EXCHANGE RATE REGIME AND HOUSEHOLD'S CHOICE OF DEBT

Summary

This 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. In 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 precisely that case: increase in household's debt which is used only for living above their means. The paper hypothesizes and proves 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 paper investigates 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). Behavior of the households is different under each exchange rate regime can be seen in the model and in the data as well.

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Neven Vidaković

Effectus Business School

Kennedy square 2

10000 Zagreb

Croatia

1. Introduction

There are many basic assumptions which are applied in economics. The two most basic ones are savings equal loans and households are not allowed to borrow in order to live above their means. This paper eliminates these two assumptions from the economic model with the main objective to investigate how households behave under alternate exchange rate regimes[1].

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 different exchange rate regime. 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.

- Stable exchange rate regime: is a type of exchange rate regime where the central bank keeps the exchange rate fixed at one value or close to one central value over large period of time. 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.

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- Variable exchange rate regime: the central bank actively affects the exchange rate and uses monetary policy to create a clear directional movement of the exchange rate.
- Free floating regime: the central bank does not participate in the FX market and the central bank is not concerned with the movement of the exchange rate over time. Exchange rate is freely allowed to move up or down and there is not clear trend over time.

The definitions of the exchange rate regimes as we have presented them in this paper are based on the direction of the exchange rate regime, not in the volatility of the exchange rate regime. This is particularly important for this paper.

What if a **choice** of 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 off the exchange rate regime, fixed vs. stable impact the behavior of economic participants. Again the focus is not on the changes in the exchange rate, but on the actual choice of the exchange rate regime. 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. Just the announcement of a regime will put economic participants into a certain frame of mind. 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 investigates several paper, 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: under stable and under variable exchange rate regime. Part three will mathematically simulate the model and will try to determine what are the households 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 are going to represent the economic model where households are allowed to have debt and increase their debt holding. We are going to create two separate models for two states of the economy: one model for variable exchange rate and one model for stable exchange rate. We are going to use the definitions of the exchange rate regime as provided in the previous part of the paper.

2.1. Households

We are going to assume the households have two different models, one for each of the monetary policy regimes. What is important is the difference between the choices made in alternative models. We are going to focus on 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 there is going to be 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. Model of household's behavior under stable exchange rate policies

The household are utility maximizing agents, the utility comes from consumption. The time is discreet. The object of the households is to maximize consumption over an infinite period of time given constrains. 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 objective of the households is:

$$\max\left[\sum_{0}^{\infty}\beta^{t}u(c_{t})\right] \text{ subject to constrains} \tag{1}$$

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 follow a novel approach and we are going to **separate savings from credit**. We are going to look at the flow of funds in each time period and we are going to allow households to have both credit and savings at the same time, this is not the standard approach in textbook like Blanchard and Fisher (1989, page 69) in which usually have the "no ponzzi assumption". We are going to investigate precisely this option, where households can parallel save and increase debt since it is the option which has occurred in real life which is to allow households to have credit. 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. This research builds further on Vidaković (2005). The inflow of money for the households in any time period is:

$$I_{t} = w_{t} + \tau * S_{t-1} + \phi_{t} \tag{2}$$

The inflow of money I comes from wage w, new debt φ, the portion of savings that gets liquidated τ; the values of τ are 0< τ <1. S is the total savings the household has accumulated up to time period t.

Following the inflow equation we are also going to have the expenditures equation in time period t. The expenditure equation is the outflow for the households and we shall define in the following way:

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

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. The portion of the total debt noted as Φ, paid off at time period t is marked with κ and it has the value 0<κ<1; s is the new savings in time period t.

Following these two equations we have given the households the ability to borrow, repay debt, liquidate their savings and make 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.

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 debt is costing the households the rate 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.

In equilibrium the E=I holds, when we solve the equations for the c we get the equation:

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

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 is above their means and save at the same time. 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 going to be

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

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*,φ*,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:

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

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

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

The model presented in the previous chapter had uncertainty only in the form of the wages, now we are going to expand the risks the households face and introduce the FX risk.

If we have a variable exchange rate, the banks will have to hedge for 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 foreign currency 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:

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

The amount of new debt φ is now stochastic since when the household obtains the loan it knows the exact value of the loan given the exchange rate in the time period. What changes in each period is the total value of savings, since the value of savings will change will the changes in the exchange rate.

The expenditure function is also going to have to be augmented. The expenditures of the households are also not known in advance.

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

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. Now the value function of the households is going to change and we are going to have:

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

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

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

Where the control function is defined as

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

So the bellman equation is going to be

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

From this recursion the households is going to form the policy function:

$$h(\tau^*, s^*, \phi^*) \tag{15}$$

The equation (15) shows the policy function in terms of the flow variables, but the policy function can also be shown in the balance variables as

$$h(S^*, \Phi^*) \tag{16}$$

The equation (16) shows the policy function as how much savings and debt the household is willing to hold at any point in time. Where S* and Φ* represent the optimal levels of debt and savings the households is willing to have in each time period. Under variable exchange rate the households is not choosing how much new debt is going to obtain, but rather the household is choosing the **total amount** of debt it is willing to hold.

So why was this so important for the model? **For starters we have to look at the 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. They just cared about the consumption, while 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 we have 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 get a loan in foreign currency and the 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 go up.

The difference between the hard and soft budgetary constraints is the main source of imbalances in the economy. If the households have hard budget constraints they will have to live within their own means. 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. So 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. Since we have concluded the stable exchange rate regime is going to increase the demand for loans the banks have to find ways to fund increase in demand for loans. If the banks cannot get funding from primary sources the bank will have to go outside of the country to obtain funding. This in turn will increase foreign debt.

However there is one major problem: the households cannot live above their standard 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:

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

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 are going to 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 and there is no need for the households to adapt in any way. With the change in the model, comes the change in the behavior. 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).
Since we are developing model one participant at the time now we are going to develop a general learning principle which will evolve over time and we are going to develop it on only one variable: nominal exchange rate. The same principle can be used on other variables as well. The model which we are going to present here closely follows Evans, Honkapohja, Williams, Sargent (2012). Rational expectations model for the movement of the exchange rate is

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

Where e is the nominal exchange rate, $E^*_{t-1}e_t$ denotes expectations of nominal exchange rate on available information at t-1. The variable z is an exogenous observable variable following stationary AR(1) process which we will define as

$$z_t = \rho z_{t-1} + w_t \quad (19)$$

Where $w_t \sim$ iid $(0, \sigma^2_t)$ and 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.
What 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). The main point is that in the stable rational expectations equilibrium the E* which is subjective should become real rational expectations E* which is equal to the model the central bank has under the rational

expectations assumptions of the one model. The monetary policy of the central bank is given by the exogenous shocks z. The variable z in our contest are monetary interventions of the central bank which change the value of the nominal exchange rate. The household (or any other participant) 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 $\beta = (1\text{-}\alpha)^{-1}\delta$. 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 (4.118) is the foundation for the law of motion of the variable 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 there is some prior distribution of β, which means the exchange rate regime switch did not occur in time period t-1 but some time before and the household is able to already have some prior values of β which are going to be distributed as $\beta \sim N(b_0,V_0)$, this 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 we set up standard Kalman filter:

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

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

In Evans, Honkapohja, Williams, Sargent (2012) there is formal prof the model converges with probability 1 if $\alpha < 1$ 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 here tells us how the households (any other economic participants) 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. In our case the households are going to "learn" the central bank's true model after the switch from stable to variable exchange rate regime.

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:

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

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 and the only way to make expectations is to have some probability distribution. This is the same probability distribution used in equation (21).

The household assumes the change of the exchange rate is going to have distribution N(μ,σ). This distribution is not correct and does not match the policy function distribution the central bank has. Here we are going to follow similar approach from Cogley and Sargent (2008).

Since the distribution the households have is wrong, thus the expectations created based on that distribution are wrong as well. The only way for households to improve their distribution is to obtain the correct distribution and the only way for the household to obtain the correct distribution is through sampling. So every time when the period ends there is going to be another item added to the sample as shown through Kalman filter in equations (23) and (24). In that case the transition equation we have been using before is now going to be changed,

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

Where θ represents the expected value of distribution of exchanges rate of the thus far collected observations of the changes in the nominal exchange rate. 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

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

As we can see the bellman equation has now changed and several new properties have been added. The first property is that the bellman equation is now created with the Bayesian expectations because there is a superscript B.

The addition of the Bayesian expectations changes the whole process of the recursion. Under the rational expectations once the 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 is going to 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

Once the monetary policy is chosen the banks are put into a framework they will follow in order to gain maximum profits under the circumstances. The banks are just like other economic participants in terms of how they are going to be modeled, however they are of great importance for other economic participants and how they behave given the exchange rate regime.

The issue of banks in transition countries has been a sensitive one. 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. The profit maximization is an optimization problem. To us the important to understand what is the portfolio choice of the banks under different exchange rate regimes and is there a difference.

2.2.1. Modeling banks as utility maximizing economic agents

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 are going to 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 profits is necessarily tied with increase in risks taken. The bank wants more profits and gets more pleasure from earning more money (the first derivative of the utility function is greater than 0). 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 (the second derivative of the utility function is less than 0). The bank has option to invest in as many investments as it can get funding for. The investments have a rate of return.

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 profit is an accounting variable, not economic variable. In accounting terms the profit is the difference between the income and the cost. Since profit is an accounting variable it is impossible for a bank, or any other firm to use the profit as a control variable. 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 the 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[2], 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 banks profits.

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

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 all other costs are covered from all other income. Although this is not technically correct we are more focused on the decisions the banks make, not on the actual value of the profits. The utility function we are going to use 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<γ<1. The importance of the choice of the utility function can best be found in Kimball (1993) where it is stressed that the foundation of most economic models is the utility function and the choice of the utility function can dictate the whole model. The value of the choice of the utility function lies in the standard risk aversion measure which is proposed by Kimball (1993):

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

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[2] 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.

Using the CRRA function we have the relative risk as a constant. The bank is always willing to risk γ per loan, a relative amount.

2.2.2. Bank's dynamic programming problem

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 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.

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 also 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, E stands for the expectations operator, and before we set up the Bellman equation we need the value function. The value function takes the form:

$$V_t(x_t) = \max E\left[\sum_0^{\infty} \beta^{-t} u(\pi_t)\right] \tag{36}$$

Subject to $x_0 > 0$, $x_\infty > 0$ is free; $x_t > 0$ for all time periods. Where x is the part of the bank's balance sheet that is interest bearing and is net of regulation imposed by the central bank. We are assuming that x has some initial value of; value x is a part of the bank's balance sheet when the bank starts the control problem, 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:

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

with $0 \leq \omega \leq 1$

In equation (38) we see two rates of return and two classes of assets. The first rate of return is r, 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 z. 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.

To obtain of the solution for the maximization problem in equation (36) we need a recursive solution of the problem. To obtain that recursive solution we will use Bellman principle of optimality as described in Adda and Cooper (2003 page 14). 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. Equation (39) is telling how the bank is going to behave. By solving the bellman equation we can find the optimal path for the bank in order to achieve the maximization of profits. First order conditions are for π

$$u'(\pi_t) = E\lfloor \beta^{-1}((1+r_t)\omega_t + (1+z_t)(1-\omega_t))V'_{t+1}(x_{t+1})|t\rfloor \tag{40}$$

For ω

$$E[V'_{t+1}(x_{t+1})(r_t - z_t)|t] = 0 \tag{41}$$

In the equation (41) we have used the fact that $(1+\theta)^{-1}(x_t + \Lambda_t - \lambda_t)$ is known at time t. Using equation (39) and the envelope theorem described in Blanchard and Fisher (1989 page 280) we can get:

$$V'(x_t) = E\lfloor \beta^{-1}((1+r_t)\omega_t + (1+z_t)(1-\omega_t))V'_{t+1}(x_{t+1})|t\rfloor = u'(\pi_t) \tag{42}$$

Now we can conclude that marginal utility of profit has to be equal to the marginal increase in x, the interest bearing part of the balance sheet. Using this relationship we can eliminate V'(x+1) from the first order conditions and get equations in (40) and (42).

$$u'(\pi_t) = E\lfloor \beta^{-1}((1+r_t)\omega_t + (1+z_t)(1-\omega_t))u'(\pi_{t+1})|t\rfloor \tag{43}$$

$$E[(1+r_t)u'(\pi_{t+1})|t] = E[u'(\pi_{t+1})(1+z_t)|t] \tag{44}$$

We can now substitute (44) into (43) the two first order conditions become:

$$u'(\pi_t) = \beta^{-1}(1 + r_t^e)E[u'(\pi_{t+1})|t] \tag{45}$$

$$u'(\pi_t) = \beta^{-1}E[u'(\pi_{t+1})(1 + z_t)|t] \tag{46}$$

As we can see the bank is trying to solve a dynamic problem of how to optimize investments of the funds it has collected.

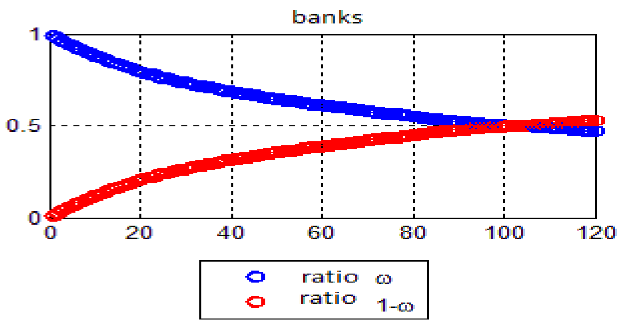
3. Model simulation

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 are going to 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 debt. On the other hand under stable exchange rate we should see higher debt holdings.

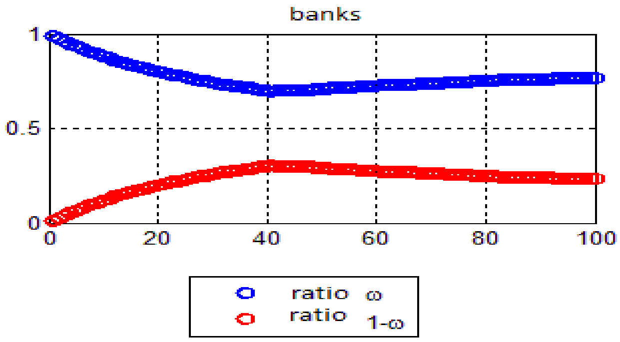
In the model we start with ω=1, so there is no household debt. Picture 1 shows what happens under stable exchange rate regime and Picture 2 shows what happens under variable exchange rate regime.

Picture 1. : ω under stable exchange rate regime



Under both exchange rate regimes we see increase in value of ω, so the households debt starts to appear and from the initial point when the banks do not lend to households they start to lend at the start of the simulation. In both cases we see there is an increase in the lending to households and after time the households start to increase in the total balance.

Picture 2. : ω under variable exchange rate regime



However there is one main difference between stable and variable exchange rate regimes. Under variable exchange rate regimes lending to households starts to decrease, peeks at around 30% of total lending and then stabilizes its portion in the balance sheet. 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 Picture 3, 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. We have performed econometric tests for both countries and have found there was an exchange rate regime switch. The details are in appendix 1.

From Picture 3 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.

Picture 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%

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 hypothetical 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 and households. 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 deterent 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: exchange rate regime switch in Croatia

In terms of the exchange rate regime switch there are three countries where it is immediately clear from the data there was an exchange rate regime switch. In case of Croatia this is not exactly clear so we are going to use Chow test.

The basic premise of the Chow test (Chow 1960) is to investigate was there a **structural break in the data, something which has altered the economic pattern of the data creation**. Chow test does not have the ability to tell us what is the reason there was a structural break in the data. This suits just fine, since we are assuming the reason for the structural break in the data was the change in the exchange rate regime in the country.

The mechanisms of the Chow test are rather simple. The actual test is done in the following way. The independent variable and independent variables are determined then a regression is run using the whole data set. Then the data set is split into two parts, before and after the suspected structural break. Then again two regressions are run; one using the data before the structural break and one regression is ran using the data after the structural break. In the end F-test is performed using the sum of squares from all three regressions.

Let us assume we have a regression with two independent variables and n+m=t time periods. We are going to assume that n is the time before the structural break and m is the time after the structural break. The n and m do not have to be the same. The regression using the t time periods is going to be

$$y = \alpha + \beta_1 x + \beta_2 z \tag{A.1}$$

We are going to run two more regressions which are going to be:

$$y = \alpha^n + \beta_1^n x_1 + \beta_2^n z_1 \tag{A.2}$$

$$y = \alpha^m + \beta_1^m x_2 + \beta_1^m z_2 \tag{A.3}$$

Superscripts indicate coefficients obtained using time periods. The null hypothesis for the chow test is:

$$\alpha = \alpha^n = \alpha^m ; \beta_1 = \beta_1^n = \beta_1^m ; \beta_2 = \beta_2^m = \beta_2^m \tag{A.4}$$

In order to test this hypothesis the following F-test is performed

$$F \sim \frac{\dfrac{S - S_1 - S_2}{k}}{\dfrac{S_1 + S_2}{N + M - 2k}} \tag{A.5}$$

Where S is the sum of squares residual from each of the three regressions, n and m and the numbers of observation and the k is the degrees of freedom. Using the appropriate F distribution table the null hypothesis is tested and either accepted or rejected.

We are trying to determine was there a structural break 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:

$$EX = \alpha + \beta_1 EX_{t-1} + \beta_2 EXMA_{12} \tag{A.6}$$

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, for Croatia the F test is

$$F \sim \frac{\frac{0{,}850245 - 0.215618 - 0.593208}{3}}{\frac{0.215618 + 0.593208}{57 + 107 - 2*3}} = \frac{0.013807}{0.005119} = 2{,}69 \tag{A.8}$$

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 that in Croatia there was also a regime switch.

Appendix 2: 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 was used from Croatian central bank's web site. For our research it is not important what was the actual rate, but thought the sample the rate on assets is greater than the rate on loans.

For utility functions parameters γ and θ where put at 2. Discount factor β is 4% per year. All these factors are consist with the parameters used in Bokan, Grguric, Krznar and Lang (2009).

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