by multiplying the firm's sales in the previous period by the production reserve stock rate. Unsold stock depreciates over time since "old" goods are more difficult to sell over time. Prices are adjusted analogously to production, i.e. in relation to the level of under- or overestimation of sales. They are changed by small amounts and never fall below the estimated marginal cost per unit of output plus some mark-up. If the planned production requires more physical capital than available, the firm tries to get a loan to buy the additional machinery. Otherwise the firm maintains its current capital stock, since it cannot reduce it actively in this model, as opposed to the input of labor, which can be adjusted by hiring or firing workers, although with some delay (an interpretation of this could be protection by labor laws; cf. Seppecher, 2012). Physical capital depreciates annually so that the firm will need to reinvest if it desires to maintain the current level of physical capital. The profits of the firm accumulate in its current account over a whole fiscal year (12 months). At the end of the year funds are set aside for research and development (R&D) investments and corporate taxes are applied to the remaining amount. The rest is transferred to the firm owners. Firms adapt the wage based on the average increase of prices.

Firms make their investment decision based on their estimated profit rate, defined as the ratio between profit and physical capital. The estimated profit of the firm is given by expected revenues minus current wages, interest payments, fixed credit repayments and expected additional credit costs. Obviously, if the profits become too low the firm needs to fire workers and reduce capital inputs, which together will lead to lower production output. In the process, firms may go bankrupt, in which case capitalist households owning the firm become unemployed.

Every period one new firm can be founded by the wealthiest worker household with a low probability. On founding, the owner of the new firm endows the firm with an operating budget for the first quarter and invests in initial machinery. The former are fully financed out of the households budget (savings), the latter is equally financed out of own budget and in form of firm credits. This is used as a proxy for risky private investment, and results in private debt which the owner cannot transfer to the firm. Newly founded firms start with production and emission reduction technologies that represent the average technology of the current firm population.

Banking system

Basically banks keep current accounts for firms, the capital goods firm and households (allowing for deficits) and savings accounts for households. In addition, they grant firm loans. They pay and charge interest for these different financial services applying distinct rates, limited by central bank interest rates. Banks have to refinance themselves, by monitoring assets (loans) and liabilities (savings). If banks lack liquidity they request loans at the central bank.

The central bank keeps current accounts for the governments (including overdraft functionality) and banks, as well as deposit facilities for banks, involving the paying or charging of interest. Furthermore it acts as a lender of last resort, but for the presented simulation experiments it does not accommodate any monetary policies.

Governments

The governments serve various roles in the model. They make transfers to unemployed and retired households, and collects taxes on labor, income and capital gains, corporate profits made by banks and firms and the capital good firm, and value-added of sales. The governments' budgets in the model are never perfectly in balance because of uncertainty about both tax revenues and government expenditures – as is the case in reality. As unemployment benefits and pensions are downward rigid, the governments have no means to cut costs and has to deficit spend if necessary. If indebted, they pay interest to banks and households (in relation to their wealth) as a proxy for government bonds. As there is one big budgetary expenditure position for our artificial governments which may vary greatly (unemployment subsidies) in dependence of the country's economic performance, governments may also be in surplus for prolonged periods depending on parameter settings. If the governments' budgets are in surplus at the end of the year, it transfers the surplus to the households in form of flat subsidies, i.e. every household gets the same share. These subsidies are transferred to the households partially on a monthly basis and immediately transferred to their savings accounts.

3. Heterogeneous credit demand as an institutional structure

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, compare Wäckerle (2013) for an evolutionary institutional economic account of credit-money.

The notion of credit inhibits investment opportunities for economic actors, which make the system disequilibrating and vulnerable to critical mass processes. 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 the cognitive, behavioural and social aspects of monetary intermediation and its effects on real economic activity.

Table 1 Generic rule taxonomy

Generic Rules			
Subject		*Object*	
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, p. 8)

The rule taxonomy provides a comprehensive categorization of what does and what may happen in an economy, but it needs active heterogeneous 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). In this paper, we concentrate on a first step for applying a generic rule-based methodology in agent-based macroeconomic models.

We suggest a prototypic generic credit rule taxonomy for credit demand rules on firm level according to a qualitative empirical survey of credit supply and demand. Hence, focus is given to the firms as credit demand rule carriers. However, this first experimental endeavour may easily serve as a schema for interconnections in a greater set of credit rule populations. In order to analyze 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. In our paper we focus on the development of credit demand rules and conceive the corresponding credit demand rule population as following.

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).

In the following, we focus on corporate lending – in particular credit demand – and highlight significant factors for 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 and cognitive rules for this case.

Table 2 A taxonomy for credit demand rules

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

4. Outlook on Simulation Experiments

Our model allows analysis of a variety of macroeconomic problems in a monetary union that are not tractable by the general equilibrium approach. First, it features a multi-country perspective tied together through a monetary union. Economies are heterogeneous by nature and structured differently with respect to productivity and aggregate demand. We aim to investigate the effects of various central bank policies on the firm structure in every country and particularly on market selection driven by consumption across countries. This effect becomes crucial if consumption is different due to social class and income/wealth inequality within and between countries. Second, in our demand-based system, consumption drives firm growth and specialization which makes the notion of credit demand significant. On behalf of empirical evidence from the European Bank Lending Survey we aim to introduce different credit demand rules in heterogeneous firm populations, again within and between countries. Third, this demand is basically dependent on the behavior of the central bank which is able to employ a variety of policies in our model. These points guide our planned simulations experiments for this paper. They involve co-evolutionary dynamics between central-banking, credit demand and firm expansion on behalf of evolving consumption behavior.

References

Berg, J., Rixtel, A., Fernando, A., de Bondt, G. and Scopel, S. (2005). The Bank Lending Survey for the Euro Area. European Central Bank Occasional Paper Series No.23.

Bernanke, B.S. and Gertler, M. (1995). Inside the Black Box: The Credit Channel of Monetary Policy Transmission. The Journal of Economic Perspectives, Vol. 9 (4): 27-48.

de Bondt, G., Maddaloni, A., Peydró, J.-L. and Scopel, S. (2010). The euro area bank lending survey matters: Empirical evidence for credit and output growth. European Central Bank Working Paper Series, No. 1160.

Christiano, L.J., Eichenbaum, M. and Evans, Ch.L. (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. Journal of Political Economy, Vol. 113 (1): 1-45.

Christiano, L.J., Motto, R. and Rostagno, M. (2010). Financial Factors in Economic Fluctuations. European Central Bank Working Paper No. 1192.

Cincotti, S., Raberto, M. and Teglio, A. (2010). Credit money and macroeconomic instability in the agent-based model and simulator Eurace. Economics: The Open-Access, Open-Assessment E-Journal 4: 2010-2026.

Chen, Shu-Heng, Chang, Chia-Ling and Wen, Ming-Chang, (2014). Social networks and macroeconomic stability. Economics: The Open-Access, Open-Assessment E-Journal 8 (2014-16): 1-40.

Delli Gatti, D., Gaffeo, E. and Gallegati, M. (2010). Complex agent-based macroeconomics: a manifesto for a new paradigm. Journal of Economic Interaction and Coordination 5: 111-135.

Delli Gatti, D., Desiderio, S., Gaffeo, E., Cirillo, P. and Gallegati, M (2011). Macroeconomics from the Bottom-up. Springer, Berlin.

Dopfer, K. and Potts, J. (2008). The General Theory of Economic Evolution. Routledge, London.

Fagiolo, G., Napoletano, M. and Roventini, A. (2013). Income distribution, credit and fiscal policies in an agent-based Keynesian model. Journal of Economic Dynamics and Control 37(8): 1598-1625.

Farmer, J.D. and Foley, D. (2009). The economy needs agent-based modelling. Nature 460: 685-686.

Gilbert, N. (2007). Agent-Based Models – Quantitative Applications in the Social Sciences. Sage Publications, London.

Godley, W. and Lavoie, M. (2012). Monetary Economics. An integrated Approach to Credit, Money, Income, Production and Wealth, 2nd edition. London: Palgrave MacMillan.

LeBaron, B. and Tesfatsion, L. (2008). Modeling macroeconomies as open-ended dynamic systems of interacting agents. American Economic Review 98 (2): 246-250.

Leibenstein, H. (1950). Bandwagon, snob, and Veblen effects in the theory of consumers' demand. The Quarterly Journal of Economics 64 (2): 183-207.

Kapeller, J. and Schütz, B. (2014). Conspicuous consumption, inequality and debt: The nature of consumption-driven profit-led regimes. Metroeconomica (online first) 1-20.

Lengnick, M. (2013). Agent-based macroeconomics: A baseline model. Journal of Economic Behavior & Organization 86 (C): 102-120.

Maddaloni, A. and Peydro, J.-L. (2010). Bank risk-taking, securitization, supervision and low interest rates: Evidence from the euro area and the U.S. lending standards. European Central Bank Working Paper Series No. 1248.

Mishkin, F.S. (1996). The channels of monetary transmission: Lessons for monetary policy. Banque de France Bulletin Digest No. 27.

Rengs, B. and Wäckerle, M. (2014). A Computational Agent-Based Simulation of an Artificial Monetary Union for Dynamic Comparative Institutional Analysis. Proceedings of the 2014 IEEE Conference on Computational Intelligence for Financial Engineering & Economics (CIFEr): 427 – 434.

Riccetti, L., Russo, A. and Gallegati, M. (2013). Unemployment Benefits and Financial Leverage in an Agent Based Macroeconomic Model. Economics: The Open-Access, Open-Assessment E-Journal 7 (2013-42): 1—44.

Seppecher, P. (2012). Flexibility of Wages and Macroeconomic Instability in an Agent-Based Computational Model with Endogenous Money. Macroeconomic Dynamics 16 (s2): 284-297.

Smets, F. and Wouters, R. (2007). Shocks and Fricitions in U.S. Business Cycles: A Bayesian DSGE Approach. American Economic Review 97 (3): 586-606.

Stiglitz, J.E. and Gallegati, M. (2011). Heterogeneous interacting agent models for understanding monetary economies. Eastern Economic Journal 37 (1): 6-12.

Souleles, N.S. (1999). The Response of Household Consumption to Income Tax Refunds.

Tesfatsion, L. and Judd, K.L. (2006). Handbook of computational economics: Agent-based computational economics, vol. 2, North Holland, Amsterdam.

Trigg, A.B. (2001). Veblen, Bourdieu and conspicuous consumption. Journal of Economic Issues 35: 99-115.

Wäckerle, M. (2013), On the bottom-up foundations of the banking-macro nexus Economics: The Open-Access, Open-Assessment E-Journal, 7(2013-40): 1-45.

Wäckerle, M. (2014). The foundations of evolutionary institutional economics: Generic institutionalism. Routledge, Abingdon.

Winter, S.G. (2000). The satisficing principle in capability learning. Strategic Management Journal 21: 981-996.