Reply to invited reader comments

We are grateful to the invited reader for her/his appreciation of our work, and for her/his useful comments. We reply in the following.

Major issues

Some clarification about the Eurace model

The technological part of the Eurace framework, and the bulk of the Eurace economic model, have been developed from 2006 to 2009 during the Eurace European project (EU IST FP6 STREP grant: 035086), coordinated by the University of Genova, where all the three authors of the present paper were working at that time. Since the end of the project, the Eurace economic model has been mainly developed in two research directions. The first one, that has been carried out by the authors of the paper, is more closely related to financial stability issues, while the second one, more related to issues concerning innovation and spatial structure, has been mainly developed at the University of Bielefeld, former partner of the Eurace consortium.

In 2009 the Eurace project delivered a Final Report with the description of the Eurace model that is now outdated, due to the work of the last 2 years. From our side, the current description of the Eurace model is presented in this paper, and its recent evolution can be traced from our last works (cited in the body of the article). The code and the details of the implementation of the model are available on request under a confidential disclosure agreement. On the side of the Bielefeld group, a detailed description of their recent evolution of the Eurace model (called Eurace@Unibi) can be retrieved here:
http://www.wiwi.uni-bielefeld.de/vpl1/research/eurace-unibi.html

The monetary aggregate in Eurace

To meet the invited reader's request we have added a new plot (figure 7) where we show the dynamics of the monetary aggregate in the Eurace economy for the three different values of αs considered. We define here the monetary aggregate as the sum of all private (i.e., held by households and firms) and public (i.e., held by the Government and the Central Bank) deposits plus aggregate banks equity. It is worth noting that, with respect to the standard definition of monetary aggregates, we include also the aggregate banks' equity in the def-

inition. This choice has been made to get a more appropriate measure of the monetary aggregate in the Eurace economy. because banks' equity can become negative, as it actually happens in the case of $\alpha = 9$ (see the bottom part of figure 3) and there is no mechanism of government bailout or of recapitalization of banks. If these mechanisms would be in place, aggregate banks' equity would be prevented to become negative at the expense of government and/or households liquidity and the monetary aggregate, defined in the standard way, would be lower accordingly. Therefore, it is important to include also aggregate banks' equity here to account for this feature.
The results showed in Figure 7 is in line with the analysis presented in the paper, showing that the monetary aggregate grows faster for higher αs in the first part of the simulation, due to the lower capital requirement requested to banks. The trend of the monetary aggregate clearly resembles the one of banks loans, because new loans "create" new deposits in the sense explained by endogenous money theory, see e.g. Fontana (2003). However, in the long run we observe that for high α the monetary aggregate falls, as a consequence of the debt deleveraging effect. Finally, it is worth noting that quantity easing in not in place in the simulations considered in this papers. To get more insights about how quantitative easing works in Eurace and about the identity between Eurace monetary aggregate on one side and the credit money created by commercial banks plus fiat money created by central banks, we invite to refer to our previous study: Cincotti et al. (2010). The above comments have been reported in Section 7.1.

Value of capital adequacy ratio according to Basel II

Basel II requires that the total capital ratio must be no lower than 8%, i.e., the minimum capital required is 8% of risk weighted assets. Additional information can be found in the web site of the Bank for International Settlements [1], in particular in a document called "The First Pillar - Minimum Capital Requirements" [2]. A minimum capital ratio of 8% would mean a maximum value for α of 12.5 in our setting. We show in the paper that already for $\alpha = 9$, the economic system becomes fragile in the long run [3]. It should be noted that the value of 8% for minimum capital requirement depends on the definition of capital. The basic one includes shareholders' equity and disclosed reserves (Tier 1) but broader definitions also can include other capital instruments. Of course banks in our model are simplified with respect to real ones and the concept of capital requirement should be considered more from a qualitative than from a quantitative point of view. Nevertheless the values considered in the paper are in line with values of the real world.

[1] See *http://www.bis.org/publ/bcbsca.htm*

[2] Basel II is based on three conceptual pillars: (1) minimum capital requirements, (2) supervisory review and (3) market discipline. The document on the first pillar can be found here: *http://www.bis.org/publ/bcbs128b.pdf*

[3] For instance, Citigroup had a (Tier 1) capital ratio of 12.9 in 2010, that corresponds to a value of $\alpha = 7.7$. See the Citigroup Financial Summary at page 20 of *http://www.citigroup.com/citi/fin/data/ar10c_en.pdf*

Initial conditions

Concerning initial conditions, we do not apply any burn-in process. Initial conditions have been chosen in order to keep realistic proportions between the different items of agents' balance sheets, and to correctly size stocks and flows dimensions. For example, the debt-to-equity ratio of firms is initialized at 2, which is a realistic value for industrial companies. Risk (weighted) assets to capital ratio for banks is set to 5. The wealth-to-income ratio for households is set to 15, with 40% of households wealth allocated into banks deposits, and the remaining 60% into financial assets. The debt-to-GDP ratio is around 85%, which is in line with the Eurozone.

Given some probability distribution, different seeds produce different realizations that affect initial conditions concerning behavioral aspects of individual agents, but balance sheet entries remain constant in the initialization phase and related by the same realistic proportions.

We added the two previous paragraph in the "Analysis of results" section of the article.

Concerning the apparent rising amplitude in the time series that the referee points out, we do not think that it depends on the choice of the initial conditions but more on the financial structure of the model. Let us notice that this rising amplitude affects mainly investments and total loans, if they are considered as absolute values (in a linear scale). However, one has to examine these amplitudes taking into account the growing dynamics of GDP. Within this perspective, it is normal that the upper bound of investment spending should grow coherently with the total output, and consequently also the total amount of loans to finance these investments will grow. Therefore, one should consider relative fluctuations more than absolutes ones and observe that the maximum amplitude of relative fluctuations remains fairly stable during the simulation.

Section 7.2

We have enriched and hopefully improved this section to meet the invited reader requests. In particular we have addressed the following points:

- simulations' number: a single simulation with a given seed and a given set of parameters takes hours. Considering 5 sets of parameters (5 values of α), we have performed 5 x 15 (seeds' number) = 75 simulations. Given our available computational power, it could have been possible to double or more the number of seeds (but not use thousand seeds); however, the standard errors of the ensemble averages reported in the table are already relatively low with 15 seeds. This indicates that increasing the number of seeds further does not bring meaningful gains;

- tables' order of appearance and position: to improve the readability, the order of appearance of tables has been changed and made consistent with the citations in the text. Tables have been also better embedded within

the text. The related time period has been explicitly reported in any caption;

- the sentence has been rephrased as follows: "In particular, one can notice that the difference among average GDP[4] levels at low values of α, i.e. $\alpha \leq 7$, is mainly given by differences in investment levels.". Yes, we argue that the fluctuations of GDP are mainly explained by fluctuations of investments, not just because are the most volatile component of GDP but also because investment (through the profits of the investment goods producers) increase income of households and then consumption. The level of investments in turn depends on the supply of credit in the economy;

- table 9: 99.1 makes sense because it means that the 20 firms went bankrupt more than once during the simulation. It is worth remembering that when a firm goes bankrupt, a new firm is created with the same endowment of physical capital and a restructured balance sheet;

- table 10 & 11: the lagged variables have been specified now in the captions of the two tables.

Minor issues

We answer to the minor points raised by the invited reader in the following.

p.6. We replaced the old unclear sentence with : "The framework is based on the extended finite state machine theory (Xmachine) which is particularly suited for writing AB models of large complex systems."

p.7. D_b^f is the debt that firm f has with bank b. Therefore the total debt of firm f is $D^f = \sum_{b \in \{banks\}} D_b^f$. Actually, in table 1 we used the notation $\lambda^{f,i}$ which is introduced later in the article and which explicitly points out to the part of the i-th loan received by firm f at a given point in time from an unspecified bank and that has still to be repayed. At any loan $\lambda^{f,i}$, there is a particular interest rate associated. This is the reason why in the following the notation has been changed. In the balance sheet table, however, it is not necessary to distinguish between loans with different rates, therefore we substitute the notation $\lambda^{f,i}$ simply with the aggregate sum of all loans, that is $D^f = \sum_{b \in \{banks\}} D_b^f$.

p.8-9. We added in footnote 2 the following sentence in order to give a reference to the reader: "The production function is described in eq. 10"

p.10. The source has been provided and is Silver et al. 1998 Silver et al. (1998).

p.10. We replaced the sentence with the following: "where unit costs c_τ^f are calculated as a weighted average of the unit costs $\bar{c}_\tau^f$, related to production q_τ^f that took place in the last period τ, and the unit costs $c_{\tau-1}^f$ which are related

[4](That is the sum of production and investments.)

to the costs of producing old goods (in previous periods) that are still unsold and stocked in the inventories I_t^f, i.e.,". There is no bar when unit costs take into consideration the cost for producing old goods. These unit costs are used to compute the price. There is a bar to characterize unit costs related to the production in the last period. In eq. 7 we are taking the weighted average between the new costs and the old (already averaged) costs. On page 11, the b without bar refers to the general skills of a worker, while $\bar{b}$ with bar denotes the specific skills, as specified at the beginning of the paragraph "Factors demand".

p.12. If the desired amount of capital is lower than the available one, the firm does not need to increase its capital endowment. This is the reason why there is no investment by the firm in this case.

p.16. This likelihood can be considered as estimated by banks. We mention it explicitly in the text now.

p.18. Yes, updated means that new loans are granted to firms and that old loans are repaid by firms. We simplified the sentence, that now reads: "For any bank b, the stocks of total deposits D^b and loans $\mathcal{L}^b$ are updated daily, according to the corresponding flows. Deposits change according to payments (i.e. flows of money among private sector agents), whereas banks loan portfolios are modified due to the granting of new loans and old loan repayments."

p.18. Dividends are simply paid directly from firms to shareholders, transferring the correspondent amount of money from firm's deposit to the shareholder deposits.

p.20. We are grateful to the invited reader for spotting an oversight in writing down the policy rule in eq. 20. The rationale behind the rule is that every month the (yearly) policy rate is adjusted to (monthly) inflation, increasing if inflation rises and decreasing if inflation drops. The correct formula reads:

$$r_\tau^{cb} = \max\left(r_{\tau-1}^{cb} + (\pi_\tau^m - \frac{r_{\tau-1}^{cb}}{12}), r_{min}^{cb}\right). \quad (1)$$

p.23. We added this sentence: "See the paragraph about "financing" in section 2 for more details on bankruptcies in the model." in order to repeat the same concepts (see also next point).

p.27. We introduce write-offs in section 2, "financing" subsection, where bankruptcies are explained. In particular, rearranging it a bit, it reads: "The significative difference between the two types of bankruptcies is the following: in case of insolvency bankruptcy, firm's debt is restructured according to a new target level of debt that has to be a fraction of firm's total assets. The exceeding part of the debt is written-off, i.e., the value of firm's loans is reduced.".

Finally, we revised the English style of the paper and we corrected all the points indicated by the invited reader in section "typos and language"; we also moved the citation about Eurace balance sheet approach as suggested.

References

Cincotti, S., Raberto, M., and Teglio, A. (2010). Credit Money and Macroeconomic Instability in the Agent-based Model and Simulator Eurace. *The Open-Access, Open-Assessment E-Journal*, 4(2010-26).

Fontana, G. (2003). Post Keynesian approaches to endogenous money: a time framework explanation. *Review of Political Economy*, 15: 291–314.

Silver, A., Pyke, D., and Peterson, R. (1998). *Inventory Management and Production Planning and Scheduling*. John Wiley & Sons.