A Small Open Economy with Heterogenous Agents Facing Interest Rate Ceilings on Loans

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Abstract

The aim of this paper is to explore the effects of interest rate ceilings in a small open economy. In order to account for many individuals and lending, a model with heterogenous agents is considered. The investigation is focused on two issues: first, how effective are interest rate ceilings at reducing loans and risk in the economy and at what cost; and second, whether imposing interest rate limits produce any different response of the variables to aggregate shocks in the economy. The results obtained from the model show that interest rate ceilings are effective at reducing high risk debt in the financial system. The cost on consumption of reducing this risk is minimum in the model. The findings for the second issue show that interest rate ceilings make debt more responsive to shocks on the interest rates. In particular, the effect in percentage points of an increase of interest rates could be twice as negative on debt under interest rate ceilings.

Keywords: Small open economy; Heterogenous Agents; Incomplete markets; Interest rate ceilings; Financial frictions, Numerical solutions.

JEL Classification Numbers: E44, F41, D52, C6

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1 Introduction

Interest rates ceilings are a legacy of the first civilizations of humanity. The oldest known reference dates from 2000-1400 B.C. in the Ancient India, and it has been present in many other cultures until present days.[1]

In general, interest rate ceilings on loans can be defined as the maximum interest rate that a financial institution can charge for lending.[2] Implicit in this definition, there is a regulator who establish a legal limit for the interest rate in the economy. The spirit of this regulation has usually been related to the concept of usury.

Nowadays, there exist interest rates ceilings in some states of the U.S., Latin America, Asia, Africa, and a large number of E.U. countries. In the U.S. interest rate ceilings would not exist in practice, since financial intermediaries are able to export credit from non-regulated states to other states where the regulation exist, see for instance Zinman (2003) [17]. For most of the nations the debate about interest rate controls is open, and in a world where the recent crisis came from financial frictions is important to have a deeper understanding of the effects of financial regulations in a macroeconomic environment.

The literature of interest rate ceilings on loans began in the 1970's with the irruption of consumers credit. One stream of these literature justify the existence of lending rates controls as a way to reduce adverse selection and the probability of default in a stable macroeconomic environment, these ideas have been formulated in Hellmann, Murdock and Stiglitz (1997) [5], and Espinosa-Vega and Smith (2001) [4]. From a different perspective, but also in favor of setting limits to the interest rates, Kurata and Tomoda (2007) [8] develop a model where interest rate ceilings play a role as an export-promoting policy. On the other side, there are those who argue that interest rates ceilings on loans would obstruct financial deepening and create excess demand in the financial markets, see for instance Makinnon (1973) [10] and Shaw (1973) [13].

Taking into account previous literature on the matter is important to answer whether this regulation is effective at reducing risk from the financial system, and to explore to what extent the excess demand created generates distortions in the economy. The approach used to answer this questions is introducing interest rate controls in a macroeconomic environment with heterogenous agents who are subject to idiosyncratic shocks and interest rates fluctuations. If the agents who face negative idiosyncratic shocks are those more indebted and riskier for the financial system, it has to be analyzed how effective interest rate ceilings are at reducing loans for these type of individuals. If any excess demand is created in

[1] Visser and McIntosh (1998) [16] give a short review of the history of interest rate ceilings.

[2] There also interest rate ceilings on deposits, which have been studied by Tobin (1970) [15], Smith (1984) [14], and Hellmann, Murdock and Stiglitz (2000) [6].

the process, the cost for those agents from not receiving these loans has to be measured. Other question addressed is whether interest rate ceilings produce any different response of the variables to different shocks in the economy, in particular is interesting to contrast how interest rate shocks affect debt in a model without interest rate ceilings and in a model with the regulation.

The model is composed by: (i) a large number of individuals who maximize a standard utility function on consumption subject to a budget constraint where savings or debt are the mechanisms to smooth consumption in a incomplete asset market, where agents hold just savings or debt for the idiosyncratic risk; this approach follows the debt elastic interest rate closing of a small open economy model used by Schmidt-Grohé and Uribe (2003) [11] with some modifications, (ii) an international financial institution or bank who sets interest rates considering a risk premium for debt which is coincidentally implicit in the debt elastic interest rate closing of the model, (iv) a regulator who establish the limits of interest rates. The model is solved computationally using numerical solution methods with some of the key features of the algorithm proposed by Aiyagari (1994) [1] where there is endogenous heterogeneity coming from uninsured idiosyncratic risk faced by agents, also along the lines of Krusell and Smith (1998) [7] there is a source of aggregate uncertainty coming from shocks to the interest rate, and (iii) an informal lender who satisfy the excess demand for debt at a higher rate premium.

In section 2 the small open economy model with heterogenous agents is explained in detail as well the role played by the international financial institution, informal lender and the regulator who establishes the interest rate ceilings. Section 3 explains the solution method used to solve the model and the calibration for the economy. In section 4 the results of the model are exposed and analyzed. Finally, section 5 concludes.

2 The Model

The first task to solve a small open economy model is to deal with the non stationarity problem that comes from an international interest rate which does not necessarily coincide with the subjective discount rate, this issue would cause a time dependent distribution for consumption and not having a steady state in the model. The most standard way used to solve this problem was assuming that the international interest rate equals the subjective discount factor, however this approach limits the model from displaying any dynamic from the steady state equilibrium and it would not be useful for the purpose of this paper where we need fluctuations in the international interest rate in order to answer the question above explained. For this reason, the stationarity problem is solved following the approach of a debt elastic interest rate premium for closing small open economy models similar to those proposed by Senhadji (1994) [12], Mendoza and Uribe (2000) [9] and Schmidt-Grohé and Uribe (2003) [11].

2.1 Agents

The economy is composed by a infinity-lived continuum of agents indexed by i $\in [0, 1]$, all of them with identical preferences. Each period $t \in [0, \infty)$, every agent has a source of funds which comes from an exogenous income $y_{i,t}$, which can either take a low $y_{i,t}^{low}$ or a high $y_{i,t}^{high}$ value around a respective mean y_m for these levels, and an endogenous debt $d_{i,t+1}$, which is subject to the specific agent decision.[3] This source of funds are used to pay debt services $[1 + r_{i,t}^l]d_{i,t}$, where r^l is an exogenous and fluctuating interest rate for the loans received from a international financial institution, and also an endogenous consumption $c_{i,t}$, which is subject to the specific agent decision. Considering this budget constraint every agent maximize their life time utility function $\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{i,t})$, where $\beta \in (0, 1)$ is the subjective discount factor.

The key element to find a steady state solution for this maximization problem in this small open economy comes from the interest rate faced by the agents. In order to obtain a steady state solution for the model, following a similar approach used by Schmidt-Grohé and Uribe (2003) [11], we let the interest rate for loans be $r_{i,t}^l = r_t^* + \Phi(d_{i,t})$, where r_t^* is an exogenous international interest shock, which can take a low r_t^{*low} or a high r_t^{*high} value around a respective mean r_m^* for these levels, and the function $\Phi(d_{i,t})$ is introduced in order to close the model and takes the role of an agent-specific risk premium.[4] Having all these elements into account we can now write the maximization problem of the agents

$$\underset{c_{i,t}, d_{i,t+1}}{\text{Max}} \ \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \ u(c_{i,t}) \quad \text{subject to,} \tag{1}$$

$$c_{i,t} + [1 + r_t^* + \Phi(d_{i,t})] \, d_{i,t} = y_{i,t} + d_{i,t+1} \tag{2}$$

Where $u(c_{i,t})$ satisfy the following conditions: $u'(c_{i,t}) > 0$, and $u''(c_{i,t}) < 0$. In order to prevent agents from accumulating debt at a rate exceeding their respective interest rates the

[3] Although we characterize agents for convenience having debt they could also be saving, in which case d takes a negative value. Therefore we can call savings $s = -d$.

[4] As we will se later this interest risk premium will give us an upward sloping supply curve for debt from the international bank from a certain point, which is coincidentally what we need in order to leave open the possibility of a potential excess demand when introducing interest rate ceilings. Think of a standard supply and demand curve where in order to have an excess demand, from setting an interest rate below the equilibrium, we need an upward sloping supply curve, which is in fact the effect of introducing $\Phi(d_{i,t})$ in the model.

following transversality condition is imposed $\lim_{t\to\infty} \mathrm{E}_0 \frac{d_{i,t+1}}{\prod_{s=0}^{t}[1+r_{i,s}^{l}]} \leq 0$. The equations that characterize the equilibrium process $\{c_{i,t}, d_{i,t}\}_{t=0}^{\infty}$ are given by:

$$E_t\ c_{i,t+1} = \beta[1 + r_{t+1}^{*} + \Phi(d_{i,t+1}) + \Phi'(d_{i,t+1})d_{i,t+1}]\ c_{i,t} \tag{3}$$

$$c_{i,t} + [1 + r_t^{*} + \Phi(d_{i,t})]\, d_{i,t} = y_{i,t} + d_{i,t+1} \tag{4}$$

Where $r^{*} = \{r^{*low}, r^{*high}\}$ and $y = \{y^{low}, y^{high}\}$ follow a Markov process given by the transition probabilities matrixes $\Pi_{r^{*}r^{*\prime}}$ and $\Pi_{yy'}$, respectively.[5] We define the current cardinal utility function and the agent-specific cardinal risk premium function as follows:

$$u(c_{i,t}) = \log c_{i,t}$$

$$\Phi(d_{i,t}) = \begin{cases} \frac{\gamma}{2}\left[\frac{d_{i,t}}{d^{*}}\right]^2 & d_{i,t} \geq d^{*} \\ 0 & \text{otherwise} \end{cases}$$

Where, $\gamma > 0$ is a risk premium parameter, and d^{*} is a level of debt from which individuals' cost of credit include the risk premium. In order to find a value for d^{*} we use the first order condition given by equation (3) for some constant values of consumption and the agent-specific cardinal risk premium function. Using for both equations $d_{i,t} = d^{*}$ give us:[6]

$$d^{*} = \frac{1 - \beta[1 + r_m^{*} + \frac{\gamma}{2}]}{\gamma\beta}$$

It is important to say that once shocks take action in the economy each agent will choose a different path process $\{c_{i,t}, d_{i,t}\}_{t=0}^{\infty}$, therefore although individuals present identical preferences they will ex-post behave in a heterogenous way. These different behavior of agents will allow us to classify them according to their indebtedness and risk. In a general classification we will let debtors be in a set D and savers in a set S. We can also classify indebted agents for whom $d_{i,t} \geq d^{*}$ in a set $\mathrm{D_{up}}$ and indebted agents for whom it doesn't in a set $\mathrm{D_{down}}$, where $\mathrm{D_{up}} \cup \mathrm{D_{down}} = \mathrm{D}$.

[5]The transition probability matrix $\Pi_{r^{*}r^{*\prime}}$ give us the conditional probability for the next period $r^{*\prime}$ given what happen in the current period r^{*}, the same applies for $\Pi_{yy'}$.

[6]Notice that d^{*} does not correspond to the steady state value of debt for the entire economy since we are just taking in consideration one type of individual for whom $\Phi(d_{i,t}) = \frac{\gamma}{2}$. We are just choosing a level for d^{*} from the steady state of the individual at the margin $d_{i,t} = d^{*}$ in the $\Phi(d_{i,t})$ function. To find the steady state value for d_t of the whole small open economy we use numerical methods.

2.2 International Financial Institution

The international bank is a financial institution who captures deposits from the public and make loans in a competitive international financial market. We will assume for simplicity that this financial institution has no reserve requirements. Following a similar approach used by Edwards and Vegh (1997) [3] we can find a solution for the maximization problem of the financial institution.

Every period the financial institution can trades bonds in the international financial market at the interest rate r_t^*. Since the bank can buy bonds in order to lend to the rest of the world at the interest rate r_t^* the spread earned from lending in our small open economy is given by $r_t^l - r_t^*$. Also, since the financial institution can always sell bonds in order to borrow at the interest rate r_t^* the spread earned by the bank from obtaining savings funds of the small open economy is given by $r_t^* - r_t^s$, where r_t^s is the interest rates received by the agents from the small open economy for their savings. As an intermediary of funds the bank incurs in a risk-related cost from lending which we will call $\Gamma(l_{i,t})$, where l is the amount of lending. With all these elements taken into account the maximization problem of the financial institution can be written as

$$\underset{l_{i,t},b_{i,t}}{\text{Max}} \sum_{t=0}^{\infty} E_0\ \delta^t \left[\int_{i\in D} [r_{i,t}^l - r_t^*] l_{i,t}\ di + \int_{i\in S} [r_t^* - r_t^s] b_{i,t}\ di - \int_{i\in D} \Gamma(d_{i,t})\ di \right]$$

Where δ^t is the real return factor for the bank, b is the amount of deposits, and s are savings of individuals in the small open economy.[7] As explained before $r^* = \{r^{*low}, r^{*high}\}$ follows a Markov process given by the transition probabilities matrixes $\Pi_{r^*r^{*\prime}}$. The first order conditions for $l_{i,t}$ and $b_{i,t}$ for the bank's maximization problem are given by:

$$r_{i,t}^l = r_t^* + \Gamma'(l_{i,t})$$
$$r_t^s = r_t^*$$

In a equilibrium without interest rate ceilings $l_{i,t} = d_{i,t}$ and $b_{i,t} = s_{i,t}$ for all i.[8] Consolidating the agents and bank solution we have $\Gamma'(l_{i,t}) = \Phi(l_{i,t})$, which means that interest rate for loans consider the risk premium. Notice that since $\Phi(l_{i,t})$ is a function of l, the first order condition for loans give us the upward sloping supply curve for loans for agents in the set $\mathrm{D_{up}}$. On the other side, individuals in the sets S and $\mathrm{D_{down}}$ face a flat interest rate, so

[7] Notice that $\int_{i\in D} i\ di + \int_{i\in S} i\ di = 1$.

[8] By defining l and d separately we leave open the possibility of excess demand when introducing interest rate ceilings.

they can obtain what they desire on savings or debt, respectively.

2.3 Regulator

The regulator of the small open economy establishes the interest rate ceilings. This control of the interest rate give us the maximum interest rate that a financial institution can charge for lending in the economy. We will assume that the algorithm used by the regulator to set the interest rate ceilings considers previous period interest rates for those who contracted debt services, and can be written as:[9]

$$IRC_t = \int\limits_{i \in D} r^l_{i,t-1} \, di$$

Where IRC_t is the interest rate ceiling imposed by the regulator each period. Lets define the set of individuals for whom the interest rate ceilings is binding as $\mathrm{D}_{\text{up}-\text{binding}}$. Considering the interest rate ceiling IRC_t, the first order condition for lending, and introducing our specific function $\Phi(l_{i,t})$, we can estimate how much the bank is willing to lend with this regulation to those in the set $\mathrm{D}_{\text{up}-\text{binding}}$, by:[10]

$$l_{i,t} = \begin{cases} d_{ss} \left| \sqrt{\frac{2}{\gamma}[IRC_t - r^*_t]} \right| & IRC_t > r^*_t \ \forall i \in D_{up-binding} \\ l_{i,t-1} & IRC_t \leq r^*_t \ \forall i \in D_{up-binding} \end{cases}$$

Notice that IRC_t will be greater than r^*_t most of the time given that IRC_t is calculated upon r^l_t, which at same time is greater than r^*_t in equilibrium or after a positive shock on r^*_t. Since r^*_t is a random variable which can rise at any time, and IRC_t depends on the past value of r^l_t, we assume that lending takes its previous value for shocks that makes $IRC_t \leq r^*_t$.[11]

2.4 Informal Lender

Since $l_{i,t} < d_{i,t}$ for individuals in the set $\mathrm{D}_{\text{up}-\text{binding}}$, we introduce an informal lender who charges an interest rate $r^{il}_{i,t} > \psi r^l_{i,t}$ with $\psi > 1$ in order to satisfy part of the excess demand created by the interest rate ceilings. We will assume that the amount of loans made by

[9]The algorithm used for the interest rate ceilings has the characteristic of being potentially binding for some individuals and does not correspond to any particular country.

[10]For those in the set S and D_{down} the regulation does not apply since they face a flat interest rate.

[11]We have to make this assumption in order to approximate the value of lending in our specification for those who face a binding interest rate ceiling in the current period for a rise on r^*_t. Given that after the shock IRC_t turns to be greater than r^*_t again, the loss of information has a minimum impact in the model and will not affect the results.

the informal lender correspond to $d_{i,t} - l_{i,t}$, where $d_{i,t}$ comes from the equilibrium without interest rate ceilings. In what follows we will call debt to the loans obtain by the bank and residual debt to the loans obtained by the informal lender.

3 Solution Method and Calibration

The second task to solve the small open economy model is to find a solution for the path process $\{c_{i,t}, d_{i,t}\}_{t=0}^{\infty}$. Given the difficulty of finding an analytical solution in our dynamic optimization problem, we use numerical methods to compute an approximation of the path process of the variables. The approach used to solve the agents' optimization problem is a solution method along the lines of the algorithms proposed by Aiyagari (1994) [1] and Krusell and Smith (1998) [7], where there exist endogenous heterogeneity coming from uninsured idiosyncratic risk faced by the agents and a source of aggregate uncertainty coming from shocks to the interest rate.

3.1 Solution Method

The dynamic optimization problem of the agents given by equations (1) and (2) can be rewritten using dynamic programming under uncertainty. The Bellman equation associated with the agents' optimization problem can be written as

$$v(d_t, y_t, r_t^*) = \underset{c_t, d_{t+1}}{\text{Max}} \left[u(c_t) + \beta E_t v(d_{t+1}, y_{t+1}, r_{t+1}^* | y_t, r_t^*) \right]$$

with,

$$E_t v(d_{t+1}, y_{t+1}, r_{t+1}^* | y_t, r_t^*) = P v(d_t, y_t, r_t^*)$$

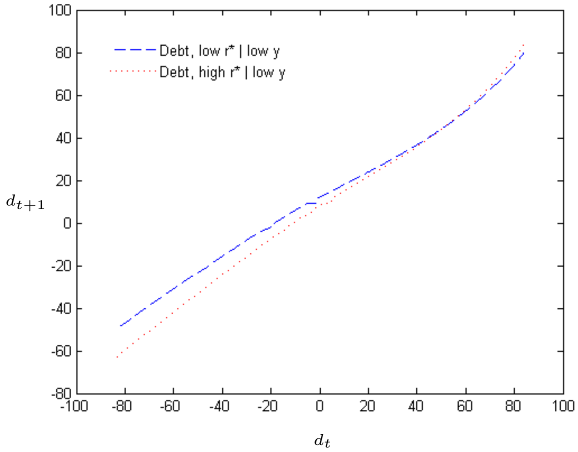
Where $v(d_t, y_t, r_t^*)$ is the optimal value function of the right hand side objective function, and P is a joint transition matrix for $\{y_t, r_t^*\}$ conditional probability Markov process and is given by:[12]

$$P = \Pi_{r^* r^{*\prime}} \otimes \Pi_{yy'}$$

Associated with the optimal value function there is a decision rule $d_{t+1} = f(d_t, y_t, r_t^*)$ that achieves the highest possible value for the objective function. The path process for c_t is obtained from the budget constraint, equation (2).

In order to solve computationally the decision rule for d_{t+1} we use the value function iteration method. The decision rule obtained for some values of r_t^* and y_t is shown in figure

[12] The objective function is obtained from equations (1) and (2).



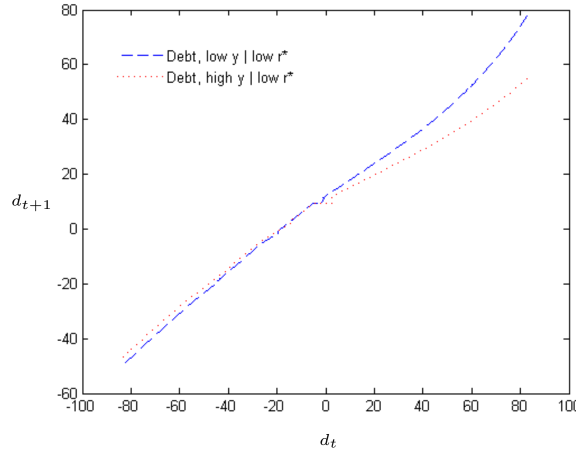


Figure 1: *Behavior of the decision rule for* d_{t+1} *for some combinations of* r_t^* *and* y_t *(negative values indicate savings).*

1 below.

What follows is to interpolate the data created in the decision rule and assign the random shocks in the economy.[13] We let the income shock to be specific for each individual and the shock on the interest rate to be an aggregate shocks which affects the whole economy. Since for every possible state of the economy there is an optimal response of the agents we are able to obtain the path process for $c_{i,t}$ and $d_{i,t}$ and the aggregate levels for this variables in our small open economy.

3.2 Calibration

There are three parameters of the model that need to calibrated: β, γ and ψ. Additional to these parameters we need to make some assumptions about the Markov process for the idiosyncratic shock on income and the aggregate shock on interest rate.

Given that there is good available information about debt, income, and interest rates for Chile, we will use this small open economy country as reference to calibrate the model.

According to Cox, Parrado and Ruiz-Tagle (2006) [2] the Chilean economy has a ratio of banking debt to Gross Domestic Product of around 20% and annual interest rates on consumer loans of around 15%. Our first approximation with this data is to establish the mean value for the exogenous income y_m in a level of 100, and the mean value for the exogenous international interest rate in a level of 15%. Testing for different values of β we

[13] Random shocks generated come from a uniform distribution.

obtain that the ratio of banking debt to income is around 20% in the model when $\beta = 0.8$. The risk premium parameter γ for the bank is established in a level of 0.01 which means that any deviation above d^* is charge by 1%. Finally, by setting the parameter ψ in a level of 2.6 we restrict the informal lender to charge any annual interest rate above 50%, which is a rate non-banking lenders in Chile charge for loans on consumption.

The Markov generating process will be characterized by shocks around the mean values of the international interest rate and income. The state values chosen for the interest rates are $r^{*low} = 0.7\ r^*_m$, and $r^{*high} = 1.3\ r^*_m$. For income the state values are $y^{low} = 0.5\ y_m$, and $y^{high} = 1.5\ y_m$. Finally, the conditional probability matrixes for the international interest rate and income are given by

$$\Pi_{r^* r^{*\prime}} = \begin{pmatrix} 0.97 & 0.03 \\ 0.03 & 0.97 \end{pmatrix}$$

and,

$$\Pi_{yy'} = \begin{pmatrix} 0.9 & 0.1 \\ 0.1 & 0.9 \end{pmatrix}$$

Theses matrix give us the conditional probabilities of moving from one state to another. In the case of $\Pi_{r^* r^{*\prime}}$ with probability 0.97 the international interest rate will stay in the same state and with probability 0.03 it will move to the other state. For income we will observe less persistence given that $\Pi_{yy'}$ makes more likely the probability to move from one state to another. The reason of establishing these parameters for the conditional probabilities is to make interest rate fluctuation not so volatile and income relatively more volatile.

4 Results

Imposing the interest rate ceiling in our model we find that on average aggregate debt is reduced by 30.49%, interest rate is lower on average by 1.42 percentage points, and consumption is reduced on average by 0.3%. In figure 2 we can observe the path process of the aggregate variables (debt, interest rate and consumption) for the baseline model and the model with interest rate ceilings.

As we can see observe from figure 2 the levels of debt and interest rates are reduced significantly with the regulation across all periods. On its part, consumption shows a similar path process for the baseline model and the model with interest rate ceilings. The intuition behind these results is that every period the bank will reduce the amount of lending for individuals for whom interest rates are binding and it will charge them with a lower interest

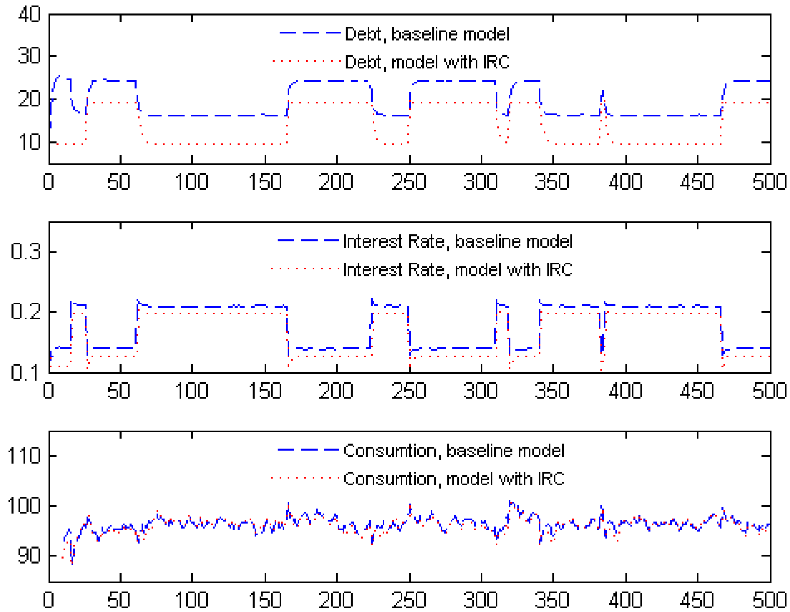


Figure 2: *Path process for the aggregate levels of d_t, r_t^l and c_t.*

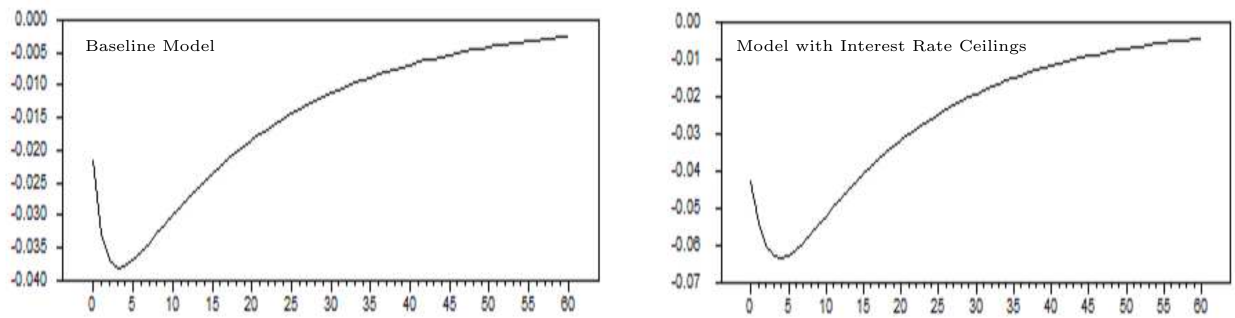


Figure 3: *Impulse response effect of a 1 percentage point shock on r_t^* over* $\ln d_t$.

rate which is the interest rate ceiling, reducing this way individuals debt services. Since individuals for whom interest rate ceiling is binding receive a lower level of debt than desired they will end up going to the informal lender who will charge them with a higher interest rate. This higher cost for residual debt is compensated by the lower debt services from banks. Therefore the funds available for consumption remain at a similar level.

Using impulse response function we are able to analyze how a shock on interest rate affect the variables of our baseline model and the model with interest rate ceilings. Given that consumption follows a similar path process for both models we will focus on the response of debt, see in the appendix the impulse response including consumption. In figure 3 we observe the response of debt to a 1 percentage point change on the exogenous interest rate.

As you can observe in figure 3 the effect of a 1 percentage point change on the exogenous interest rate produce a current decline on debt of around 2% in the baseline model to then continue falling to almost 4% in the third period. On the other hand, for the same impulse response function in the model with interest rate ceilings a much deeper decline on debt in the current period is produced of around 4% to then continue declining to around 6.3% in the fourth period.

The intuition behind this amplified response of debt in the model with interest rate ceilings is that since interest rate ceiling is defined as an average of all the interest rates for indebted individuals, a rise on the interest rate will smoothly change the interest rate ceiling while supply for loans by the bank is contracting considerably. Since for those individuals who face binding interest rate ceilings debt is sharply declining the overall debt of the economy will be lower too in our model with interest rate ceilings. In figure 4 we can analyze the effect of an increase of interest rate for individuals for whom interest rate ceiling is binding. As you can see in figure 4, an increase of exogenous international interest rate in the baseline model for a particular type of individual will have a negative effect on debt moving from point A to point B. On the other hand, in the model with interest rate ceilings a much larger negative effect on debt happens moving from point A' to point C'. To understand this notice that at beginning of the period, under interest rate ceilings, the representative individual for whom interest rate ceiling is binding is at point A'. In the next period the economy faces an increase of exogenous interest rate. Given that interest rate ceiling is calculated on the previous period interest rate, the interest rate ceiling will remain at the same level, but since supply curve for loans shifts left in that period we will observe a new equilibrium at point B. In the subsequent period the interest rate ceiling will adjust smoothly upward which will cause the equilibrium for the individual to be at point C. Then, the effect of an increase of the exogenous interest rate on debt will be much more negative under interest rate ceiling than in the baseline model.

It is worth noticing that interest rate ceilings are effective at reducing vulnerability of the agents in the economy. We can use as a measure of vulnerability $\frac{(1+r_t^l)d_t}{y_t}$, which is the ratio of debt services over income. As we can see a lower income and greater debt service makes individuals more vulnerable. The effect of interest rate ceilings over this variable in the model with respect to the baseline model is a fall of vulnerability of 39.63%. The measure of vulnerability can be consider a close indicator of the probability of default in the model and the overall risk of the economy.

Summarizing interest rate ceilings produce a large decrease on lending in the model of around 30.49%, the cost on consumption of this regulation is minimum given the reduction on debt services for the bank. Also interest rate ceilings are highly effective at reducing the overall risk of the economy. Finally, we find that interest rate ceilings make debt more

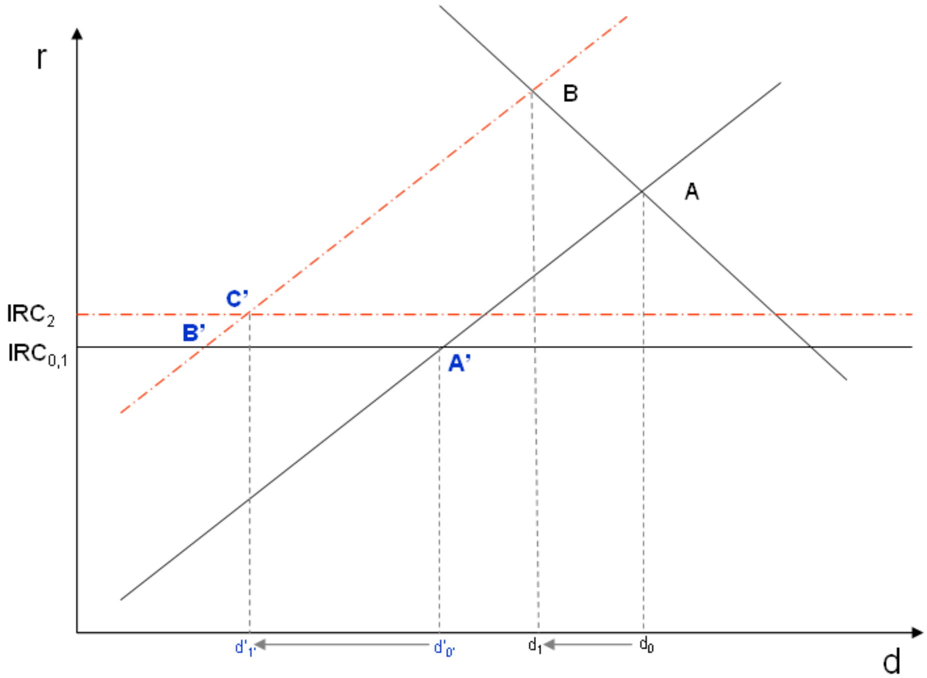


Figure 4: *Effect on debt of an increase of the exogenous interest rate r_t^* for individuals who face binding interest rate ceilings. In the baseline model we observe a movement from A to B. In the model with interest rate ceilings we will observe a movement from A' to C'.*

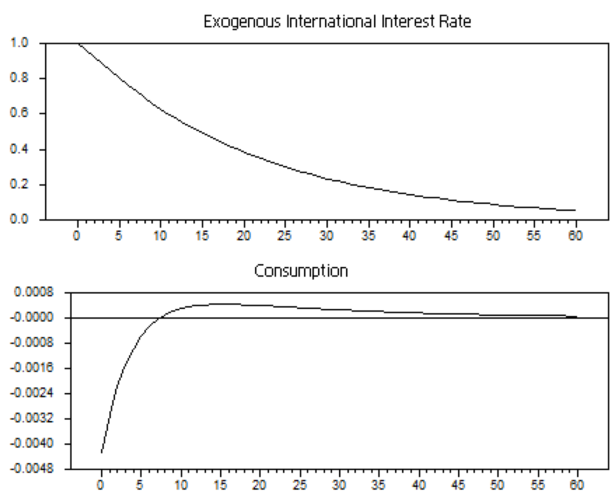
sensitive to increases on the interest rates. In particular, the effect in percentage points of an increase of interest rates could be twice as negative on debt under interest rate ceilings.

5 Conclusions

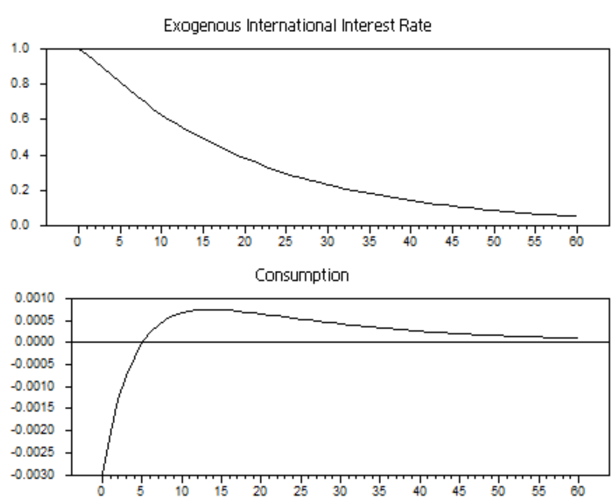
From a simple small open economy framework with heterogenous agents the most relevant results on the effects of interest rate ceilings in the laboratory economy have been presented. The findings coincide with those who argue that interest rate ceilings are an effective way to reduce risk in the financial system. On its part, although is true that interest rate ceilings produce excess demand for financial intermediation in the financial market there is no sign that this regulation could have a negative effect on consumption. The effects on welfare of a regulation of this type is beyond the scope of this model but it is important to mention that it could be analyzed under the perspective of financial deepening and productivity. An important finding of the model is that interest rate ceilings generate a distortionary effect in the dynamic of the variables in the model, in particular debt is more responsive to shocks on interest rates. The results obtained from the model indicate that under interest rate ceilings the negative effect of an interest rate increase is two times larger than without this regulation.

Appendix

Impulse Response - Baseline Model



Impulse Response - Model with Interest Rate Ceilings



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