Exchange rate regime and household's choice of debt

Vidakovic, Neven

Effectus University college for finance and law

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EXCHANGE RATE REGIME AND HOUSEHOLD'S CHOICE OF DEBT

Summary

The paper looks at the impact of the exchange rate regime and the household's choice of debt. One of the characteristics of economic transition in eastern European countries was an increase in overall debt holding. Standard economic theory assumes the relationship S=I. According to this relationship the households should use debt only for purchases of durable goods; however in some eastern European countries there was a large increase in consumer loans which are not recognized under standard no-ponzi assumption of economic models. This paper aims to investigate the case when debt is used to live above household's budget constraint. Our model shows a significant impact on the choice of the amount the debt the households are willing to hold is due to the choice of the exchange rate regime made by the central bank. The models investigates household's behavior in two main cases: stable exchange rate regime (exchange rate regime with FX risk) and variable exchange rate regime (exchange rate regime without exchange rate risk). The households make different choices under alternate exchange rate regime; this pattern of is behavior shown in the model and verified by the data.

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Neven Vidaković

Effectus Business School

Kennedy square 2

10000 Zagreb

Croatia

nvidakovic@vsfp.eu

1. Introduction

The two most basic assumptions used in macroeconomic models are that savings equal loans and households are not allowed to borrow above their budget constraint. This paper eliminates these two assumptions with the main objective to investigate how households behave under alternate exchange rate regimes[1] when the two assumptions are not used.

The standard approach to economic modeling is to use the two stated economic assumptions in a general equilibrium model and then analyze a particular behavior under certain shock. This paper takes a completely alternate route. We remove the two assumptions and investigate behavior of households under two different exchange rate regimes. The main implication of the paper lies in the assumption the behavior of economic participants is going to change where there is a change in the exchange rate regime.

Before we move any further we have to make a clear definition what is an exchange rate regime for the purposes of this paper. One of the basic distributions of the exchange rate regimes was done by IMF and it can be found in Von Hagen and Zhou (2002), Frankel (1999) and Crockett (2003). These authors have three main exchange rate regimes: fixed, intermediate and free floating regimes. However the definition of these regimes is based on the amount of *movement* of the exchange rate, not on the *direction* of exchange rate. In this paper we are going to assume alternate definitions of the exchange rate regime.

Definition: under stable exchange rate regime the central bank keeps the exchange rate fixed at one value or close to one central value. Over time the exchange rate does not exhibit a clear directional movement, the movement of the exchange rate is similar to a flat line or mean reverting series[2].

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[2] The views expressed herein are those of the authors and do not necessarily reflect the views anyone else.

Definition: under variable exchange rate regime the central bank actively changes the exchange rate and uses monetary policy to create a clear directional movement of the exchange rate[3].

The definitions of the exchange rate regimes as we have presented them are based on the direction of the exchange rate regime, not on the volatility of the exchange rate regime.

Does a **choice** of the exchange rate regime, as we have defined it, has an important impact on the behavior of the economic participants? This paper will argue that it does. We will investigate how does a choice of the exchange rate regime, fixed vs. stable impact the behavior of economic participants. The full scope of the possible effects is large and it was fully developed in Vidaković (2013), in this paper we are going to focus on the choice of the amount of credit the households are willing to hold under each exchange rate regime.

The actual choice of the exchange rate regime will at the same time determine the behavior of economic participants. In essence we are dealing with multiple model agents. The economic participants have one model for each state of the economy (choice of the exchange rate regime). Since the model for each exchange rate regime is different, the behavior of economic participants is going to be different as well.

The issue of economic switching and multiple models in the economy has been investigated several papers, but it was never used to investigate how does the change in the exchange rate affect the choice of credit. One of the best examples to investigate economic switching in a standard economic model can be found in Farmer, Waggoner, Zha (2007) who investigate new-Keynesian models and regime switching. Same authors also investigate what happens when there are forward switching expectations in Farmer, Waggoner, Zha (2009). Others investigate what happens when agents have multiple models like in Cogley and Sargent (2008).

The rest of the paper is separated in following way. Part two will develop a model with two states of the system: stable and variable exchange rate regime. Part three will mathematically simulate the model and will try to determine what are the household's

[3] There is also a third possibility of free floating regime where the central bank does not participate in the FX market; however this regime is o no interest to us.

preferences in terms of debt under alternate exchange rate regimes. Part four will test the model on empirical data. Part five concludes.

2. The model

In this part of the paper we will create the economic model where households are allowed to have debt and increase their debt holding. The second economic participant we will model are banks. Our main focus will be on the different choices under alternate exchange rate regime.

2.1. Households

We will assume the households have two different models, one for each of the monetary policy regimes. Our main focus will be on the amount of credit the households are willing to have under each exchange rate regime choice.
As mentioned there are two basic models one of each exchange rate regime. The households know the state of the monetary policy. They do not assume or expect a switch in the monetary policy. The monetary policy is given exogenously to the households by the central bank and we assume the credibility of the central bank.

2.1.1. Household under stable exchange rate regime

The households are utility maximizing agents, the utility comes from consumption. The time is discreet, t=0,1,2,3…. The object of the households is to maximize consumption over an infinite period of time given budget constraint. The households make their expectations under the rational expectations hypothesis. The household live in the current exchange rate regime and do not assume there is going to be an exchange rate regime switch. The maximization objective of the households is:

$$\max\left[\sum_{t=0}^{\infty}\beta^{t}u(c_{t})\right] \qquad (1)$$

The household tries to maximize the utility over time; the utility comes from consumption c. The *u(c)* function is a continuous, twice differentiable function, β is a discount factor.

In this model we are going to use a novel approach and we will **separate savings from credit** by focusing on the household's cash flow. This approach will allow households to have changes in both credit and savings at the same time. The assumptions from standard textbooks like Blanchard and Fisher (1989, page 69), are removed in this model. We will investigate a case where households can parallel save and increase debt since this case be found in the data. The credit is obtained from the bank. It is possible for the household to have payments both for savings and credit repayments in the same time period. The inflow of money for the households in any time period is:

$$I_t = w_t^e + \tau * S_{t-1} + \phi_t \tag{2}$$

The inflow of money I comes from wage w, new debt ϕ, the portion of liquidated τ; the values of τ are $0 < \tau < 1$. S_{t-1} is the total savings the household has accumulated up to time period t.

Following the inflow equation we can also present the expenditure equation in time t. The expenditure equation is the outflow for the households and we shall define as:

$$\mathrm{E}_t = c_t + s_t + \kappa * \Phi_{t-1} \tag{3}$$

The household expenditures or outflows E can be divided into consumption c, savings s and the portion of the existing debt paid off in that time period. Total household's debt is Φ, portion of debt paid off at time period t is κ and it has the value $0<\kappa<1$; s_t is the new savings in time period t.

The inflow and expenditure equation show us the household can borrow, repay debt, liquidate savings and create new savings all in the same time period. We have also allowed the households to repay a portion of the existing debt and to obtain new debt in the same time period, just like it can liquidate savings and create new savings at the same time.

Savings and debt accumulate over time and the accumulation can be expressed with the two following equations:

$$\Phi_t = \sum_{0}^{t-1} \phi_{t-1}(1+r_i^*)^{t-1-i} \text{ with some maximum value of } \Phi^* \tag{4}$$

$$S_t = \sum_{0}^{t-1} s_{t-1}(1+r_i)^{t-1-i} \tag{5}$$

The cost of debt for the households is r*, this it is the rate the bank is offering to the household. We shall assume the interest rate is the same for each household, exogenous and perfectly inelastic for any level of demand. The household gets savings rate of r also from the bank.

The equilibrium is E=I, now we can solve the equations for the c and get:

$$c_t = w_t^e + \tau * S_{t-1} + \varphi_t - s_t - \kappa\Phi_{t-1} \tag{6}$$

The equation (6) represents the flow of consumption in every time period for the households. As the equation (6) shows there is a possibility for the households to decrease total savings, have new savings, get new debt and repay old debt on one time period. The consumption equation (6) is the transition equation in our model.

The main characteristic of the model and the difference between this model and the standard model is the combination of debt and savings at the same time. With the inclusion of new debt ϕ in the consumption equation (2) we have created a possibility for households to have a **desired** level of consumption which removes standard budget constraint. So the choice of debt will also depend on the lifestyle the household wants to live.

Using the model set up thus far we are now going to set up the Bellman equation for the households under stable exchange rate regime. The value function for the model is:

$$V(A) = \sum_{0}^{\infty} \beta^t u(c_t) \tag{7}$$

The terminal condition is going to be transversality condition. The control function for the problem is *u(c)* so the Bellman equation is:

$$V(A_t) = \max_c \left[\frac{c^{1-\theta} - 1}{(1-\theta)} + \beta V(A_{t+1}) \right] \tag{8}$$

Subject to the equation (6). Out of the recursion presented in the Bellman equation the households are going to obtain a policy function $h(c^*,\phi^*,s^*)$, and they are going to plan their optimal path of consumption over time.

In this model the only risk for the household comes from the wages. And we are going assume the wage follows a simple autoregressive process:

$$w_t^e = \alpha w_{t-1} + \varepsilon$$

Where w is wage, α is the autoregressive coefficient and ε is the disturbance with distribution $N(0,\sigma)$

2.1.2. Model of household's behavior under variable exchange rate policies

In previous part for households the main risk comes from changes in the wages, now we are going to expand the model and introduce the FX risk. If we have a variable exchange rate, the banks will have to hedge the currency risk and the best way to do that is to transfer the risk over to the customer. The transfer of risk can be done easily by lending in foreign currency or embedding a foreign currency clause in the loans. Because of this transference of the FX risk by the banks, under the variable exchange rate the households are going to take on the exchange rate risk every time they get a loan from the bank. In order to hedge their own position, the households will have to save in foreign currency. This way the increase in loan is going to be somewhat offset by the increase in savings.

Under the variable exchange rate, with the foreign currency clause embedded in their loans the households do not know what their amount of debt is going to have in each period. The income function with FX risk is going to be:

$$I_t^e = w_t^e + \tau * S_{t-1}^e + \phi_t \tag{9}$$

The wage w and savings are stochastic, while the new debt is not stochastic since the households know the exchange rate at time t. The expenditure function is also going to have to be augmented.

$$\mathrm{E}_t^e = c_t^e + s_t + \kappa * \Phi_{t-1}^e \tag{10}$$

The consumption is expected and so is the amount of debt the household is going to have in the current time period. The actual amount of the debt repayment in local currency is not fixed since the debt is denominated in the foreign currency and the changes in the exchange rate are going to cause changes in the amount of the debt the household has. The value function is:

$$V(A) = \max E\left[\sum_{0}^{n} \beta^i u(c_i)\right] \tag{11}$$

By equating the I^e and E^e we get the following function for consumption

$$c_t^e = w_t^e + \tau * S_{t-1}^e + \phi_t - s_t - \kappa * \Phi_{t-1}^e \tag{12}$$

Where the control function is defined as:

$$f(\tau, s, \phi) \tag{13}$$

The Bellman equation is:

$$V(\tau, s, \phi) = \max_{c,\phi}\left[f(\tau, s, \phi) - \beta E\left[\sum_{n}^{n-t} \beta^{i} \{u(c_i)\} \right]\right] \quad (14)$$

From this recursion the households forms the policy function h(τ*,s*,ϕ*). Where values τ*, s*, and ϕ* are optimal values to solve the Bellman equation. We can also present the solution to the Bellman equation (14) as values of total debt and savings the households are willing to have at any time period h(S*,Φ*). Under variable exchange rate the households is not choose how much new debt to obtain, but rather the household chooses the **total amount** of debt it is willing to hold.

For each exchange rate regime (state of the system) the households have different policy functions. In the model with the fixed exchange rate regime the households did not care about the level of debt because their consumption was not affected by the changes in the exchange rate. In the model with the variable exchange rate regime the households are taking into concern the total amount of debt they have since size of the debt and repayments of the debt are stochastic. This is directly imposed by the foreign exchange rate risk created by the variable exchange rate regime chosen by the central bank.

We could look at the whole regime choice from a different perspective as well. Using the logic presented in Santini (2007) and Vidaković (2008) we could look at the choice of the monetary policy as a budget constraint. Under the stable exchange rate regime the households have a soft budget constraint because they can borrow as much as the banks are willing to lend them. Under the variable exchange rate regime the households have a hard budget constraint. If the households want to have more debt the households have to take on the exchange risk.

From the model it is clear the exchange rate can be an important policy tool to control the level of debt the households are willing the hold thus making the exchange rate a tool for control of the credit policy in the economy. We have directly seen in the model how the choice of the monetary policy affects the behavior of the households.

The stable exchange rate regime in essence gives the household's free hands when it comes to debt. In that case the only determinant of the level of debt the households are going to have is the households' time preference of consumption and the debt limit imposed by the bank. In case the households want to have preference towards present consumption, they are going to obtain as much debt as possible and consume as much as they can in the near future. If the individual household preference is towards the future then the households will increase their savings rate and save in order to be able to consume more in the future.

Given the model presented here, it is not hard to understand the strong increase in household debt in ex-socialist countries over the last two decades. If the households have strong consumption preferences towards present and there are no restrictions for the banks to meet the increase in demand for loans, there is going to be an explosion in household debt. This type of behavior was presented in Kraft and Jankov (2004).

Under the variable exchange rate the choice of the exchange rate regime is the one which serves as stopping tool for the increase in household's debt. The variable exchange rate with the exchange rate risk transfer serves as deterrent for the households to get debt just to increase their consumption.

Under the variable exchange rate policy when the household obtains a loan in foreign currency or with foreign currency clause the household is going to have to compare their expectations of wage growth with their expectations of the change in the exchange rate. If the exchange rate is depreciating more than the household's wage is growing, by choosing to have debt the household will have to decrease consumption as a result of the changes in the nominal exchange rate since their payment annuities are going to change with the changes in the exchange rate.

The difference between the hard and soft budget constraints is the main source of imbalances in the economy. If the households have hard budget constraint they will have to live within their budget constraint. If the households do not have hard budget constraint, but can borrow from the banks as much as they want, the whole dynamics of the economic system of the small open economy changes, as observed in Zbašnik (2008).

With the ability to borrow freely the households can satiate their consumption as much as they want. The policy choice of fixed exchange rate directly changes the behavior of the households. However the alternate behavior of households will change their relationship with other economic participants as well.

However there is one major problem: the households cannot live above their budget constraint for infinite period of time. At one point in time the level of debt reaches the level where the banks are no longer willing to give loans to the household. At the point of maximum debt the household's consumption can be presented with the following equation:

$$I_t =^{e}_{w_t} + \tau * S^{e}_{t-1} - \kappa * \Phi *_{t-1} \tag{17}$$

Now the income of the households is the wage, plus liquidated savings minus the repayment of debt. The debt is Φ* and it indicates the households has reached the upper limit of debt. Naturally the paradox here is that if the household does not have any savings or it does not want to liquidate accumulated savings the available income for the households is going to be below the wage. This hard landing will decrease the consumption of the households and their standard will fall. Even if the household decides to keep the unnaturally high level of consumption by liquidating the savings this also has a limit since the savings the households have accumulated are not infinite. The stop in lending and the consequences of that stop have been described in Vidaković (2005a).

The choice of the variable exchange rate regime leads to completely different outcome then the choice of the stable exchange rate regime. The variable exchange rate regime immediately serves as a hard budget constraint of for the households and a deterrent against living above their means.

2.1.3. Exchange rate regime switches

In this part we are going to discuss the implications of the exchange rate regime change. We will model the switch in the monetary exchange rate regime and its implications. The focus will be when the exchange rate regime changes from fixed to a variable exchange rate regime.

The switch from stable to variable exchange rate regime is more "stressful" for the households since the households have to learn the true model the central banks is using to change the exchange rate. Because of introduction of the exchange rate risk the households will have to adjust their debt holdings. Increase in exchange rate implies decrease in consumption since the depreciation causes debt annuity to go up. Also there will be adjustment in obtain new debt to finance consumption.

Once there is a change from variable to stable exchange rate regime the households switch their model as well. The change in the model is instantaneous. With the change in the model, comes the change in the choices made. The households have to learn the model which the central bank is using. The models which use learning techniques and situations where expectations are not perfectly rational can be found in Hansen, Sargent, Turmuhambetova, Williams (2006), Marcet and Sargent (1989), Pearlman and Sargent (2005), Woodford (2006).

When the central bank switches to variable exchange rate, the households have to learn the model central bank is using to change the exchange rate. The model presented here closely follows Evans, Honkapohja, Williams, Sargent (2012). Rational expectations model for the movement of the exchange rate is

$$e_t = \mu + \alpha E^*_{t-1} e_t + \delta z_{t-1} + \eta_t \tag{18}$$

Where e is the nominal exchange rate, $E^*_{t-1}e_t$ denotes expectations of nominal exchange rate on available information at t-1, η_t is an unobservable white noise shock with $E\eta^2_t = \sigma^2_\eta$. The value of the intercept μ will be put to 0 for simplicity. The variable z is an exogenous observable variable following stationary AR(1) process which we will define as:

$$z_t = \rho z_{t-1} + w_t \tag{19}$$

Where $w_t \sim$ i.i.d $(0, \sigma^2_t)$.

This particular set up gives us is the ability to look at the monetary policy from two separate perspectives. First perspective is the expectations E* which do not have to be true rational expectations, but can be based on subjective distributions of household of future changes in the exchange rate. The expectations E* might be something which is deeply rooted in household's mentality like fear of inflation or fear of devaluation as described in Gregurek and Vidaković (2008). In the stable rational expectations equilibrium the subjective expectations operator E* should become objective rational expectations E* equal to the model the central bank has. The actual conduct of the central bank’s monetary policy is given by the exogenous shocks z. Since the household does not know what the central bank will do, so they have to learn how the central bank works. For the equations (18) and (19) the rational expectations solution is

$$e_t = \frac{1}{(1-\alpha)} \delta z_{t-1} + \eta_t \tag{20}$$

For simplicity we will set $\beta = (1-\alpha)^{-1}\delta$. What participants try to do is to learn the changes of β over time and to be able to do that they will have to employ Bayesian techniques. Using simplified notation we can now get the participants beliefs and how they evolve over time.

$$e_t = \beta z_{t-1} + \eta_t \tag{21}$$

Where we will assume $\eta_t \perp z_{t-1}$ and $\eta_t \sim N(0, \sigma^2_\eta)$. The equation (21) is the foundation for the law of motion for β. As times goes by the exogenous shocks z will change the value of the variable β because the households will learn the central bank's model. So now we are going to set the law of motion as

$$e_t = b_{t-1} z_{t-1} + \eta_t \tag{22}$$

Where b_{t-1} is the t-1 estimate of β. For mathematical purposes we are going to assume the prior distribution of β is $\beta \sim N(b_0,V_0)$, the prior distribution implies a posterior distribution of $f(\beta \mid y^{t-1})$ where y is equal to $y^t = (y_t, y_{t-1}, y_{t-2}, ...)$ and $y'_t = (p_t, z_t)$ of the form $N(bt,V_t)$. In order to update the parameters and get observations from which they can learn the model the central bank is using, the households have to have a mechanism which allows them to learn through observations. Because of this we can use standard Kalman filter:

$$b_t = b_c + \frac{V_{t-1} z_{t-1}}{\sigma^2_\eta + V_{t-1} z^2_{t-1}} (e_t - b_{t-1} z_{t-1}) \tag{23}$$

$$V_t = V_{t-1} - \frac{z^2_{t-1} V^2_{t-1}}{\sigma^2_\eta + V_{t-1} z^2_{t-1}} (e_t - b_{t-1} z_{t-1}) \tag{24}$$

In Evans, Honkapohja, Williams, Sargent (2012) there is formal prof the model converges with probability 1 if α < 1 and they also get that

$$V_t = \frac{\sigma_\eta^2}{(t-1)S_t - z_t^2} \to 0 \tag{25}$$

With probability 1 for all σ^2_η regardless of whether σ^2_η is correct or not.

The model presented shows how the households learn over time and how eventually the rational expectations model prevails: the central bank and the economic participants end up having the same model.

We are now going to implement the learning process in our model and we are going to connect the household consumption choice with the learning model. We can define the variable exchange rate regime as:

$$f(e) = \sum_{t=0}^{n} (1 + \delta_t^e) x_0 \tag{26}$$

Where δ is the change in the exchange rate given the actions performed by the central bank. The parameter δ is stochastic.

When the exchange rate regime changes the households are aware they have to modify their model for the exchange rate risk. There are two possibilities: the rate of change of the exchange rate is known to the households and rate of change of the exchange rate is not known to the households.

Case 1: the rate of change is known. In this case the expectations are made rationally and the Bellman equation has the same form as before:

$$V(\tau, s, \phi) = \max_c \left\{ f(u(c), \phi) - \beta E^{RE} V_{t+1}^{RE}(\tau_{t+1}, s_{t+1}, \phi_{t+1}, \Phi_{t+1}) \right\} \tag{27}$$

Where RE now shows that the expectations are made rationally under the rational expectations hypothesis.

Case 2: the rate of change of the exchange rate is not known to the households. When the exchange rate regime switch is announced the household does not know what the average rate of depreciation going to be is and the household has to make expectations using the probability distribution from equation (21).

Since the household does not know the conduct of the monetary policy, the household has to assume the probability distribution for the changes in the exchange rate. Initial this distribution is wrong, but over time the household learns the true distribution using the Kalman filter learning mechanism we have described in equations (23) and (24). Because of the introduction of Kalman filter we have to change our transition equation to:

$$c_{t+1} = g(\tau_t, s_t, \phi_t, \theta_t) \tag{28}$$

Where θ represents the expected value changes in the nominal exchange rate, based on the collected observations. The parameter θ is obtained from the Kalman filter through learning process described in the equations (23) and (24). Given this knowledge we can change the Bellman equation to be

$$V_t^B(\tau_t, s_t, \phi_t, \theta_t) = \max_c \left\{ f(u(c), \Phi) - \beta E^B V_{t+1}^B(A_{t+1}, \Phi_{t+1}, \theta_{t+1}) \right\} \tag{29}$$

Bellman equation has now changed and it has Bayesian expectations noted with superscript B. The addition of the Bayesian expectations changes the whole process of the recursion. Under the rational expectations once the Bellman equation is obtained the households solve the dynamic programming problem and the solution is valid for every time period. With the Bayesian expectations that is not the case. Since the mean of the distribution of the exchange rate changes every period, the Bayesian households obtains the Bellman equation every period and then solves the dynamic programming in each time period and not just once and for all like under the rational expectations. From this process comes the aversion towards high level of debt. Over time the households obtain the correct distribution of the changes in the nominal exchange rate and the households and the central bank are going to have the same distribution leading to the rational expectations equilibrium.

2.2. Banks

The banks are profit maximizing firms and will try to maximize profits under given exchange rate regime. In eastern European countries the role of the banks in the economy and process of privatization countries has been sensitive. For example Ribnikar (1995, 2004b) saw banks as desirable to be privatizes, but important enough for the economy not to be privatized fast. On the other hand Kraft (2002, 2003) and Kraft, Faulend, Tepuš (1998) see privatization of banks and sale of bank to foreigners as something very beneficial.

The central bank imposes the monetary policy onto banks. Once the banks know the monetary policy they try to minimize the cost of regulation and maximize their profits. To us the important to understand what is the portfolio choice of the banks under different exchange rate regimes and is there a difference.

We are going to model banks as utility maximizing economic agents. The banks behave in the same way as the households do except the object of the maximization is not consumption, but profits. In banking business the profit comes from buying money (getting deposits from primary and/or secondary sources of funds) at some price and selling it (giving out loans or participating in trading activities) at a higher price. The difference between cost of funds and the price of funds "sold" gives bank's net interest income and consequently profit. The pursuit of profit takes place while the banks are trying to solve the problem of minimizing the business risks and maximizing the profits. The assumption of maximizing profits, while minimizing the risk is the theoretical basis for using the utility function. We will assume the utility function has following standard properties $u'(\bullet)>0$ and $u''(\bullet)<0$, utility function is continuous and as least twice differentiable. The increase in profit is necessarily tied with increase in risks taken. The bank wants more profit; however increase in profits is followed by increase in risk exposure, making the pleasure of each new dollar earned under higher risk less and less pleasurable. We will assume the bank has option to invest in as many investments as it can get funding for and the investments have a positive rate of return.

The profit is an accounting variable, not economic variable. In accounting terms the profit is the difference between the income and the cost. The bank can influence either the income or the costs and then see the results in the profits. The profit can be influenced only indirectly. In order to have profit in the utility function we have to derive the connection between income, expenditure and then use that connection as the control variable. The formula for profit will be:

$$\pi = rA - \delta L \tag{30}$$

Where π is profit, A is a matrix for assets and L is the matrix for liabilities[4], r is the vector of the interest rates on assets and δ is the vector of the interest rates on liabilities. Assets have to equal liabilities because of funding we get the following equation for bank's profit.

$$\pi = rA - \delta A = A(r - \delta) = \tau A \tag{31}$$

Where τ is the vector of the net effective interest rate the bank gets or the interest rate spread between the assets and liabilities. We are assuming there are no other costs. Although this is not technically correct we are more focused on the decisions the banks make, not on the actual value of the profits.

We will use CRRA class of utility function so the bank has relative risk per unit of exposure. The bank has a fixed percentage of risk acceptances for each investment. This gives the bank flexibility in its investments, but at the same time the bank has a fixed risk tolerance. The utility function is:

$$u(\pi) = \frac{\pi^{1-\gamma}}{1-\gamma} \tag{32}$$

Where π is profit and γ is elasticity of substitution with the value $0<\gamma<1$. The importance of the choice of the utility function can best be found in Kimball (1993). The value of the choice of the utility function lies in the standard risk aversion measure which is proposed by Kimball (1993):

[4] We are only going to look at the interest bearing assets and interest bearing liabilities plus capital. We are not going to look at other items of the bank's balance sheet. So when we are referring to assets or liabilities we are referring to the interest bearing parts of the balance sheet plus capital.

$$-\frac{u''}{u'} \tag{33}$$

The banks face two separate optimization problems. The first problem is how to maximize the profits from the credit portfolio, which is derived from the funds collected in liabilities and then allocated in assets. The second optimization problem is how to minimize the cost of regulation. The assets of the bank are going to be separated in two vectors, shown in the matrix form they are

$$A_t = \begin{bmatrix} x_t \\ q_t \end{bmatrix} \tag{34}$$

Where A is total assets at time t, x is the interest bearing assets and q is the part of assets allocated specifically as demanded by the regulation. Since we are not interested in the interplay between the central bank and the bank we are only going to focus on the x part of the balance sheet and treat q as fixed.

The problem will be stochastic since the banks face risk in their business and have to create expectation about future. Basic set up of the problem can be found in Cooper and Adda (2003). The bank tries to maximize present value of expected utility from profits over time.

$$\max E\left[\sum_{0}^{\infty} \beta^{t} u(\pi_t)\right] \tag{35}$$

The profit is noted as π, discounted over by the rate β in order to get the present value of profit since 0<β<1, E stands for the expectations operator. The value function is:

$$V_t(x_t) = \max E\left[\sum_{0}^{\infty} \beta^{-t} u(\pi_t)\right] \tag{36}$$

Subject to $x_0 > 0$, $x_\infty > 0$ is free; $x_t > 0$ for all time periods. We are assuming x has some initial value; the end value is free, so we do not impose a growth limit on banks. We are also assuming that through time the value of x is greater than 0, since it would be impossible for the bank to have no interest bearing assets in this part of the balance sheet. The transition equation for interest bearing part of the balance sheet is:

$$x_t = x_{t-1} + (\Lambda_t - \lambda_t) \tag{37}$$

In each period the bank has net interest bearing assets x_{t-1} from the previous period and the current period changes in the values of interest bearing assets. Where Λ_t represents the incoming funds into the bank, λ_t are the outgoing funds in each time period.
Since we are investigating do banks alter their lending under alternate exchange rate regimes we are going to give banks two possibilities: to lend to lend to households and to lend to all other participants in the economy. The formula for profit in each time period will be:

$$\pi_t = [x_{t-1} + (\Lambda_t - \lambda_t)][zr_t\omega_t + r_t^e(1-\omega_t)] \tag{38}$$

In equation (38) we see two rates of return and two classes of assets. The first rate of return is z, which is the average rate of return on all other assets in the balance sheet and it is portion of ω of the interest bearing assets. The second group is the loans to households, those loans have the 1-ω portion of the risk bearing assets and the expected rate of return is r. As we can see both rates have subscript t, which denotes time period and superscript e which denotes expectations about the risk bearing rate of return for the banks.
Now we can set up the Bellman equation:

$$V_t(x_t) = \max_{\pi_t \omega_t} \{u(\pi) + \beta^{-1} E[V_{t+1}(x_{t+1})]\} \tag{39}$$

The E in Bellman equation indicates expectations since the bank has risk bearing assets where the rate is not known with certainty, but it has to be obtained through expectations.

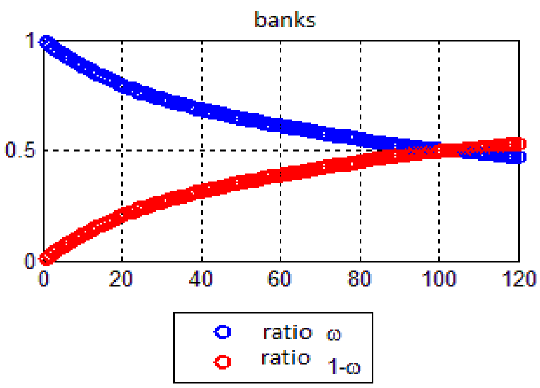
3. Model simulation

We are going to test the model in two separate ways. First we are going to perform a Matlab simulation of the model and in the next part of the paper we will perform a real life data test of the model.

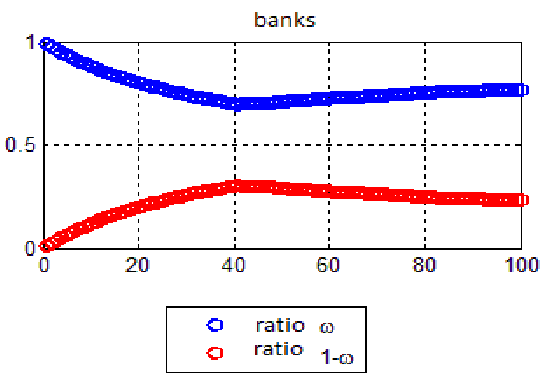
The parameters used for the model are given in the appendix. Going back to the main thesis of the paper we should see different amounts of credit the households are willing to hold under different exchange rate regimes. Under variable exchange rate regime we should see smaller amounts of credit because the households do not prefer large debt holding because of foreign exchange risk. On the other hand under stable exchange rate we should see higher debt holdings.

In the model we start with ω=1, so there is no household debt. Picture 1 shows what happens under stable exchange rate regime and Picture 2 shows what happens under variable exchange rate regime.

Picture 1.: ω under stable exchange rate regime



Picture 2.: ω under variable exchange rate regime



Source: author's calculation

Under both exchange rate regimes we see increase in value of ω, so the household's debt starts increase. However there is one main difference between stable and variable exchange rate regimes. Under variable exchange rate regimes lending to households peeks at around 30% of total lending and then starts to decrease. On the other hand lending to households under stable exchange rate regime steadily increases over time and as we can see close to the end of the simulation takes over as the majority of bank's lending. From the simulation we can see over time the lending to households completely crowds out lending to other participants in the economy.

4. Real life example

The real life example will be performed on Croatia, Hungary, Latvia and Slovakia. First we have to define the exchange rate regimes. As it is obvious from the data in Table 1, there is no need for econometric testing for Hungary and Slovakia since from the data we can see the exchange rate is variable and then it switches to stable exchange rate regime. Therefore the econometric testing will be form only on Croatia and Latvia. The test used was Chow test based on Chow (1960) which is used to determine was there a structural break in the data. In our case the cause for the structural break is the change in the exchange rate regime.

In case of Croatia we are going to use the ARMA regression. Using the monthly time series for the exchange rate we are going to have the following regression:

$$EX = \alpha + \beta_1 EX_{t-1} + \beta_2 EXMA_{12} \tag{40}$$

Where the EX is the exchange rate and the $EXAM_{12}$ is the 12 month moving average of the exchange rate. The two time periods we are going to split the data into are going to be 1994 – 2000 and 2001-2008 for Croatia. Using the F distribution table for k=3 and 158 we get that the p value is 4,8%, which is just below a 5% significance level. In this particular case we are going to reject the null hypothesis and state there was a regime switch in Croatia.

For Latvia the first time period is going to be 1993-1999 and the second time period is going to be 2000-2008. The F value we are going to base on the F distribution with k and t-2k. In our case that is 3 and 186. P value we have obtained is 0 to the 4^{th} decimal clearly indicating that there was a structural break.

From Table 1 we can clearly see the data confirmation of the model. In Hungary the data follows the model perfectly. The household loans start with almost 40% at the start of the data and we can clearly see the decrease of the amount of household loans in the amount of total long. Then in 2001 Hungary stabilizes the currency and the loans to households start growing and the amount of loans to households a portion of total loans more than doubles. With the start of the financial crisis in 2008 the Hungarian Forint starts to depreciate and the portion of loans stabilizes and from 2009 to 2011 it is almost unchanged. Also at the same time period the currency depreciates 15% so portion of growth of loans can also be contributed to the depreciation of the exchange rate, not to actual growth of loans.

Table 1: ω under variable exchange rate regime

	Croatia		Hungary		Latvia		Slovakia	
end of year	Croatian kuna	1-ω	Hungarian forint	1-ω	Latvian Lats	1-ω	Slovečka Krona	1-ω
1990	:		83,77	39,7%	:			
1991	:		101,40	27,8%	:			
1992	:		101,68	29,2%	1,01			
1993	:	9,4%	112,35	30,1%	0,67		37,04	7,3%
1994	6,96	12,7%	136,73	26,1%	0,67		38,48	6,5%
1995	6,96	14,5%	183,30	21,3%	0,71		38,86	5,4%
1996	6,94	19,6%	206,91	14,9%	0,70		39,95	5,0%
1997	6,96	26,3%	224,71	16,1%	0,66	2,4%	38,43	6,1%
1998	7,29	29,7%	252,39	14,1%	0,66	5,2%	43,21	7,6%
1999	7,68	34,7%	254,70	15,0%	0,59	13,3%	42,40	10,1%
2000	7,58	38,6%	265,00	16,8%	0,58	17,3%	43,93	12,1%
2001	7,37	40,5%	245,18	21,9%	0,56	21,8%	42,78	18,3%
2002	7,48	44,8%	236,29	28,9%	0,61	26,7%	30,13	21,3%
2003	7,65	49,8%	262,50	36,1%	0,67	36,0%	30,13	25,5%
2004	7,67	51,9%	245,97	40,5%	0,70	42,4%	30,13	35,1%
2005	7,37	53,3%	252,87	42,2%	0,70	50,0%	30,13	40,9%
2006	7,35	52,9%	251,77	42,3%	0,70	59,1%	30,13	42,0%
2007	7,33	54,5%	253,73	43,8%	0,70	61,1%	30,13	42,9%
2008	7,32	54,7%	266,70	46,1%	0,71	61,4%	30,13	44,9%
2009	7,31	53,5%	270,42	48,1%	0,71	62,0%	1,00	48,3%
2010	7,39	52,3%	277,95	50,8%	0,71	61,9%	1,00	50,8%
2011	7,53	50,0%	311,13	50,2%	0,70	60,2%	1,00	51,5%

Source: author's calculation and central bank's data

Similar pattern can be seen in Slovakia as well. The ratio of loans in the bank's balance sheet was low as long as the currency was depreciating. Then in 1998 the currency stabilizes and the loans to households start to grow as the portion of total loans. The increase is even faster as the Slovakia stabilizes the currency because of the joining of the EMU.

What is most startling cases we can see here is the crowding out effect the loans to households have on other loans. Just like the case of our model we see the loans to households over time take over as the majority of loans in the balance sheet. Just like in the model over time the loans to households crowed out other loans and they become the dominant balance in the balance sheet.

Model is consistent for Latvia as well. The ratio of household's loans is increasing, which we see in the model, but it truly explodes once the exchange rate stabilizes.

5. Conclusion

This paper sets forth to investigate the effects of the exchange rate regime choice on banks, households and distribution of debt. The main feature of the model presented in this paper is the ability of households to hold both debt and savings at the same time. In this property the model significantly differs from other models where savings equal loans. In this model savings can equal to credit and the credit can be used to increase consumption. Further the model assumes the FX risk plays a significant role in the actual decision process of the households. If the exchange rate is stable the propensity of households towards debt is greater. On the other hand if the exchange rate regime is variable, the very existence of the FX risk will serve as a deterrent towards the households and debt holding.

The model is tested in both laboratory and real life setting. We can see from the tests two main facts: the choice of the exchange rate regime plays a significant role in terms of the debt holdings of the households and savings equals loans assumption needs to be revised when modeling eastern European transition economies.

Apart from the confirmation of the model in the data the more implication of the model is the importance of the exchange rate regime on the bank's credit policy. This paper has shown that just the choice of the exchange rate regime has significant impact on the economy.

Appendix 1: the data

In order to calibrate the model for matlab simulation we used to following data and parameterization. The wages were taken from Croatia in period 31.12.2001 – 31.12.2008. For the variables exchange rate the Slovenian exchange rate was used from period 10.1999 – 12.2003. Savings was set as 20% of wages. This assumption is empirically consistent with Croatia. We could have used various parameters for savings, but that is not the object of the research.

Initially the banks' balance sheet was set at 0 loans to households. Interest rates on loans and deposits were used from Croatian central bank's web site. For utility functions parameters γ and θ were put at 2. Discount factor β is 4% per year. All these factors are consistent with the parameters used in Bokan, Grguric, Krznar and Lang (2009).

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