

## Money Creation and Financial Instability: An Agent-Based Credit Network Approach Answer to Referee Report 1

*Referee:* The authors explore an interesting and original avenue of research which has been growing rapidly in recent years: the development of agent based models of a monetary economy. In addition, the authors try to achieve macroeconomic (stock-flow) consistency of their results, which is an issue often neglected in similar simulation models, although it is essential for any macroeconomic model to be logically coherent.

We are happy that the referee is generally sympathetic with our approach. All given comments are constructive and will surely help to increase the readability and quality of the paper. We have taken careful consideration of all comments and hope to meet the referee's expectations. Below, we answer every point in detail.

*Referee: 1.* The authors choose to concentrate on the monetary side of transaction among individuals and banks, adopting very simple assumptions on production and demand of goods and services, which are the rationale for the demand of financial assets.

*It is not clear what are the implications of such assumptions for the results in the paper. The demand for cash and bank deposits, which is explicitly modeled by the authors, has a rationale when investment plans must be financed in advance, and depends on the size of such plans, while the demand for liquidity from individuals depends on expenditure and uncertainty.*

*It would be interesting therefore to discuss more in detail what are the consequences for the results of the paper of their assumptions about investment and consumption of individuals/firms in the model*

In line with the literature (Bezemer, 2011 among others), we tried to combine ACE with the SFC approach to explicitly account for the financial sector. Thereby, we focused on behavioral rules of agents which are as simple as possible but are still able to generate complex dynamics, i.e. we implemented zero-intelligent agents (Chen, 2012). Furthermore, we capture the encouragement of Caverzasi and Godin (2013) for a didactical use of SFC models which should ease the comprehension of economic dynamics if they're sufficiently simple.

*Referee: 2.* The authors explicitly refer to the stock-flow-consistent (SFC) literature for their assumptions about the balance sheet of all agents in the model. However, the authors' version of stock-flow-consistency seem only to imply the obvious fact that a cash payment for an agent is a cash receipt for another agent, and that both transactions must be taken explicitly into account.

Regarding SFC we refer to the definition of *Patterson and Stephenson* (1988), p. 789, whereupon flows induce changes in stocks of equal size. Moreover, according to the SFC literature (e.g. Caverzasi and Godin, 2013), we see stock-flow consistent models as a kind of macro models which integrate all stocks and flows of the economy using its main components, namely a (consistent) double-entry accounting framework and behavioral rules/equations.

These models are typically formalized by a set of matrices which reproduce balance sheets and transactions of each sector of the economy by explicitly accounting for the change of stocks due to flows of the current period, i.e. at an aggregate level. Since our aim is to provide proper micro-foundation we model every single balance sheet of every single agent which enables us to avoid the sectoral matrix representation of the model.

Moreover, we define the Equity position in the balance sheets according to the standard financial

reporting rules of the FASB: "Equity or net assets is the residual interest in the assets of an entity that remains after deducting its liabilities" (*Financial Accounting Standards Board, Statement of Financial Accounting Concepts No. 6, Elements of Financial Statements, 1985, page 21.*)

*Referee:* It turns out that the Central bank has no assets! And therefore it is not clear what the Central bank "equity position" is. In the SFC literature, as in reality, the Central bank issues cash in exchange for other financial assets (discount operations etc with banks; government bills etc.; foreign currency, ...)

Our intention was to keep central bank behavior as simple as possible. Therefore we decided to restrict the central bank's behavior to external control of the money amount and requiring a minimum reserve. We are, however, aware that our modern monetary system has a lot of important aspects that are still missing in our model. Of course one could integrate all the aspects of modern central banking (like RePos, standing facilities, ...), and indeed we plan to do so in a future version of the model. What we can do (already in this version) is to give banks the possibility to refinance via RePos with the central bank. Since this question overlaps with block 5 below, we give a detailed answer there.

*Referee:* 3. In connection to the previous point: the authors justify their assumptions about money demand on the basis of the "standard macroeconomic textbook" which derives the "multiplier of bank deposits" that the authors adopt as the basis of the behavior of agents. The authors seem to ignore the fact that practically all of the SFC literature considers the "standard macroeconomic textbook" approach to be wrong, unrealistic, and inconsistent, since the only way for money to be injected into the system in a way consistent with the "money multiplier" is an helicopter drop, which the authors actually adopt, thus making their model completely unrealistic. In my view it is wrong to talk of "The Endogenous Creation of Money" (page 11) when money is initially created through an exogenous helicopter drop, and only later "endogenously" multiplied through bank deposits.

In our model we use different monetary aggregates: Cash, Reserves and Credits which constitute M0 and M1. With endogenous, we mean that the private (banking) sector creates part of the aggregate M1 by granting credits to the households. Instead of just calculating the equilibrium outcome of this aggregate we let it grow by an interactive process. Money is therefore a result of the behavioral interactions, insofar it is endogenous. Maybe we have to point out that money is not yet endogenous as it is in the "endogenous approach to money" found in the Post Keynesian literature to avoid confusion.

*Referee:* 4. A minor point regards the assumption about banks "withdrawing a credit" (page 9), which again is completely unrealistic, as the authors admit, and when introduced has the potential to create by itself a financial crisis.

We are aware that the withdrawal of credits is not a realistic behavior. We failed however to discuss that we use this assumption only as a proxy. In reality banks grant credits to the real sector for a given period of time. During this time they cannot simply withdraw such credits at any time. What they can do, however, is to refuse the renewal of due credits. Although we have this process in mind, we decided (for simplicity) to apply another modeling approach.

Under normal conditions a loan (once granted) runs forever. We interpret this as the bank permanently renewing it when becoming due. This simplifies our model a lot since we do not have

to model explicitly all the thousands of different individual loans. The only thing we have to account for in our model is the case when a bank refuses to renew a loan. Technically we model this by sending the “withdraw” signal but we have in mind that an old loan is not renewed.

We are clear that the process of bringing outstanding loans down takes some time. A bank has a large number of loans that are all due at another point in time. When bringing loans down, the bank therefore has to wait for one loan after the other to become due. This aspect is accounted for in our model by assuming that only one “withdraw” signal can be sent at the same time and each household only pays back a fraction of the loan (approximately 15%) each time.

We are clear, that we have to clarify better what we have in mind, and that this signal sending is only a proxy for a more realistic process.

*Referee: 5. I would strongly encourage the authors to further develop this line of research, at least by changing their assumptions about bank behavior towards realism, so that banks can obtain cash from the Central bank to fulfill loan requests – an assumption which will make the C.B. balance sheet look more reasonable.*

We absolutely see this point. We are aware that the exogenous approach to money (with money dropping from the helicopter) is not very realistic. However, our intention was not to argue in favor or against the endogenous money approach. We wanted to demonstrate the power of agent-based modeling.

Mainstream economics focuses on equilibrium. As a result its models are intrinsically very stable and optimal in some sense. We show that an equilibrium is only a limiting case of a much richer process. Relaxing the equilibrium assumption in such a way, is extremely interesting since it allows to analyze endogenous breakdowns. To make this point as clear as possible and for the reader as easy to understand we stay close to the mainstream approach.

Of course this can also be done within an “endogenous money approach”. But this makes our model much more complicate and the article much more lengthy. It also makes the paper less understandable from a mainstream perspective.

We are already working on a model with “endogenous” money. So there is one thing that we can offer for the current paper that would be achievable in reasonable amount of time and article pages: We can add a section where we endow banks with some kind of save assets (e.g. AAA-bonds). In order to get high powered money, the banks could make use of RePo operations with the central bank. In this way we can make the banks and central bank less passive and also move into the direction of the “endogenous approach”. This is the final goal of a future version anyway.

Tentative results show that our main findings do not change significantly. The exogenously given level of AAA-Bond does influence the stability of the system but the equilibrium and the possibility of crisis and breakdowns are preserved. We may also be able to analyze the effect of the level of bank equity on the systems' stability. E.g. one can be interested in systemic risk as a function of the Core Capital Quota (as defined in BASEL 3). We conjecture that stability will grow monotonically with CCQ and maybe reach an upper bound at some given value. Such analysis requires, however, to perform a series of monte carlo experiment which imposes a tremendous computational burden. We have not been able to perform such analysis so far.