Referee 2 – Replies to comments

First of all, we would like to thank the reviewer for finding interest in our paper and for his/her interesting and stimulating remarks. Now, we will try to answer all the issues raised in the review.

1. Before answering this point, it is important to point out that the Iceace model is not an evolution or an enrichment of the Eurace model , but it is really a different model, yet with similarities not much in the modelling features, which are common in a few cases, but in the general approach. In the introduction we wrote that the "The modelling approach followed in developing the Iceace model is largely based on the EURACE model and simulator". Actually, here we want to refer strictly to the modelling approach and not the model itself. Later, we explain what we imply with "modelling approach": "the stock-flow consistency modelling approach and the careful balance sheet accounting both at the single agent and at the aggregate level."

We understand however that some misunderstanding may arise, therefore we added in the Introduction the following paragraph to better specify the key differences between Iceace and Eurace.

"However, the two models are quite different. First, Iceace is generally simpler than Eurace as it does not include at the moment investments in capital goods, it does not include stocks and government bonds markets, and it is characterized by a simpler labor market with no heterogeneity of technical skills among workers. Second, Iceace has a new important added feature that is absent in Eurace, i.e., the residential housing market and the related mortgage loans provided by banks. This new feature allows to better model and study a credit-driven (real estate) asset bubble and its impact on the business cycle. This feature is considered crucial in order to explain the recent financial and economic crisis both in Iceland and worldwide."

These differences are the reason why we decided to devote so many pages to describe the features of the Iceace model, which are actually new, in full detail.

2.1. It is true that there is no rental market for housing in the model. The main reason for this is that in Iceland at most 15% of households rent their housing in the free rental market, and another 5% rent their housing, usually at a lower price, from municipalities or from other public organizations (See (in Icelandic) http://www.hagstofa.is/lisalib/getfile.aspx?itemid=1172 for details).

2.2. The Equity fund has been included in the model as an intermediary because in the Icelandic economy the importance of the stock market is negligible, while funds, like pension funds, play a very important role in equity investing. In this respect, it is worth noting that the equity fund in our case, and ultimately the households in the model, can reinvest some of the received dividends into firms that have been rationed in the credit market. This feature works as a sort of proxy for a stock market and is in line with the pecking order theory of capital structure (Myers and Majluf 1984).

2.3. Yes, we agree that construction firms in the model have backward looking expectations; however we think that this is consistent with the empirical evidence we found. Looking at figure 1 we see that construction firms in Iceland tend to increase their production when housing prices increase. We also see that while the no. of transactions in the housing market in Iceland differs greatly from year to year, the production of housing increases year-on-year right up to the collapse of the economy in 2008. Also we see from table 1 that

bankruptcies in the construction industry in Iceland almost doubled in 2009 and has remained high since the crisis started. This seems to suggest that construction firms in Iceland are more driven by short term profit rather that long term sustainability. In general it seems reasonable to model the construction industry in such a way that they look at the price of housing when deciding how much to produce, rather than the demand for housing. We have also introduced a limit on the amount of new houses that can be built in one year in our model. This entails that construction firms in the model will increase their production, when housing price is on the rise, up to this limit given by the capital goods they are endowed in the beginning of the simulation.

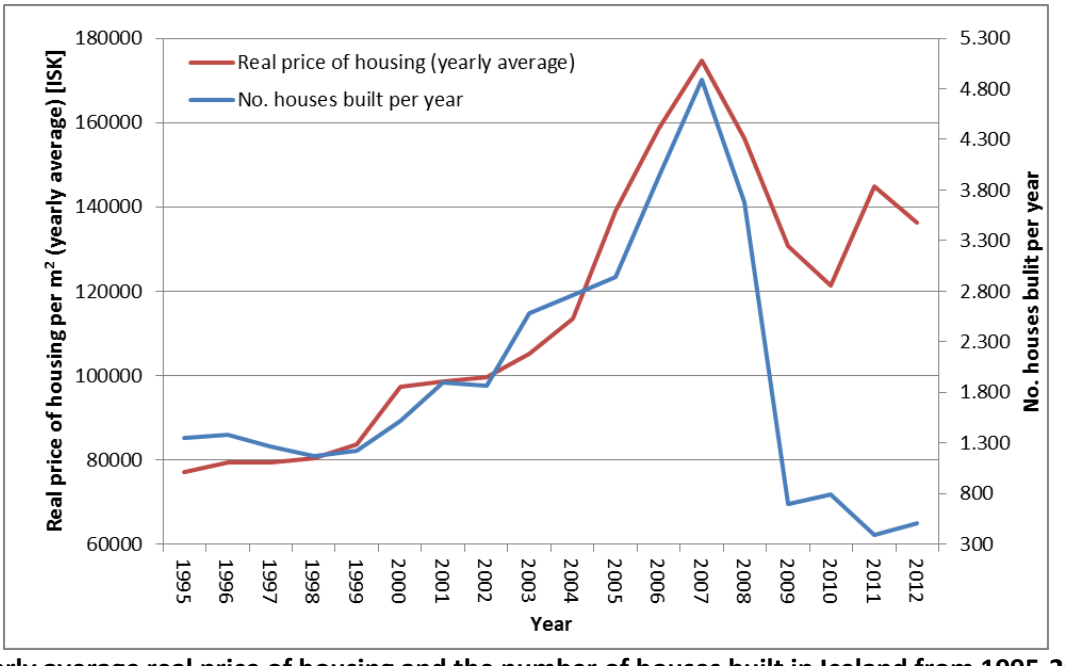

Figure 1: Yearly average real price of housing and the number of houses built in Iceland from 1995-2012. Data obtained from Registers Iceland (http://www.skra.is).

Year	No. of bankruptcies of construction firms	No. of transactions in housing market
2000	32	10,201
2001	54	9,430
2002	72	10,100
2003	105	11,960
2004	78	14,359
2005	61	15,836
2006	82	11,897
2007	103	15,252
2008	150	6,241
2009	257	3,679
2010	260	4,707
2011	330	6,596
2012	228	7,623

Table 1: No. of bankruptcies of construction firms and transactions in the housing market in Iceland from 2000-2012. Data obtained from Registers Iceland (http://www.skra.is) and Statistics Iceland (http://www.statice.is).

2.4. The authors agree that this is restrictive, but when modeling the housing market we have tried to look into the behavior of homebuyers and sellers in Iceland. Usually when buying a house, any given household is also selling a house e.g. buying a three bedroom apartment and selling a two bedroom apartment. By doing this we also make housing investment lumpy, as described in Erlingsson et al. 2013, which means that a considerable change needs to happen w.r.t. a household's financial situation for it to buy more housing. The authors feel that this restriction is therefore reasonable. Households do not have an investment motive when buying and selling housing. In Teglio et al. 2014 we have addressed this issue where certain households have an investment motive when buying and selling housing.

3. The numbers for the ratio of construction firms to other firms as well as the ratio of number of employees in the construction industry and the yearly growth rate of the housing stock are specific to Iceland. We do not have this information for other small open economies, so we cannot say if this applies. If one wanted to use this model for a different (small open) economy one thing that should be done is to gather this kind of data for the economy in question and change the initial conditions accordingly.

4.1 The question of the referee gives us the opportunity to explain some key feature of our modeling approach. If we intend the term "micro-founded" in a broad sense, we argue that there are no models that are more "micro-founded" than agent-based models like the one we are proposing in this paper. Actually, macro variables are the aggregation of the interaction of thousands of agents which exchange real and financial assets in different markets. The idea is the so-called bottom-up approach, where modeling in a reasonable way agents' behaviors and taking into account all the balance sheet constraints (this is the key point) we can reconstruct the aggregate macroeconomic dynamics. In this respect a micro-foundation in the Friedman-Lucas style is not coherent with the philosophy of our modeling perspective. Usual micro-founded models need rational expectations, or a mechanism to have inter-temporal constraints, in order to be consistent. We think that the permanent income hypothesis and all its derivatives do not capture the real behavior of households (as, for instance, many studies of experimental economics suggest) but that their main virtue is to fit in the machinery of mainstream macro models. We think that our consumption rule, inspired by the buffer stock theory of Deaton and Carroll (Deaton 1992 and Carrol 2001) is more realistic. Moreover, let us remark that we do not need the inter-temporal budget constraint because we have a much stronger constraint in the model, which is the balance sheet constraint at the level of the individual (not representative) agent. The balance sheet constraint is the key engine for the dynamics of our model because, in addition to impose inter-temporal restrictions to the agents, it especially imposes cross constraints in the relation between agents that hold for each time period *t*.

4.2 We agree that the spread of the mortgage rate with respect to the CB rate could be variable, reflecting some microeconomic or macroeconomic conditions. For instance, in Raberto et al. 2012, when studying the impact of banking regulation on macroeconomic stability, the loan's rate was depending on firm's financial fragility (e.g. the debt-equity ratio). The same criterion could be adopted with households, adjusting the mortgage rate according to the financial robustness of the borrower. In this case, our guess is that subprime lending would increase even more the instability of the credit market. Another possibility, as suggested by the referee, would be setting the mortgage rate according to some macro condition, like an estimate of the current credit risk in the market, or even considering macro-prudential regulation as provided in Basel III accords. We think these scenarios should be considered for further policy experiments, but they wouldn't amend the main conclusion of our current paper about the existence of a trade-off between short-run growth and systemic stability.

4.3 Actually, there is a flourishing debate about the opportunity for central banks to target asset prices in their conduct of monetary policy. However, a clear and shared vision on this issue is still missing among economists and policy makers. An article of the magazine "The international economy", published in 2009, collects the opinions of 20 experts on the issue and gives an idea of the heterogeneity of viewpoints (see http://www.international-economy.com/TIE_F09_AssetPriceSymp.pdf).

It is not straightforward to understand how to target the asset prices (and which asset prices) using only the policy interest rate instrument. It would mean to find a trade-off between consumers and assets prices, using simulation to test different weights combinations. Of course this can be done and could hopefully give us some sort of insight.

In our opinion, it could be interesting to use other policy instruments in order to monitor the dynamics of asset prices. A main candidate as an additional instrument is a macroeconomic prudential figure for banks capital to be determined in a dynamic way by central banks, according to the business cycle. The capital requirements should rise when there is a possibility of an asset price boom. We already explored this strategy with positive results within a macroeconomic agent-based model in Cincotti 2012.

In this way we should avoid to have high interest rates when there is no consumer price pressure, and would give the central bank an effective instrument with which to fight asset price bubbles.

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