

Referee 1 – Reply to comments

1. We agree with the referee that it would be more appropriate indeed to focus the introduction of the paper on the effects of housing bubbles and busts in a macroeconomic context. We have then modified the introduction as follows.

“This paper aims to study the macroeconomic effects of different mortgage policies by banks and related changes in housing prices. The idea is that stricter or looser evaluation criteria for granting mortgages can affect the real economy through the leverage of the household sector and the housing price channel. According to a well-established literature, positive shocks to asset prices improve firm’s borrowing and investments, leading to positive outcomes in the economy (Holmstrom and Tirole (1997) and Kiyotaki and Moore (1997)). Furthermore, the wealth effect of raising housing prices increases aggregate demand and leads to higher production and employment. However, as pointed out in Chakraborty et al. (2013), these arguments are leaving out the potentially negative effect of asset-price (in our case housing-price) increases. The main arguments are related to the crowding out of lending to commercial firms due to the predominance of mortgage loans, or, more in general, a misallocation of resources across sectors which reduces welfare. However, the recent crisis has shown how an asset bubble can increase the financial fragility of the whole economic system with potentially destructive effects when the bubble bursts. In order to address this issue, we consider the problem of housing bubbles as an endogenous mechanism that depends on the characteristics of the economic system and on policy decisions. Our aim is to analyze the transmission channels of the housing bubble and to study how the negative macroeconomic impact could be mitigated or prevented.”

2. This is an important point that needs a clarification on our side: the model has not been fully calibrated on the Icelandic economy, although the authors plan to do so in future work. However, we have in some cases looked to evidence from the Icelandic economy and set certain parameters according to data from the Icelandic statistical office (statice.is), as can be seen in section 3.1 of the paper, in order to set initial conditions and parameters to values consistent with a realistic economy in terms of relative size and dimension. We therefore amended the first paragraph of section 3.1 as follows:

“We initialize the balance sheet of economic agents both by looking into empirical evidence from the Icelandic economy and by setting the initial values of the variables from a limited set of assumptions. However, our aim is not to calibrate the model in order to take into account the different stylized facts of the Icelandic economy, but just to restrict the degrees of freedom of the model and to set initial conditions and parameters to values consistent with a realistic economy in terms of relative size and dimension.”

In light of this we think that adding a section on the recent housing bubble in Iceland is not relevant at this time.

3. We agree with the reviewer that setting the productivity of capital to an infinite value would make the amount of physical capital irrelevant as production input. However, as written in text just after Eq. 1, the amount of physical capital, and its value is relevant for the financial position of the firm, i.e. its leverage and net worth, which then affect the behavior of the Equity Fund in providing new funds through equity capital and then the likelihood of bankruptcy for the firm, see section 2.4. We then

decided to formally include the physical capital as a production factor, even if irrelevant as production factor, not only because it is indeed relevant for the financial position of the firm but also in sight of future developments of the model that will be characterized by finite capital productivity and firm investments.

4. The reviewer is right when saying that productivity of work is equal and constant across both firms and workers, but workers' skills should not be considered as technical abilities here, but more like social skills. In other words, households (workers) are heterogeneous in term of their ability or skill to maintain the job and to get a new job if unemployed. In this respect, we have included an explicative footnote in the labor market section. The reason for introducing these social skills is twofold. First, we wanted to reduce as far as possible the random features of the simulation, like random sampling in the labor market to select the fired households whenever necessary, and then reduce the random noise that may affect the results. Second, there was a direct research goal, not presented in the paper; the aim was to understand to what extent the long-run wealth distribution among households could be affected by a deterministic and heterogeneous feature of households like social skills.

5. The reviewer is right as construction firms, like regular firms, do not make investments in new capital goods so to adjust their capital stock. As investments in new capital necessarily involve financing issues, given the scope of the paper, our choice was to simplify the financing issues by focusing the lending activity of the banking system on the housing market trading, where bubbles and busts occurs, while firms and construction firms can still borrow funds for banks but just to finance their regular activity, then to an usually limited extent. However, it is worth noting that construction firms can try to adjust the number of employees they have through the labor market, thus producing more or less housing, based on their production plan. We have initialized the construction firms in such a way that they can theoretically increase the stock of houses by 1.5% (see the parameter ρ^s in table 7) per year. This maximum increase in the housing stock is based on Icelandic data of newly produced houses in recent years; the data includes a housing boom and bust. In that way we incorporate the size of the construction sector during a housing boom into the model. Finally, the authors plan to introduce capital goods in a future version of the model.

6. Yes, production decision by construction firms is characterized also by a random component, however it is worth noting that the main driver of decisions is given by the housing price. This modelling choice is rooted on empirical evidence. 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 than 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 physical capital they are endowed at the beginning of the simulation.

To clarify this modeling choice we have added the following to subsection 2.1.2 (Construction Firms):

“Looking at empirical data¹ of the Icelandic housing market and construction industry, we find that the amount of houses constructed by construction firms in Iceland seems to be led by the price of housing. Therefore construction firms in the model look to the price of housing when deciding the amount of houses to construct. This modelling choice is also strengthened by the fact that when housing price started to drop in Iceland, after the recent housing bubble, the number of bankruptcies of construction firms increased significantly. This seems to suggest that construction firms in Iceland are more driven by short term profit rather than long term sustainability.”

7. Yes, loans to firms have an infinite duration and are never paid back. We understand that this is somehow an unrealistic assumption but we think it can be acceptable. Indeed, modeling complex systems in general needs several simplifications and assumptions as shown in the literature using ABM, DSGE models or other methods. The rationale of this assumption was to avoid the complication of devising an appropriate decision making concerning the choice of different loans durations and then to avoid dealing with the complication of the term structure of interest rates. It should be considered also that in the real world it often happens that old loans are paid back by getting new loans; in fact, the aggregate amount of loans in the economy generally increases, except during depressions when credit crunch applies and deleveraging phases occur. In normal conditions, the net aggregate effect for loans is then similar both in the real world and in the Iceace artificial economy. Finally, it is worth noting that the focus of the model is not on credit to the production sector but on credit to households; mortgages in fact have a finite duration and need to be paid back partly every quarter along with interests. Moreover, if the households sector becomes over-indebted, it starts to deleverage and a reduction of the overall amount of mortgages in the economy occurs, with critical consequences for the business cycle.

8. Taxes, government transfers and unemployment benefits are all taken into account. The first paragraph in section 2.5 will be changed and should read:

“At the beginning of each month, households set their consumption budget, i.e., the amount of money to spend on the consumption market during the month. The consumption budget C_B^h of any household h depends on the labor Z_l^h and capital Z_e^h income realized in the last quarter² and on its quarterly mortgage expenses, $R^h = \sum_m R^{m,h}$. The labor income consists of wages, W^h , unemployment benefits, $\xi_u W^h$, and general benefits, $\xi_g W^h$, so we have $Z_l^h = W^h + \xi_u W^h + \xi_g W^h$. Any households then determines its monthly disposable income, Y^h , taking into account the labor tax, t_l , and capital tax, t_e , as:

$$Y^h = \frac{1}{3}(Z_l^h(1 - t_l) + Z_e^h(1 - t_e) - R^h)”$$

¹ Data obtained from Registers Iceland (<http://www.skra.is>) and Statistics Iceland (<http://statice.is>).

² It is worth remembering here that the labor income changes on a monthly basis, while capital income and mortgage payments are computed and accounted quarterly. The labor income is then the sum of three months, or one quarter, worth of labor income.

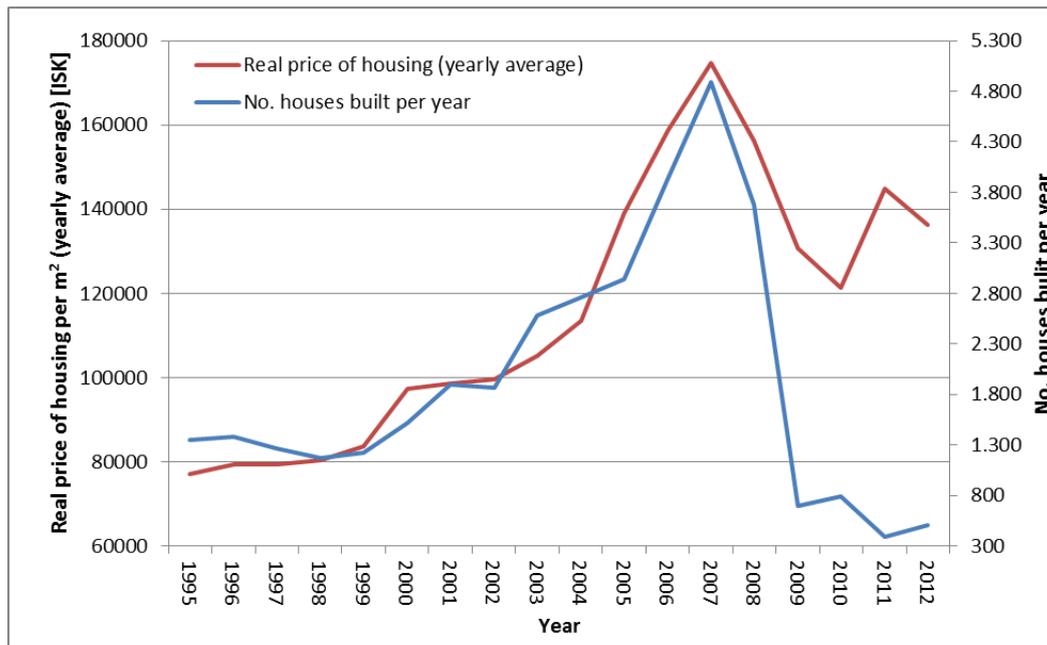


Figure 1: Yearly average real price of housing and the number of houses built in Iceland from 1995-2012. Data obtained from Registers Iceland (<http://www.skra.is>).

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>).

9. The purpose to include general transfer benefits is to model welfare transfers and costs for the government, like e.g. hospitals, schools, public offices, that, contrary to unemployment benefits, are a substantial component of public spending that is independent from the business cycle. In this respect, we have added an explicatory footnote in section 2.6. It is also worth noting that, as the transfer benefit per head is set to an initial fraction equal to 50% of the mean wage, its aggregate value is usually expected to cover an important part of GDP as it can be observed for the public sector in modern OECD economies.

10. It is true that fluctuations of GDP are not realistic. In particular, in the case of high β , after a violent crisis we observe a GDP recovery at a very high pace. However, we never claimed that our time series are quantitatively realistic or that they are related to a specific economy. From our point of view, the results have to be considered in a comparative perspective. We are performing what-if analysis in order to understand how different scenarios can affect the macroeconomic system, and we observe clear statistical differences. Moreover, observing the time series of many economic indicators, we are able to recognize the economic transmission channels that are the main determinants of the observed differences. This methodology allows us to offer a quite detailed description of what is going on in the economy, by analyzing the interaction of the heterogeneous agents.

Taking advantage of referee's comment, we would like to clarify some aspects about our methodology. The model is not calibrated, meaning that we didn't perform a systematic adjustment of the parameters of the model. The idea is to use behavioral rules and parameters which are taken from well-established literature, from well-known management procedures or from empirical data. The main issue is to initialize the system in a stock-flow consistent way, setting the initial value of some of the state variables and the value of some basic parameters according to the previously mentioned rules. Then, all the initial values of the other variables should be fixed by balance sheet constraints or by linking their value to the value of other variables or parameters according to observed empirical ratio levels.

Of course the fact that some time series are not very realistic means that the model has still to be improved and represents a strong incentive for us to work on it. The calibration of the model in order to have more realistic quantitative outcomes or to be able to simulate the economy of a real country (or set of countries) would be a remarkable achievement. This is one of the major points in our agenda. Nevertheless, we think that the model as it is can give a contribution to disclose some relevant economic interactions that have been undervalued by the mainstream literature.

11. The aim of this model is not to explain the long-run economic growth and we do not consider it a key point in our study. Actually, in the abstract we affirm that "a too severe regulation can slow down economic growth". However, our purpose was not to claim that the model shows long-run economic growth, but to suggest the existence of a trade-off between short-run growth and systemic stability.

Once we have clarified that the purpose of our model is not to explain long-run growth, we don't want to evade referee's question and we will go into the details about it.

First of all, it should be clear by comparing the upper and the lower parts of figure 1 that the long-run growth in the model is given by a general decline of the unemployment rate in the economic system. So, it is true that human capital does not change, that there is no improvement in technology, and that capital is not growing, but labor input is not constant as figure 1 clearly shows. The reason of this decline in the unemployment rate is given by the initial conditions of the model, which determine, after an initial adjustment period of around 1 year, a rate of unemployment around 25% - 30%. Then the model shows that economic growth is faster when credit money is pumped into the system but the price to pay is a higher systemic instability.

We would like also to comment another detail related to economic growth. Looking to figure 1, and focusing the attention to the blue line (with $\beta = 0.25$) at year 14, one can notice that the GDP is growing despite a full employment situation. The reason for this is a technical one, related to the definition of real GDP we used in the model. First we compute nominal GDP including new houses production, and then we use inflation of the consumer price index (i.e., the price of the consumption good) to transform nominal GDP into real GDP. However, the housing price index growth (figure 3) is increasing somewhat faster than the consumer price index growth (figure 7), and so, when calculating real GDP, the numerator is in general growing faster than the denominator (which doesn't take into account housing price inflation). This provides a further explanation of the GDP growth in the model, given by the choice of calculating real GDP using consumer price index.

We changed the second paragraph of section 3.2 to clarify this issue:

“The monthly GDP levels associated with different β s are plotted in figure 1. It is obtained from the total value of both housing and consumption goods production (nominal GDP), corrected by the consumer price index, which includes only consumption goods. The black line corresponds to the most restrictive attitude towards borrowers ($\beta = 0.20$), meaning that a high income to housing expenditure ratio is requested to get a loan, whereas the red line corresponds to the most permissive case ($\beta = 0.40$), that we could homologate to subprime lending. The blue ($\beta = 0.25$), and green ($\beta = 0.30$) lines represent two intermediate cases.”

Chakraborty, Indraneel and Goldstein, Itay and MacKinlay, Andrew, Do Asset Price Bubbles Have Negative Real Effects? (November 5, 2013). Available at SSRN: <http://ssrn.com/abstract=2246214> or <http://dx.doi.org/10.2139/ssrn.2246214>

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Kiyotaki, Nobuhiro, and John Moore, 1997, Credit Cycles, *Journal of Political Economy* 105, 211-48.