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1. Introduction

The case of Japan showed that the zero bound is a problem for the conduct of monetary policy that even nowadays has to be considered. For several years Japan experienced deflation and a short rate very close to zero leaving monetary policy almost helpless to boost economic activity. The same fears came up in America and Europe as economic performance deteriorated and nominal interest rates were lowered rapidly to stimulate the economy. However, lowering the interest rate to stimulate the economy is only possible when interest rates are above zero.

In this paper it shall be explored how optimal monetary policy is conducted with the constraint that interest rates cannot fall below zero and how large the risk to hit the bound is in the euro area. The first part is done in a New Keynesian model with sticky prices but flexible wages the second in an estimated model of the euro area.

The outline of the paper is as follows. In the next chapter an overview of the work on the zero bound and monetary policy is presented. Thereafter the New Keynesian model as it was presented by Eggertson and Woodford will be used to determine optimal policy. It will be shown that quantitative easing, as it was done by the Bank of Japan, is not an appropriate tool in the model surrounding to escape a deflation spiral and what should be done instead. It will be shown that credible commitment is able to overcome most of the distortions induced by the zero bound.

The central bank should commit itself to a target for the price level instead of a target for the rate of inflation. The optimal solution involves credible commitment to cause subsequent inflation when deflation vanishes. This management of expectation will help to escape a deflation spiral faster and causes lower welfare losses.

After treating the phenomenon in a model surrounding it shall be explored what the chances are to slide into that vicious circle if monetary policy follows a Taylor rule and how likely the zero bound is under different wage contracting specifications. This will be done in a small estimated euro area economy model.

It shall also be considered how the announcement of a positive inflation target well above zero may help to avoid the zero bound. This was done by the European Central Bank that changed its target from an inflation rate between zero and two to a rate below, but close to, two percent.

Finally the results will be discussed focussing on the assumptions that were made to derive them and what would change if these assumptions are not appropriate.

2. Literature

There exists a widespread literature on New Keynesian models using nominal rigidities. Wolman (1998) uses a shopping time specification to analyse if the zero bound is a vital constraint to monetary policy.[1] His conclusion is that the zero bound does not impose difficulties for monetary authority. He even shows that a regime of moderate deflation is welfare superior to a regime of moderate inflation even though the zero bound binds in several periods. The recommendation for deflation depends on the way money, in form of balances needed for consumption, enters the utility function. Transaction costs are lower at zero nominal interest rates. In his model even consumption is larger in a deflationary surrounding because low interest rates raise investment and hence output. This seems to contradict the experience of Japan that had very low or even negative growth rates in the deflationary period. Wolman also assumes perfect pre-commitment so that monetary policy is credible and the

[1] Wolman, Alexander 1998a.

target value for the price level path can be achieved. This means even with zero nominal rates real rates can be lowered by raising inflation expectations.

Krugman (1998) uses several small models with a cash in advance (CIA) constraint to show that it is crucial to influence expectations about future inflation to escape a deflationary spiral.[2] He stresses that monetary expansion that is believed to be only transitory will have no effects in raising inflation expectations. So there is a credibility problem of monetary policy. The Bank of Japan doubled the monetary base in a period of only six years without affecting the price level so obviously people believed the Bank of Japan will undo the expansion when the economy escaped the deflationary spiral.[3] But this expectation makes policy actions useless. Money will just be horded and short term bonds and money are perfect substitutes. The solution he describes is that the central bank convinces the market that it will allow prices to raise sufficiently and this is achieved by "credibly promise to be irresponsible" for the higher rates of inflation after the bound stops being a constraint.[4]

Lars E.O. Svensson (2003) states that the optimal solution is to guarantee that interest rates will be kept at zero for some time even when the recession and deflation is over.[5] This is the optimal policy because the private sector will expect this policy and inflation expectations rise what in turn reduces the real rate. And again it is crucial that monetary authority can credibly commit itself to such a policy. He also states that a target path for the price level is better than a target for the rate of inflation because when the target for the rate of inflation is not achieved in one period it does not matter for the next. With a price level target shortfalls in one period must be compensated with higher inflation so that long term inflation

[2] Krugman, Paul 1998.
[3] Internetsource 1.
[4] Krugman, Paul 1998 page 28.
[5] Svensson, Lars E.O. page 150.

expectations are changed which are more important for the economy. However, Svensson does not present a model to derive the optimal solution but as will be shown below it is the optimal commitment solution derived from a rational expectation model with nominal rigidities.

Bennett T. McCallum uses a model of an open economy and uses the exchange rate as a policy instrument.[6] This leads him to the conclusion that even with the zero bound binding the influence of monetary policy on the exchange rate helps to pull the economy out of the deflationary spiral. While other authors deny a substantial effect from this "beggar thy neighbour" policy McCallum finds that in simulations of a small but complete optimizing model calibrated to the U.S. economy there are large effects.[7] More of that will be explained below.

Ben S. Bernanke et al. explore the alternatives of monetary policy when the zero bound binds.[8] To these non standard policy tools belongs communication policy to shape public expectations about the conduct of monetary policy, changing the structure of the central bank balance sheet and quantitative easing. The model used in this paper will show that quantitative easing and changing the structure of the balance sheet will have no effect in a rational expectation model.

Gauti B. Eggertson (2003) analyses the difficulties arising from the credibility problem of the government.[9] It is the same problem as above. The optimal solution involves keeping nominal rates low for some time even if the deflation and recession is over. Only these expectations will pull the economy faster out of the recession. But when the recession is over the government has a preference to maintain low inflation instead of causing inflation. If the private sector expects that then this mechanism does not work. This is the credibility problem. The government

[6] McCallum, Bennett T. 2000.
[7] For example Krugman, Paul 1998 page 4.
[8] Bernanke, Ben et al. 2004.
[9] Eggertson, Gauti B. 2003a.

has to commit itself to being irresponsible.[10] Eggertson does this by adding new policy instruments. Deficit spending will increase debt and this should lead to inflationary expectations by the private sector because inflation will lower the real value of debt for the government. Inflation expectations will lower the real rate of return and raise aggregate demand so that the price level rises. However, this will only work if monetary policy and fiscal policy are coordinated. When the central bank is goal independent this will not have the desired effect. Another possibility when the zero bound binds is to issue more money and buy real assets. This will work when the ricardian equivalence does not hold. Goal independence seems to explain why the deficit spending in Japan has failed to increase economic activity even though debt rose dramatically from 65% of GDP in 1992 to now over 160% of GDP.[11]

The possibilities to escape the deflation trap that are discussed in the literature can be summarized by portfolio balance theory, depreciation of the own currency and credible commitment to alter expectations about the conduct of monetary policy in the future.

The first two will be shown to be irrelevant in the framework introduced below. The last one however is most important for the management of expectation that will be the optimum in the model used throughout this paper. The model of Eggertson and Woodford was chosen because it is the benchmark New Keynesian model with a very general description of the economy.

The model below will show that commitment is superior to discretion in fighting deflation and that the way out of the vicious circle involves management of expectation that can only be achieved with credible commitment.

[10] Eggertson, Gauti B. 2003a page 4.
[11] Internetsource 2.

3. The Model

The model that is explained here in detail is taken from Eggertson and Woodford.[12] In the next subchapter the household's optimization problem is explained and their optimality conditions are derived. Afterwards the optimality conditions of the firms are derived. Then the general rational expectations equilibrium conditions are derived. It will be shown that all equilibrium conditions can be stated without money to show that quantitative easing is no policy instrument to fight deflation. It will also be shown that portfolio balance effects play no role in the New Keynesian model with monopolistic competition and sticky prices that is explained in the next paragraphs.

3.1 Households

For the following analysis it is assumed that households and companies behave rational. The aggregate price level and the consumption aggregate are of Dixit Stiglitz form.[13] The consumption aggregate is given by

$$C_t = \left[\int_0^1 c_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}$$

Where $c_t(i)$ is the amount of good i consumed in period t. The amount of goods is normalized to one so that the infinite number of goods is distributed on the unit interval between zero and one. The price aggregate is given by

$$P_t = \left[\int_0^1 p_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

[12] Eggertson, Gautti B. and Michael Woodford 2003a.
[13] Dixit, Avinash K. and Joseph Stiglitz 1977.

Where $p_t(i)$ is the price of good i in period t. θ measures the constant elasticity of substitution as will be shown below in the derivation of the demand function for a certain product.

3.1.1 Utility maximization

The representative household seeks to maximize a discounted sum of utility from today to eternity of the following form.

$$E_t \sum_{T=t}^{\infty} \beta^{T-t} \left[u(C_T, \frac{M_T}{P_T}; \xi_T) - \int_0^1 v(h_T(j); \xi_T) dj \right]$$

The first term in the brackets denotes the utility derived from consumption (C_T) and real money balances ($\frac{M_T}{P_T}$). Real money balances add utility because money reduces the time needed for purchasing goods (shopping time).[14] Without money holdings every transaction would be quite time consuming. This is the rationale for money in the utility function.

The second term denotes the disutility of labor as a function of the time worked. Here ($h_T(j)$) denotes the time that is used to supply labor of type j. The integral is used because it is assumed that the representative household supplies every type of labor. It would be possible to write the disutility of labor for the case that a household only supplies one type of labor. But this would demand that every type of labor is supplied by an equal number of households.[15]

Utility of periods in the future is discounted with β. The discount factor is smaller than unity because households prefer consumption today over consumption tomorrow. ξ_T is a vector collecting exogenous disturbances such as preference

[14] Walsh, Carl E. 2000 page 49.
[15] Woodford, Michael 2003 page 144.

shocks or government purchases which are assumed to be exogenous in the model employed here.

The representative household maximizes the utility function subject to an intertemporal budget constraint. This budget constraint has to be satisfied in every single period from today onwards to eternity. It is assumed that households do live forever because this is a good approximation for the case that the household does not exactly know the date of death or the terminal period.

$$E_t \sum_{T=t}^{\infty} Q_{t,T} \left[P_T C_T + \delta_T M_T \right] \leq W_T + E_t \sum_{T=t}^{\infty} Q_{t,T} \left[\int_0^1 \Pi_T(i) di + \int_0^1 w_T(j) h_T(j) dj - T_T^h \right]$$

Where $Q_{t,T}$ denotes the stochastic discount factor used to discount expenditures and profits that are expected to occur in period T to the present date t.

$$Q_{t,T} = \beta^{T-t} \frac{u_c(C_T, \frac{M_T}{P_T}; \xi_T)}{u_c(C_t, \frac{M_t}{P_t}; \xi_t)} \frac{P_t}{P_T}$$

The left hand side of the budget constraint shows the expenditures consisting of total nominal consumption spending given by $P_T C_T$ and the opportunity cost of the nominal money balances. Here $\delta_T = \frac{i_T}{1+i_T}$ is the opportunity cost of holding one unit of money. Holding one unit means to waive the interest paid at the end of the period and this is then discounted with the nominal interest rate.

The right hand side of the budget constraint consists of the nominal wealth (W_T) that a household has accumulated up to period T. Wealth is accumulated when the budget constraint in a certain period was not exhausted. The representative household is a shareholder of every company and receives profits ($\Pi_T(i)$) from the companies of which he is a shareholder. It is assumed that the representative household owns shares of all companies so that the integral is used to sum all

profits. The term $\int_0^1 w_T(j)h_T(j)dj$ determines the nominal wage the household receives for supplying labor. Since the household offers all types of labor, the total wage consists of the nominal wage for labor of type j multiplied with the time that he supplied labor of type j. This is then summed up over all types of labor. The last term on the right hand side is the nominal tax less subsidies (T_T^h) a household has to pay to the government.

Using the budget constraint and the utility function the household maximization problem is as follows

$$MaxL = E_t \sum_{T=t}^{\infty} \beta^{T-t} \left[u(C_T, \frac{M_T}{P_T}; \xi_T) - \int_0^1 v(h_T(j); \xi_T) dj \right] -$$

$$\lambda \left\{ E_t \sum_{T=t}^{\infty} Q_{t,T} [P_T C_T + \delta_T M_T] - W_T - E_t \sum_{T=t}^{\infty} Q_{t,T} \left[\int_0^1 \Pi_T(i) di + \int_0^1 w_T(j) h_T(j) dj - T_T^h \right] \right\}$$

3.1.2 Optimality condition

From the first order conditions for consumption of the above stated Lagrangian an Euler equation of the following form is derived.

$$u_c(C_t, \frac{M_t}{P_t}; \xi_t) = \beta E_t \left[u_c(C_{t+1}, \frac{M_{t+1}}{P_{t+1}}; \xi_{t+1})(1 + i_t) \frac{P_t}{P_{t+1}} \right]$$

This condition links marginal utility of consumption today with marginal utility of consumption tomorrow. It states that the marginal utility of consumption today equals the expected discounted marginal utility tomorrow, where i_t is the nominal interest rate. The discount rate is the real rate since the nominal rate is deflated with the price level.

$$u_c(C_t, \frac{M_t}{P_t}; \xi_t) = \beta E_t \left[u_c(C_{t+1}, \frac{M_{t+1}}{P_{t+1}}; \xi_{t+1})(1 + r_t) \right]$$