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THE EFFECTIVENESS OF MONETARY POLICY AND THE STRUCTURAL CHANGE IN THE FINNISH FINANCIAL MARKETS

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Abstract

The aim of this paper is to compare the effectivenss of monetary policy in the "old" Finnish credit market system with both deposit and loan interest rates fixed with an emerging "new" system where a part of the deposit market is organized as a competitive market section where the interest rate on the so-called "market money" is determined by the interest rate on the central bank debt of the banks as a reference interest rate. The results depend on whether the central bank pursues a sterilization policy in the market for central bank debt of the banks or not. If it does, and the interest rate of central bank debt of the banks is constant, we can infer that monetary policy is more effective in the new system in the sense that a given change in the central bank (discount) interest rate has a larger impact on the volume of loans supplied by the banks than in the old system. In the case where the central bank interest rate responds to the central bank debt of the banks the new system is less favourable for the effectiveness of policy. We can also find a possibility of perverse effects of policy, i.e. a tightening of central bank policy can, although in rather improbable cases, even result in an increase in bank lending. It is, however, to be noted that these results are based on the volume of bank lending as the only transmission mechanism of monetary policy. The effects of interest rate changes on the expenditures of the private sector should be imposed on these credit rationing effects but are largely omitted here.

* I thank professor Erkki Koskela for valuable comments and suggestions. Naturally, all responsibility for remaining errors and omissions is solely the author's.

1. INTRODUCTION

In recent times the Finnish financial system has been under a structural change, see Bingham and Åkerholm (1982), Koivisto (1983), Korhonen (1981), and Puntila (1982). Traditionally, there have been rigid interest rates on both loans and deposits of the banking system. The average interest rate on loans (in domestic currency) has been controlled by the central bank and the deposit rates have been set by a mutual agreement of the banks. The only changes in the nominal interest rates have taken place as a consequence of changes in the discount rate of the Bank of Finland. Monetary policy has mainly operated by altering the degree of credit rationing through changes in the interest rates charged from the banks on their central bank debt, see figure 1 on page 3.

During the recent years there has, however, been going on a process of structural change in the Finnish financial markets. In short, the banks have started to compete with each other on the funds of the firm sector, the liquidity position of which has been quite strong in contrast to the 1960's and 1970's. We need not here discuss in any great detail the various reasons behind this development.[1)] A reference interest rate for the banks in their competition for these funds is naturally the interest rates on their central bank debt.

The banks have all the time been under control of the central bank concerning their average loan rate of interest. Therefore, the banks in part

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1) See the references mentioned above.

channelled these funds further on to their finance companies which are not controlled in their interest setting. In May 1983 the Bank of Finland allowed the commercial banks partly to shift the increased cost of funds on to their loan interest rates, and this caused a new change in the system.

In the following we make a comparison concerning the effectiveness of monetary policy in the following three schematic institutional systems,

1) the "old" system (section 3) described above (old)
2) a "new" system (section 4) where the banks are not allowed to shift any of their increased cost of funds to their interest rates on loans (new 1)
3) a "new" system where a part of these costs is shifted to interest rates (new 2).

The only instrument of policy considered here is a change in the cost function r_{cb} of the central bank debt of the banks, and the only transmission channel of monetary policy is bank lending.

The traditional starting point of financial market analysis in Finland has been the assumption of (a permanent) credit rationing in the bank loan market as a result of the rigid interest rates. We do not discuss here the relevance of this assumption but take it to be valid also in the new system where competitive features are becoming more prominent. It is anyway to be remembered that the competitive market section is only a small fraction, of the order of 10 per cent, of the whole deposits of the banks. So we can feel quite safe in operating with this hypothesis of credit rationing also in the new environment.[1)]

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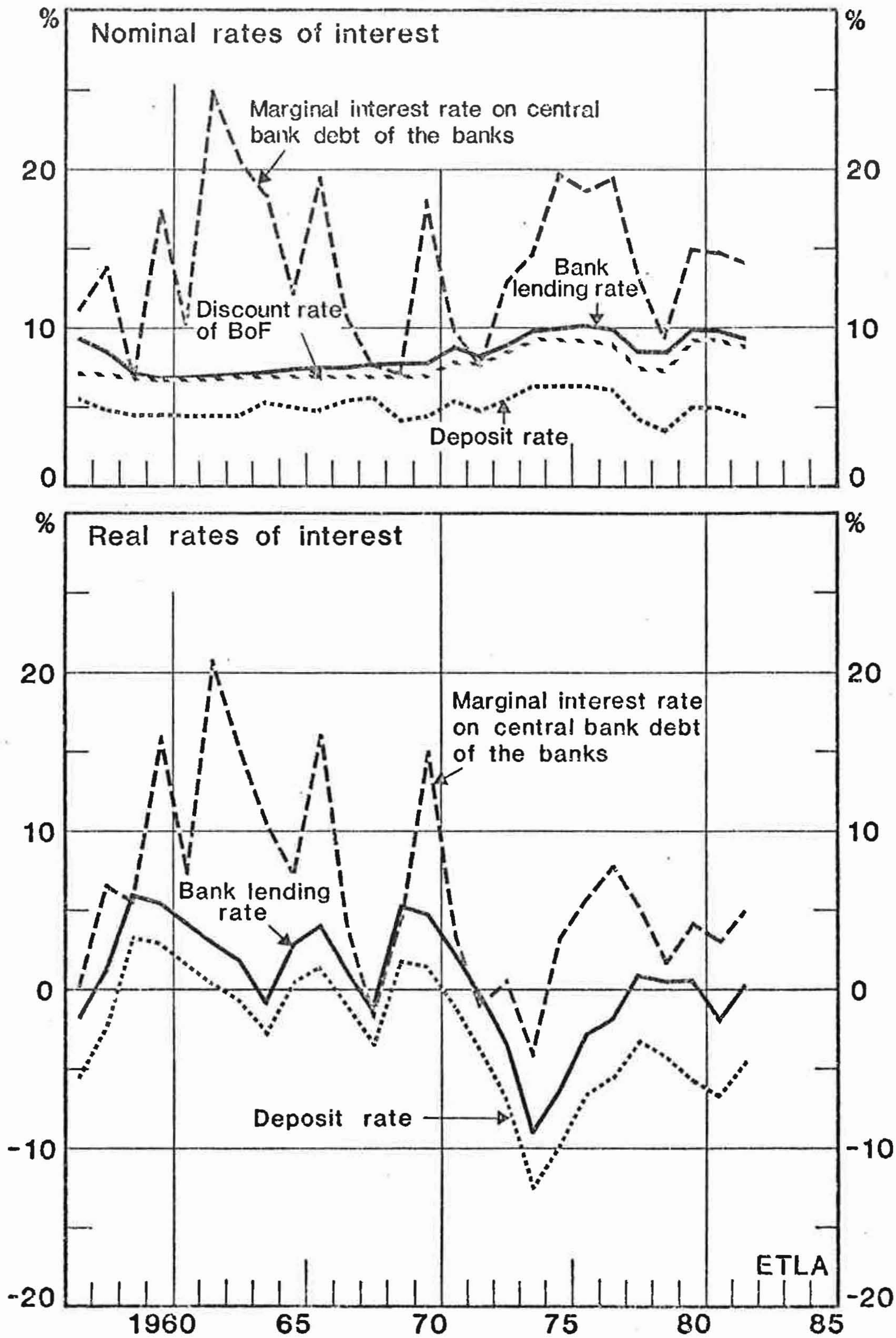
1) So far the only theoretical paper where this new financial environment has been embedded in a macromodel is to the author's knowledge Mustonen and Salonen (1983).

Figure 1. Nominal and real interest rates in Finland



The traditional analysis of the effectiveness of monetary policy and the structure of financial market is by Tobin and Brainard (1963). They considered the problem, how the existence of financial intermediaries as banks and their supply of assets which are substitutes for base money issued by the monetary authority, may reduce the effectiveness of policy. Another important field is how the monetary system and monetary policy dampen or amplify various random shocks arising in the financial market or in the real economy. In this paper we do not consider this important problem-setting which could, however, in a quite straightforward way be incorporated in our model, see on this kind of analysis Santomero and Siegel (1981).

The structure of the paper is as follows. In section 2 we present in more detail the structure of the model, the behaviour of the various market participants and the assumptions related to this. We then present the pseudo-equilibrium equation system for the rationed financial markets. In section 3 we analyze the responsiveness of bank lending to changes in central bank interest rates in the "old" system and in section 4 in the "new" system. We consider as separate cases two institutional arrangements of the market for central bank finance of the banks, the first being the traditional system with debt quotas for each bank and rising penalty interest rates on excess use of central bank finance. The second is the present call money system with a pooled market and one common call money rate for all banks "irrespective" of the debt of a bank.[1] Section 5 is devoted to present some modifications of the model, and section 6 briefly summarizes the results of the paper.

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1) See footnote 1 on page 19.

2. THE BASIC ASSUMPTIONS

The model consists of three sectors of the economy: the central bank, the domestic banking system and the private sector. The balance sheets of these sectors are the following.

The central bank

$R + CBD = C + O_{cb}$, where

R = foreign reserves, net[1)]

CBD = central bank debt of the banks

C = central bank money (notes and coin)

O_{cb} = other liabilities, net

The banking sector

$L_b = D + CBD + O_b$, where

L_b = loans to the private sector

D = deposits of the private sector which are in the new system divided into ordinary deposits D_o and "market money" deposits D_c, $D = D_o + D_c$.[2)]

O_b = other liabilities, net

The private sector

$D + C = L_b + L_f + NW$, where

L_f = foreign debt, net (in domestic currency)

NW = net financial wealth

1) Changes in foreign reserves could be decomposed into intervention (flow) by the central bank to keep the effective exchange rate unchanged and the valuation component (capital gain) arising from changes in either the effective exchange rate of the Finnish mark or in the relative values of various currencies depending on the reserve asset composition of Bank of Finland. Because we are here only considering the case of fixed exchange rates, the problems related to the difficulty of separating these two items in practice can be omitted.

2) In the old system we only have ordinary deposits, $D = D_o$.

The foreign currency position of the banks is closed, so these items net out in the balance sheet of the banks. We assume that the foreign borrowing which is channelled to firms through the balance sheet of the banks is a perfect substitute for the private sector's own direct foreign borrowing, so this is included in L_f, and they are determined by the same behavioral equation. Domestic and foreign assets and loans are not perfect substitutes in the short run considered here, otherwise naturally the credit rationing system would break down and the domestic interest rate would be tied to the foreign interest rates. The supply of foreign loans is supposed to be perfectly elastic at the world interest rate r_f which is exogenous to our small country.

The foreign exchange rate is fixed and there are no expectations on any future changes in the exchange rate. The policy instruments consist solely of monetary policy operations in the market for central bank finance of the banks.

The domestic interest rate on loans r is set fixed by the authorities and this creates (the possibility of) credit rationing in the loan market. In the present system where the loan interest rate partly reacts to the interest rate on the market money deposits, the central bank fixes as earlier a reference loan interest rate to which the banks may add the extra costs, see footnote 1 on page 18. The deposit interest rate r_D on ordinary deposits is basicall ight to the reference loan rate with a fixed marginal.

The net wealth of the private sector is kept fixed as usual. We omit here portfolio decisions concerning holdings of real capital and concentrate solely on decisions concerning financial portfolio allocations.

3. THE "OLD" FINANCIAL MARKET SYSTEM

3.1. Behaviour of the private sector

Part of the private sector, mostly firms in the open sector of the economy, have access to foreign credit. The sheltered sector does not have this channel. Primarily the behaviour of the private sector is described by the so called notional demand functions which assume that the price system equilibrates all markets. In the rationed credit market case we have to transform the notional equations into quantity constrained demand functions which take into account the possibility of excess demand in the credit market and its spillovers to other markets.[1)] We denote by λ the excess demand for bank loans L^d-L^s, which is then one argument in the private sector's constrained behavioural equations, see on this problem in more detail Neary and Roberts (1980) and Muellbauer and Portes (1978).

In the following we omit cash - quite a small and hardly ever followed item in practical monetary analysis - from the behavioural system in spite of its central role in some theoretical model constructions.

The rationed demand equations for the private sector are then[2)]

$$
\begin{array}{llllllll}
 & -\bar{L}_b^d(W,Y,r,\lambda,r_D,r_f), & \bar{L}^d_{b_W}>0, & \bar{L}^d_{b_Y}>0, & \bar{L}^d_{b_r}<0, & \bar{L}^d_{b_\lambda}<0, & (\bar{L}^d_b)_{r_D}>0, & (\bar{L}^d_b)_{r_f}>0 \\
(1) & -\bar{L}_f^d(W,Y,r,\lambda,r_D,r_f), & \bar{L}^d_{f_W}>0, & \bar{L}^d_{f_Y}>0, & \bar{L}^d_{f_r}>0, & \bar{L}^d_{f_\lambda}>0, & (\bar{L}^d_f)_{r_D}>0, & (\bar{L}^d_f)_{r_f}<0 \\
 & \bar{D}^d(W,Y,r,\lambda,r_D,r_f), & \bar{D}^d_W>0, & \bar{D}^d_Y>0, & \bar{D}^d_r<0, & \bar{D}^d_\lambda<0, & \bar{D}^d_{r_D}>0, & \bar{D}^d_{r_f}<0 \\
\hline
\text{sum:} & W & 1 & 0 & 0 & 0 & 0 & 0
\end{array}
$$

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1) See on this e.g. Muellbauer and Portes (1978).

2) In the summation of the partial derivatives we have to take those of the liability equations with minus sign.

The partial derivatives of the equations are constrained by the usual adding-up restrictions of portfolio models. As usual, there are only two independent equations in the system, one being included in the others through the wealth constraint. There are two endogenous variables here: foreign net debt L_f and the tightness of the domestic credit market, λ. As the domestic interest rate on deposits in the market section is supposed to be tied to the policy instrument of the central bank, i.e. to the interest rate on central bank debt of the banks, it is also exogeneous.

The behavioural equations (1) are supposed to have the usual property of gross substitutability when r is replaced by the "effective" interest rate on loans $r+\lambda$. Typically the excess demand for loans arises from the desire of the private sector to hold more real capital given the expected yield on capital (not explicitly presented in equations (1)) and the administrated interest rate r. However, it is important to note, also in practice, that the effect of credit rationing has an effect on the demand for money, because by reducing money balances in tight credit market conditions the private sector can acquire a better portfolio balance and compensate a cut in loans by running down its deposit holdings. This is an often neglected point.

3.2. Behaviour of the banking system

The behaviour of the banking sector and its loan supply has been quite extensively analyzed in Finland, see Koskela (1976), Oksanen (1977), Tarkka (1979), Willman (1981), Alho (1982), Vihriälä (1983), Creutzberg (1983), Mustonen and Salonen (1983). In partial equilibrium context usually no attention is paid to the demand for deposit constraint, and no explanation is given why the credit multiplier is supposed to be able to do its work, i.e. the notional credit supply function is derived. In full equilibrium context, on the other hand, it has been supposed that the private sector is always on its notional demand curve for deposits, see Kähkönen (1982). It is clear that under rationing we must take into account not the notional but the rationed demand for deposits by the private sector. Ceteris paribus, inceased bank lending decreases the tightness on the credit market and so lowers λ. This will increase the demand for money, and so we can find a basis for the credit multiplier effect.[1)]

One possibility is that there are various regimes in the loan market, i.e. that the banks may also be rationed, there is an excess supply of loans. Without any further discussion we omit this case in the following analysis.

We start the analysis from the "old" system where the average interest rates on loans and deposits are kept fixed. We specify along the lines of Alho (1982) that the representative bank's behaviour depends on two

---

1) It is hardly the case that the demand for money would increase hand in hand with the increase in loan supply. If this were the case, the whole effect of credit rationing would be reflected only in the money market as an economization of money balances by the private sector. Monetary policy would have no effect whatsoever on the desire to hold and change the stock of real capital. This is naturally an important empirical point to be studied. We cannot discuss this problem properly here because the goods market is not considered in our model.

goals: its profit π_i and its market share in the loan market L_i/L.[1)]
In our static environment we skip all the rich dynamic considerations related to this problem, and so we have as the objective function for the bank

$$U = U(\pi_i, L_i/L) .$$

This is maximized under the constraints of the balance sheet of the bank and the constrained demand function for deposits,

(2) $$U(\pi,L) = \max \text{ s.t. } L = D + CBD + 0_b \text{ and } D = \bar{D}^d(W,Y,r,\lambda,r_f).$$

The key institutional arrangement in the relations between the central bank and the banks is the institution of the banks being continuously in debt to the central bank. The terms at which this is organized is the main policy instrument of the central bank in controlling monetary developments. The central bank sets a cost schedule $r_{cb}(CBD)$ for the central bank debt of the banks which is later on more fully analyzed. The profit of the bank is thus

(3) $$\pi = rL - r_D D - r_{cb}(L - D - 0_b) .$$

The necessary condition for the optimum loan supply can now be derived as

$$r'_{cb}(L-D-0_b) = (\frac{U_L}{U_\pi} + r - r_D D_L)/(1 - D_L), \text{ where } D_L = \frac{dD}{dL} \in [0,1] ,$$

which we can write further as

(4) $$r'_{cb} = r + (1 - D_L)^{-1}(U_L/U_\pi + (r - r_D)D_L) > r , \text{ because } U_L, U_\pi, r - r_D > 0.$$

1) In the sequel we replace the symbol L_b for bank loans by just L.

The derivative of the cost function r_{cb} is the so called marginal interest rate on central bank debt of the banks, denoted by r_m, a key variable in the loan supply and liquidity policy of the banks and in the policy of the central bank. Generally the optimum loan supply from (4) is larger than the profit maximizing one, so in the optimum we have $d\pi/dL < 0$, see more closely on this Alho (1982), pages 23-29. The sufficient condition for the loan supply optimum is

$$U_{LL} + U_{\pi L}\frac{d\pi}{dL} + U_{\pi}\frac{d^2\pi}{dL^2} < 0 \text{ , and so}$$

(5) $$U_{LL} + U_{\pi L}(r - r_D D_L - (1 - D_L)r'_{cb}) - U_{\pi}(1 - D_L)^2 r''_{cb} < 0 .$$

U_{LL} is generally negative, and we may take $U_{\pi L}$ also as negative, $d\pi/dL$ is negative in the optimum and r''_{cb} as positive, so it is not a priori clear that (5) is negative. However, we may feel quite safe here because $U_{\pi L}$ may typically be assumed to be quite small, even zero, and then (5) is certainly negative if $r''_{cb} \geq 0$.[1)]

The loan supply function of the banks can now be written as

(6) $$L_b^S = L_b^S(D + O_b,\ r, r_D, a)$$

where a is a shift parameter in the marginal cost function $r_m = r'_{cb}$ for the central bank debt of the banks.

---

1) The second derivative r''_{cb} is non-negative because the marginal interest rate on central bank debt is either flat, we have the so called call money market system, or rising when we have a quota system for each bank. We return on this separation more closely in section 4.2.

3.3. The full model of the financial markets

As mentioned above, from the basic behavioural equations of the private sector one can be eliminated by the wealth constraint.[1] We choose to eliminate the equation for deposits leaving us with two equations, the equilibrium conditions for the domestic and foreign loan markets.

The model for the equilibrium of the financial markets thus consists of two equations

$$(7) \qquad L_b^s(D + O_b, r, r_D, a) = \bar{L}_b^d(W, Y, r, \lambda, r_D, r_f)$$

$$(8) \qquad L_f = \bar{L}_f^d(W, Y, r, \lambda, r_D, r_f)$$

As a third equation we need the central bank policy function. The basis for it is the connection between the central bank debt of the banks and the foreign capital import of the private sector. The total net foreign debt of the country, NFD, is divided between the foreign assets of the central bank and the foreign debt of the private sector.[2] So we have

$$(9) \qquad NFD = -R + L_f .$$

Combining this with the balance sheet of the central bank we get

$$(10) \qquad CBD = NFD - L_f + O_{cb} .$$

1) The three variables are also linked to each other by the money supply identity i.e. the combined balance sheet of the banks and the central bank, see formula (20) on page 17.

2) As is already clear from above , we do not explicitly consider the public sector in this paper.

So, the third equation of the model is in the case where the central bank "passively" fixes the cost function for the central bank debt the following[1)]

$$(11) \qquad r_m = CBD'(NFD - L_f - 0_{cb}).$$

By differentiating equation (11) with respect to r_m and λ we get

$$(12) \qquad \frac{d\lambda}{dr_m} = - \frac{1}{r''_{cb}\bar{L}^d_{f_\lambda}} .$$

This is negative indicating the offset property of the behaviour of the public with respect to actions of monetary policy. This is a partial relationship. The full equilibrium solution of the model gives a positive relationship between λ and r_m. In the sequel we suppose for simplicity that the slope r''_{cb} of the marginal interest rate r_m on the central bank debt is a constant.

3.4. Effectiveness of monetary policy in the old financial market system

The condition for the optimum loan supply of the banks is, see (4) above

$$(13) \qquad U_L + U_\pi \frac{d\pi}{dL} = 0.$$

Next, we carry out with the aid of this equation a comparative static analysis concerning the reaction of the optimal loan supply $\hat{L}$ of the banks with respect to a change in the marginal interest rate r_m of the

1) Naturally, there are numerous possible policy reaction functions, and in section 4.2. we consider the case of sterilization policy in the market for central bank finance of the banks, when r_m is a constant.

central bank debt. By differentiation of (13) with respect to $\hat{L}$ and r_m we get

$$(14) \qquad [U_{LL} + U_{\pi} (\frac{d^2\pi}{dL^2}) + U_{\pi\pi} (\frac{d\pi}{dL})^2] d\hat{L} + [U_{\pi\pi} (\frac{d\pi}{dr_m})(\frac{d\pi}{dL}) + U_{\pi} \frac{d(\frac{d\pi}{dL})}{dr_m}] dr_m = 0$$

For simplicity we have here assumed that the cross derivative $U_{\pi L}$ is zero. From this we can solve the relationship between the loan supply of the banks and a change in the marginal interest rate schedule,

$$(15) \qquad \frac{d\hat{L}}{dr_m} = - \frac{U_{\pi} \frac{d(\frac{d\pi}{dL})}{dr_m} + U_{\pi\pi} (\frac{d\pi}{dr_m})(\frac{d\pi}{dL})}{U_{LL} + U_{\pi} \frac{d^2\pi}{dL^2} + U_{\pi\pi} (\frac{d\pi}{dL})^2} .$$

As we can see from expression (15), a comparative analysis of the reaction $d\hat{L}/dr_m$ is quite awkward. So, we decide to concentrate solely on the case where the objective function of the bank is of the following additive type[1)]

$$(16) \qquad U(\pi,L) = a\pi + bL^c \, , \; a,b,c \geq 0, \; c \leq 1 .$$

In this old system we have (the elements of (15) can be derived from the corresponding expressions in section 4.2. by setting s = h = 0)

$$(17) \qquad (\frac{d\hat{L}}{dr_m})_{old} = \frac{(1 - D_L) r''_{cb}}{\frac{-U_{LL}}{U_{\pi}} + (1 - D_L)^2 r''_{cb}} (\frac{dD}{dr_m})$$

We return later on to consider more closely the term dD/dr_m, see section 4.2.

1) This objective function is naturally quite specific, but it anyway captures the idea that the banks have these two goals and does not speculate on the internal relationship between them.

4. THE "NEW" FINANCIAL MARKET SYSTEM AND EFFECTIVENESS OF MONETARY POLICY

4.1. The financial market model in the new environment

As mentioned above in section 2, in the new market system we divide deposits D into ordinary deposits D_o and market money deposits D_c. We must now transform the behavioural equations (1) to correspond this new situation. We denote by r_D the interest rate on the ordinary deposits and by r_D^c the interest on the market money deposits.

$$
(1)' \quad
\begin{array}{ll}
-\bar{L}_b^d(W,Y,r,\lambda,r_D,r_D^c,r_f),\ldots,(\bar{L}_b^d)_{r_D^c} > 0 \\
-L_f^d(W,Y,r,\lambda,r_D,r_D^c,r_f),\ldots,(\bar{L}_f^d)_{r_D^c} > 0 \\
\bar{D}_o^d(W,Y,r,\lambda,r_D,r_D^c,r_f),\ldots,(\bar{D}_o^d)_{r_D^c} < 0 \\
\bar{D}_c^d(W,Y,r,\lambda,r_D,r_D^c,r_f),\ldots,(\bar{D}_c^d)_{r_d^c} > 0 \\
\hline
\text{sum:} \quad W \qquad\qquad\qquad\qquad 0
\end{array}
$$

Here we have only written down the new partial derivatives with respect to market money interest rate r_D^c, the partial derivatives with respect to the "old" variables presented in (1) being also here of the sign as in (1), but naturally not of the same magnitude.

The banks now supply two kinds of deposits, the interest rate r_D on ordinary deposits being fixed as before. The supply of these deposits by the banks is perfectly elastic at this interest rate[1]. Concerning the

---

1) Santomero and Siegel (1981) show that this is true if either the competitive deposit rate is linked with a constant margin to the yield on bonds (or capital) or if the deposit rate r_D is fixed below the equilibrium value determined by a deposit market supply-demand equilibrium (not presented in our model).

supply and interest rate determination of the market money deposits we could suppose that also their supply is "perfectly", or in practice elastic enough, at the interest rate r_D^c which is tied to the marginal interest rate r_m on the central bank debt of the banks, i.e.

(18) $$r_D^c = r_m - m$$

where m is a fixed margin. If we derive the supply function of the market money deposits and the demand function for central bank debt by the banks we get the result that given the volume of their credits, the banks are willing to absorb all available deposits at interest rates r_D^c below r_m, but at interest rates higher than r_m they are not willing to take any. The decision making of a bank naturally concerns, not just various means of financing a given volume of credits, but also the magnitude of the loan supply to be extended to the public. Here we may encounter a problem because in practice the interest rate r_D^c has been higher than the loan interest rate r. So an overall optimum for a bank cannot include a perfectly elastic supply curve for market money deposits, on profit maximization grounds solely. Market share considerations might, on the other hand, change the situation.

We anyway make the assumption that the banks fix the interest rate and the private (firm) sector determines the volume of the market money deposits. So now we have the model for the financial markets.

(19)
$$
\begin{aligned}
L_b^s(D_c+D_o, r, r_D, r_D^c, a) &= \bar{L}_b^d(W, Y, r, \lambda, r_D, r_D^c, r_f) \\
L_f &= \bar{L}_f^d(W, Y, r, \lambda, r_D, r_D^c, r_f) \\
D_c &= \bar{D}_c^d(W, Y, r, \lambda, r_D, r_D^c, r_f) \\
r_m &= CBD'(NFD - L_f - O_{cb}) \\
r_D^c &= r_m - m
\end{aligned}
$$

The forth behavioural equation is deleted because of the balance sheet constraint of the banks, or the money supply identity between the financial market variables,

(20) $$D_c + D_o = L_b - NFD + L_f - O_b - O_{cb}.$$

Consider now a change in the institutional system to take place at moment t_0. Because the interest rate on domestic deposits increases, there is an increased willingness to hold these. There is also an incentive to increase both domestic and foreign borrowing (and reduce the holdings of real capital). So in reality we are likely to experience a phase of monetary expansion after moment t_0 if the private sector can fulfill its desired portfolio allocations.

4.2. Effectiveness of monetary policy in the new system compared to the old system

The main thing we want to study is how the loan supply of the banks reacts in different institutional systems to policy changes of the central bank. We start to analyze this by first studying the reaction of the banks' profits to the measures of the central bank. In order to simplify notations we denote by s the share of the market money deposits of all deposits, $s = D_c/D$, and in a similar way in derivatives with respect to D_c we replace D_c by sD. This does not, however, mean that we assume this share s to be constant. The profit of the representative bank is generally in the new situation(s)

$$(21)\qquad \pi = rL - (s(r_m - m) + (1 - s)r_D)D - r_{cb}(CBD).$$

In the new2 case the reaction of the loan interest rate to a change in the cost of funds for the banks is

$$(22)\qquad \frac{dr}{dr_D^c} = h\,[\,s + r_D^c\,\frac{(\bar{D}_c^d)_{r_D^c}}{L_b}\,] = hs\,[\,1 + \varepsilon(D_c, r_D^c)\,]\ \text{where}$$

$$\varepsilon(D_c, r_D^c) = \frac{r_D^c}{D^c}\,\frac{dD^c}{dr_D^c} = \text{own interest elasticity of } D^c.$$

Here h is the proportion of the increase in costs which the banks can transfer further on to their loan interest rates.[1)] The value of this parameter h is 50 % starting from October 1983.

We can now derive

$$(23)\qquad \frac{d\pi}{dL} = \frac{dr}{dr_m}\,\frac{dr_m}{dL}\,L + r - s\,[\frac{dr_m}{dL}\,D + (r_m - m)\,\frac{dD}{dL}\,] - (1 - s)r_D\,\frac{dD}{dL}$$

$$- \frac{ds}{dL}\,(r_m - m - r_D)D - r'_{cb}(L - D - 0_b)(1 - \frac{dD}{dL})\,.$$

Further by using the results

$$(24)\qquad \frac{dr_m}{dL} = r''_{cb}\,\frac{dCBD}{dL} = r''_{cb}(1 - D_L)\ \text{where as before}\ D_L = \frac{dD}{dL} = \frac{dD_o}{dL} + \frac{dD_c}{dL}\text{, and}$$

$$\frac{ds}{dL} = s(1-s)(\,\sum_i \frac{1}{r_i}\{\varepsilon(D_c, r_D^c) - \varepsilon(D_o, r_D^c)\}\frac{dr_i}{dr_m})\ r''_{cb}(1-D_L),\ \text{where}\ r_i = r, \lambda, r_D^c$$ [2)]

---

1) The reference point in the calculation of this shift of costs is the controlled lending rate of banks, i.e. we have $r = r_o + hs\,(r_D^c - r_o)$ where r_o is the rate of interest of the banks set by the central bank. We also assume in (22) that the ratio of D_c to L_b is s.

2) See the appendix more closely on this.

we can write (23) after some manipulations

$$(25) \qquad \frac{d\pi}{dL} = r + r''_{cb}(1 - D_L)\,[\,sh(1+\varepsilon(D_c, r_D^c))L - sD\,[\,1+(1-s)(\sum_i \frac{1}{r_i}(\varepsilon(D_c, r_i) - \varepsilon(D_o, r_i))\frac{dr_i}{dr_m})(r_m - m - r_D)] - s(r_D^c - r_D)D_L - (1-s)r_D D_L - r'_{cb}(1-D_L)\,.$$

We must now impose some restrictions on the model in order to get clearcut results. It is indeed awkward to handle at the same time both the case where r''_{cb} is positive and the share s of the market section is an endogeneous variable, because then the expression in (15) becomes quite complicated, so we decide to concentrate just on two special cases which, however, are of much empirical relevance. The first is the case where r''_{cb} is positive, we have the quota system in the market for central bank finance of the banks, but the share s of the market section is a constant. This could be considered a sensible approximation if the own interest elasticity of the market money deposits is not very big, i.e. a rise in the marginal interest rate on the central bank debt of the banks does not raise (essentially) the share of the market section. The second is the case where we have the so-called call money market system for the central bank finance of the banks, and now r''_{cb} is zero. In this case we allow the share s to react to changes in the deposit rate for the market money deposits.[1]

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1) In separating the cases with $r''_{cb} > 0$ and $r''_{cb} = 0$ we must bear in mind that it is relevant for the banks in their decision making even in the (formal) case of fixed r_m (i.e. $r''_{cb} = 0$) to consider the reaction function (11) above and make expectations on changes of r_m as a consequence of changes in the indicators relevant for the central bank, one of which is certainly the foreign exchange reserves and the actual central bank debt of the banks.

The case with $r''_{cb} > 0$ and s constant

We can in this case derive fairly easily the expression (15) in the three different environments. With some manipulations we get in the new2 case

$$(26) \qquad \frac{d\hat{L}}{dr_m} = \frac{hs + (\frac{\partial D}{\partial r_m})r''_{cb}(1 - D_L + s(2D_L - 1)) - (1-(1-s)D_L)}{-\frac{U_{LL}}{U_\pi} + r''_{cb}(1 - D_L)(1 - D_L + 2s(D_L - h))} .$$

In this expression we have the term $\partial D/\partial r_m$ which we consider more closely below in (27). Let us now suppose that it is negative. If $\partial D/\partial r_m$ were positive, as we shall see,we would get a perverse outcome of central bank policy: credits would increase as a result of tightening policy. The denominator is likely to be positive, and is certainly positive if $h < D_L$. If D_L is of the order of 20 %, and s is 10 % and h is the present 50 %, the second term in the denominator is .544 r''_{cb}, and so we can safely operate with the denominator as positive. So, in order to get the desired result that $d\hat{L}/dr_m$ is negative, the nominator should be negative. To ensure this, the sum of the first and third terms should be negative if $\partial D/\partial r_m$ is negative (and $1-D_1+s(2D_L-1)>0$). With some inspection the sum of two terms is negative (-0.78).

We can decompose the term $\partial D/\partial r_m$ as follows

$$(27) \qquad \frac{\partial D}{\partial r_m} = \frac{\partial D}{\partial r^c_D}\frac{\partial r^c_D}{\partial r_m} + \frac{\partial D}{\partial r}\frac{\partial r}{\partial r_m} + \frac{\partial D}{\partial \lambda}\frac{\partial \lambda}{\partial r_m} \quad \text{and } D = D_o + D_c .$$

Concerning the components of this expression we have from above

$$\frac{\partial r^c_D}{\partial r_m} = 1 \text{ and } \frac{\partial r}{\partial r_m} = hs .$$

The term $\partial\lambda/\partial r_m$ (which is positive, see (39) below) we consider more closely later on. By the assumption of gross substitutability we infer that $\partial D/\partial r_D^c = \partial(D_o + D_c)/\partial r_D^c$ is positive. From (1) we have both $\partial D/\partial r$ and $\partial D/\partial\lambda$ as negative. So we can write (26) as

$$(28) \qquad \frac{\partial D}{\partial r_m} = \underbrace{\underset{(-)}{\frac{\partial D_o}{\partial r_D^c}} + \underset{(+)}{\frac{\partial D_c}{\partial r_D^c}}}_{(+)} + hs \underset{(-)}{\frac{\partial D}{\partial r}} + \underset{(-)}{\frac{\partial D}{\partial\lambda}} \underset{(+)}{\frac{\partial\lambda}{\partial r_m}} .$$

A priori we cannot say that this is always negative. If we would not have the market money section at all we would know for sure, given the assumptions in (1), that (28) would not be positive. The introduction of the market deposit system is thus likely to reduce (28) because probably the middle term is quite neglible. Clearly, we cannot solve this problem without making a simultaneous analysis with the aid of the full model (19) of the financial markets. However, we may get into substantial troubles of simultaneity here because, as we shall see in section 5, the term $d\lambda/dr_m$ also depends generally on $d\hat{L}/dr_m$, the quantity we actually want to solve here.[1)]

So, let us suppose that $\partial\lambda/\partial r_m$ is fixed in the various cases and then consider in section 5 relaxing of this assumption.

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1) As this reveals,we are not here tightly obeying the assumption of this section that s is a constant. To impose this would not, however, here be sensible because then the problem with (28) would become totally unclear.

In the old case we have from

$$(29) \qquad \left(\frac{d\hat{L}}{dr_m}\right)_{\substack{old \\ r''_{cb}>0, \\ s=s_o}} = \frac{\left(\frac{\partial D}{\partial r_m}\right)_{old} r''_{cb}(1-D_L) - (1-D_L)}{-\frac{U_{LL}}{U_\pi} + r''_{cb}(1-D_L)^2} .$$

In the new1 case we have

$$(30) \qquad \left(\frac{d\hat{L}}{dr_m}\right)_{\substack{new1 \\ r''_{cb}>0, \\ s=s_o}} = \frac{\left(\frac{\partial D}{\partial r_m}\right)_{new1} r''_{cb}(1-D_L+s_o(2D_L-1)) - (1-(1-s)D_L)}{-\frac{U_{LL}}{U_\pi} + r''_{cb}(1-D_L)(1-D_L+2s_oD_L)} .$$

The new2 case is already presented in (26). To make comparisons we assume (heroically)to be able to take the parameters D_L, U_{LL} and U_π the same in the different environments.

We can infer that in "shifting" from (29) to (30) the nominator increases, if $D_L < 0.5$, which we assume to be the case[1] and the denominator increases, if $D_L<0,5$ which we assume to be the same and if $\partial D/\partial r_m$ is the same in the different environments. On the other hand, the denominator incereases. And if on the other hand, because of offsetting capital flows, we have

$$(31) \qquad \left(\frac{\partial D}{\partial r_m}\right)_{old} < \left(\frac{\partial D}{\partial r_m}\right)_{new1} < 0 ,$$

we could draw the conclusion that in absolute terms policy is less effective in the new1 case than in the old case i.e.

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1) The deposit multiplier interpretation of D_L would justify it to be on average of the order 20 % because this represents the average size of the various banks/banking groups in Finland.

$$(32)\qquad \left|\frac{d\hat{L}}{dr_m}\right|_{\substack{old\\ r''_{cb}>0,\\ s=s_0}} > \left|\frac{d\hat{L}}{dr_m}\right|_{\substack{new1\\ r''_{cb}>0,\\ s=s_0}}.$$

When shifting from the new1 to the new2 case we see that the nominator in (26) becomes bigger (smaller in absolute terms) and the denominator becomes smaller (also in absolute terms), so we cannot directly say what the total effect is. Using the hypothetical parameter values presented above we get the result that

$$(33)\qquad \left(\frac{d\hat{L}}{dr_m}\right)_{new1} = \frac{\left(\frac{\partial D}{\partial r_m}\right)_{new1} 0.74r''_{cb} - 0.78}{-\frac{U_{LL}}{U_\pi} + 0.67r''_{cb}}$$

$$(34)\qquad \left(\frac{d\hat{L}}{dr_m}\right)_{new2} = \frac{\left(\frac{\partial D}{\partial r_m}\right)_{new2} 0.74r''_{cb} - 0.73}{-\frac{U_{LL}}{U_\pi} + 0.59r''_{cb}}$$

The smaller r''_{cb} is, i.e. the slower the marginal interest rate on central bank debt rises as a function of the debt, the more likely is the case new2 to be more favourable for the effectiveness of policy. The outcome also depends on the interest elasticity (28) in the different systems. Probably this is smaller in absolute terms in the new2 case which would change things in favour of the new1 case.

<u>The case with $r''_{cb} = 0$ and s variable</u>

We now turn to the important case when $r''_{cb} = 0$ and when we have the so-called call-money market case in the market for central bank finance of the banks. In other words, we may interprete this case as one where the central bank pursues a sterilization policy in the market for central bank finance of the banks. At the same time we allow the share s of the market deposit section to be variable. Many of the above expressions are greatly simplified in this case because now the marginal interest rate r_m on central bank debt of the banks does not react to endogeneous developments in the financial markets.

In this case the expression (25) simplifies to

$$(34) \qquad \frac{d\pi}{dL} = r - s(r_m - m - r_D)D_L - r_D D_L - r'_{cb}(1 - D_L) .$$

Proceeding further we first find that the derivative $d^2\pi/dL^2$ is in this case zero, which causes problems for the sufficient condition of optimum to be valid, see more closely on this below. In order to calculate the result (15) we use the expressions (22) and (24) above.

Now we can calculate the expression (15) as

$$(35) \qquad \frac{dL}{dr_m} = \frac{1}{-U_{LL}/U_\pi}[hs(1 + \varepsilon(D_c, r_D^c)) - s(1 - s)\sum_i \frac{1}{r_i}[(\varepsilon(D_c, r_D^c) - \varepsilon(D_o, r_D^c))\frac{dr_i}{dr_m}](r_D^c - r_D)D_L - (1 - (1 - s)D_L)], \text{ where } r_i = r, \lambda, r_D^c \quad ^{1)}$$

In the old case this is of the form (here $r_D = r_D^c$ because there are no market deposits)

$$(36) \qquad \left(\frac{dL}{dr_m}\right)_{\substack{\text{old} \\ r''_{cb} = 0}} = \frac{1}{-U_{LL}/U_\pi}[-(1 - D_L)] < 0 .$$

In the new1 case we have

---

1) The summation of the interest elasticities comes from writing $s = D_c(r, \lambda, r_D^c)/D(r, \lambda, r_D^c)$ and that in principle $\partial r/\partial r_m$, $\partial r_D^c/\partial r_m$ and $\partial\lambda/\partial r_m$ differ from zero, see the appendix.

$$(37) \qquad \left(\frac{d\hat{L}}{dr_m}\right)_{\substack{new1\\ r''_{cb}=0}} = \frac{1}{-U_{LL}/U_{\pi}}[-s(1-s)(\sum_i \frac{1}{r_i}[(\varepsilon(D_c,r_D^c)-\varepsilon(D_o,r_D^c))\frac{dr_i}{dr_m}](r_D^c-r_D)D_L$$

$$-(1-(1-s)D_L)] .$$

The solution of the whole problem is not yet ready because on the right hand side of (35) and (37) we have the term $d\lambda/dr_m$ which depends on the outcome of the whole financial market model and therefore also on dL/dr_m, the term we want to solve. We have two possibilities here. First, we can constrain the model by assuming that $\varepsilon(D_c,\lambda)=\varepsilon(D_o,\lambda)$, i.e. that increase of tightness would cause the same decrease in relative terms in deposit holdings of the market money and ordinary deposits. It might, of course,be argued that the latter is bigger than the former because the holders of the ordinary deposits are probable under more severe credit rationing. We, however, in this paper retain this assumption. Secondly, we may solve from the financial market model the term $d\lambda/dr_m$ and insert it in (35) and (37), see on this section 5.

In the special case just mentioned and also in general if $d\lambda/dr_m>0$, (35) and (37) are negative because the sum of elasticities in (35) and (37) is positive, see the appendix on this. So, the effectiveness of policy is bigger in the new 1 case than in the old case. This is so because the increase in the central bank call money interest rate hits directly the profitability of the banks through the first term in brackets in (37). This gives a further incentive for the banks to cut their lending. In the new2 case, on the other hand, the effectiveness of policy is reduced in comparison to the new1 case because the first term in brackets in (35) is positive. This represents the effect that a rise in the interest rate on market money deposits and an increase in their volume also cause in the new2 system a shift of the increased costs to the loan interest rate of the banks. This naturally dampens the need of the banks to reduce their lending. Especially with low interest rate elasticities in (35) it is possible that policy is less effective in the new2 case than in the old case.

Summarizing this section on comparison of effectiveness of policy we could infer that the results depend on the system being obeyed by the central bank in the market for central bank finance of the banks. The present system which is a call money market system would seem to favour policy operating through the volume of bank lending.[1] We must, however, bear in mind that this is the only channel of monetary policy considered here. In the new2 case policy also operates to the real economy through the interest rate channel which enforces the effectiveness of policy and thus counteracts the above conclusions of less effect of policy in the new2 than in the new1 case.

As can be seen from the formulas (35)-(37) above, this case where $r''_{cb} = 0$ may cause problems because the denominator goes to zero if U_{LL} is for one reason or another zero, e.g. when the banks just maximize their profits.

The difficulties naturally arise already in the derivative (24) (or (34)). If r''_{cb} is zero, the marginal interest rate on central bank finance r_m is a constant. So we have the case that $d\pi/dL$ is either positive or negative for all values of L. In the former case the optimum loan supply grows without any limit, and in the latter case it reduces to zero. We should thus expect wild fluctuations in the bank loan market as a consequence of shifts in the call money market interest rate set by the central bank, which is hardly the case in practice. Of course, the observed smoothness could be a result of the adjustment costs the banks have to face in changing their loan supply.[2]

1) We must remember that the new2 policy may change things to less effectiveness than in the old system.

2) Tarkka (1983) has explicitly considered adjustment costs in deriving the loan supply function of the banks.

If we consider the sign of the derivative (34) with reasonable values of the various parameters we can infer that quite likely the marginal interest rate r_m is so high that $d\pi/dL$ is negative.[1] So, the solution for the loan supply optimum necessarily requires positive loading for the market share goal.

If, on the other hand, the central bank keeps its call money interest rate so low that $d\pi/dL$ is positive, we have to question the existence of the credit rationing phenomenon, at least temporarily, because the loan supply with or without a market share target would be infinite. This would lead the analysis to quite different rails, and we do not aim to follow them here.

5. A "RATIONAL EXPECTATIONS" INTERPRETATION OF THE MODEL

There is also another (serious) problem with the above comparisons, because we have so far taken the parameter D_L to be fixed and the same in the old and new systems. We must make a closer inquiry to find whether this assumption can be made or not. Basically we have from above

$$(38) \qquad D_L = \bar{D}_\lambda^d \left(\frac{d\lambda}{dL}\right) = \bar{D}_\lambda^d \left(\frac{d\lambda}{dr_m}\right)\left(\frac{dL}{dr_m}\right)^{-1} .$$

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1) If $D_L = 0.2$, $s = 0.1$, $r = 0.1$, $r_D = 0.05$ and $m = 0.02$, $d\pi/dL$ is only positive if $r_m < 0.11$.

The term $d\lambda/dr_m$ is in fact an outcome of the whole financial market model, equations (7), (8) and (12) (or equations (19)). Solving these equations gives

$$(39) \qquad \frac{d\lambda}{dr_m} = \frac{1}{\frac{\bar{L}^d_\lambda}{L^s_{r_m}} + r''_{cb}\,\bar{L}^d_{f_\lambda}} > 0 .$$

This means that tightness of the financial markets, i.e. the degree of credit rationing, increases as a result of a tightening stance of monetary policy. From (39) we see that this tightening is the smaller the higher is the offset through capital flows ($\bar{L}^d_{f_\lambda}$), the less the loan supply of banks reacts ($L^s_{r_m}$) and the more the private sector reduces its loan demand, i.e. shifts to other sources of finance (deposits) in tight monetary conditions ($\bar{L}^d_\lambda$).[1] If we have the case $r''_{cb} = 0$, i.e. the so called pure quota system discussed above, we would get by inserting (39) into (38)

$$(40) \qquad D_L = \bar{D}^d_\lambda / \bar{L}^d_\lambda ,$$

which could probably be taken as a constant in the different systems. Naturally D_L is also constant, if $\bar{D}^d_\lambda$ could be taken to be zero. However, in the general case we get the result

1) We must remember in this connection the identity $\bar{L}^d_\lambda + \bar{L}^d_{f_\lambda} = \bar{D}^d_\lambda$.

$$(41) \qquad D_L = \frac{\bar{D}^d_\lambda}{\bar{L}^d_\lambda + r''_{cb}\,\bar{L}^d_{f_\lambda}\,L^s_{r_m}},$$

where $L^s_{r_m} = dL^s/dr_m$ is in fact the reaction coefficient we want to solve in this paper. So we must make a new solution procedure to find out the final solution.

It is good to stop now to think about the model and its different interpretations. Above we have derived the behaviour of the banking sector as if it makes plans on its loan supply policy taking the deposit multiplier D_L (or the credit multiplier $(1-D_L)^{-1}$) as a fixed parameter. Basically we can have two views concerning the interpretation of this parameter. First, we may just take it as a fixed parameter, the value of which is formed by the (representative) bank on the basis of its market share in all deposits and the effectiveness of its various means and arrangements to increase the dependancy of its deposits on its own lending.

Secondly, as we have just gone through, the deposit multiplier D_L is in reality an endogeneous variable which is determined by (the model of) the financial markets. We could make the extreme, or in a way the rational expectations assumption, that the banks are aware of this fact and also base their policy on this. Indeed, we could argue that in a credit rationing system the adjustment costs are relatively low for the banks to change their loan supply as a consequence of expected or unexpected changes in their deposits. The banks would already in their planning take account of the "true model" which tells the outcome of their loan supply on their deposits. By penetrating in this direction we would in one part of the model introduce a rational expectations formulation. It is, however, quite easy to see that the solution of this model is quite awkward and involves a nonlinear equation system in the quantity $d\hat{L}/dr_m$ to be solved.

By (40) in the call money market system we do not encounter a problem of the kind just discussed. We also face the term $d\lambda/dr_m$ in connection of the deposit reaction dD/dr_m in (27). If we now insert (39) into (27) we may try to relax the assumption made above in the case of $r''_{cb} > 0$. First, we can note that if the reaction $d\hat{L}/dr_m$ is stronger on the assumption that dD/dr_m is the same in different regimes, relaxing this assumption intensifies this difference in the effectiveness of policy.

We may now calculate the expression (29) in this wider context when U_{LL} is zero as an example of taking into account of the whole financial market model. By imposing (41) in (29) we get

$$(42) \qquad \left(\frac{d\hat{L}}{dr_m}\right)_{old} = \frac{1}{r''_{cb}(\bar{L}^d_{f_\lambda})}\left(\frac{\bar{D}^d_\lambda}{1 - D_L} - \bar{L}^d_\lambda\right)$$

From this we see that in order to get a reaction of the correct sign, we must have $|\bar{D}^d_\lambda| > (1 - D_L)|\bar{L}^d_\lambda|$, i.e. that tightening of credit rationing must decrease deposit holdings more than loan demand. We cannot be a priori sure of this because by (1) we only have $D^d_\lambda - \bar{L}^d_\lambda = \bar{L}^d_{f_\lambda} > 0$.

6. CONCLUSIONS

We have in this paper considered the working of the Finnish bank loan market and the process of its recent structural change. We hope to have been able to formulate in a sensible way a simple stock equilibrium model for the outcome of the endogeneous financial variables in the financial sector of the economy under credit rationing keeping the real side of the economy as fixed all the time. We also tried to go carefully through the behavioural assumptions concerning the behaviour of the banks when deriving their loan supply policy.

The main goal was to compare the effectiveness of monetary policy on the loan supply of the banks in a bang per buck-sense in different institutional systems of the financial markets. The conclusions which we could draw were not in the case where r''_{cb} is positive clearcut. In the case of a call money system we could infer definitively that the institutional change toward more competitive arrangements can increase the effectiveness of policy. We also encountered the possibility of perverse effects of monetary policy. In the call money market case we can also quite safely eliminate these, and so they seem to appear only in the quota system.

In the quota system with marginal interest rate r_m rising, on the other hand, we could infer that the structural change in some respects would in fact reduce the effectiveness of policy. We must, however, confess that the structural change itself has led towards a case where the quota system with the possibility of different marginal interest rates on various banks is left (gradually) aside, as has also been the actual development.

It is, however, to be remembered that we have here considered as the only transmission mechanism of monetary policy the loan supply of banks. In the new2 system we also encounter in addition to the credit rationing effect treated here, an interest rate effect enforcing the effectiveness of monetary policy which may change with big enough interest elasticity of consumption and investment expenditures the above results. So, we hope that the ideas and discussions presented here would give a starting point for further study in this obviously interesting and important field.

APPENDIX: The share of the market section s as a function the call money rate r_m

We can write s as follows

$$s = \frac{D_c(r,\lambda,r_D^c)}{D\ (r,\lambda,r_D^c)}$$, all other variables in (1)' being constant.

By total differentiation we get

(1) $$\frac{ds}{dr_m} = \frac{ds}{dr}\frac{dr}{dr_m} + \frac{ds}{d\lambda}\frac{d\lambda}{dr_m} + \frac{ds}{dr_D^c}\frac{dr_D^c}{dr_m} .$$

Further, we have with some manipulation

(2) $$\frac{ds}{dr_i} = s(1-s)\frac{1}{r_i}[\varepsilon(D_c,r_i) - \varepsilon(D_o,r_i)]$$

where $\varepsilon(D\ ,r_i) = \frac{dD}{dr_i}\frac{r_i}{D_c}$.

By inserting (2) into (1) we get the expression presented in (35).

The sum of elasticities presented in (35) and (37) can be written as follows

(3) $$\frac{1}{r_i}\sum_i[\varepsilon(D_c,r_D^c) - \varepsilon(D_o,r_D^c)]\frac{dr_i}{dr_m} = D_c^{-1}\sum_i\frac{dD_c}{dr_i}\frac{dr_i}{dr_m} - D_o^{-1}\sum_i\frac{dD_o}{dr_i}\frac{dr_i}{dr_m} ,$$

Let us first consider the sums $\sum_i dD_c/dr_i$ and $\sum_i dD_o/dr_i$. If we impose the condition of symmetry on interest elasticities in the asset demand functions, definitively the first of these sums is positive because the corresponding sum over all interest rates in (1)' is zero and the missing derivatives in the sum $\sum_i dD_c/dr_i$ are negative. The second sum $\Sigma_i\ dD_o/dr_i$ is generally negative because the individual terms in this sum are negative. The terms dr_i/dr_m are as follows

$$\frac{dr}{dr_m} = hs(1+\varepsilon(D_c, r_D^c)) > 0 \text{ and } \frac{dr_D^c}{dr_m} = 1 > 0 \ .$$

And if we assume that $d\lambda/dr_m$ is positive, i.e. that tightening of monetary policy increases credit rationing, all the three multiplier terms in (3) are positive. So, the latter term in (3) is certainly negative. The first term can be further written as

$$\sum_i \frac{dD_c}{dr_i}\frac{dr_i}{dr_m} = \frac{1}{3}\left(\sum_i \frac{dD_c}{dr_i}\right)\left(\frac{1}{3}\sum_i \frac{dr_i}{dr_m}\right) + 3 \text{ cov } \left(\frac{dD_c}{dr_i}, \frac{dr_i}{dr_m}\right)$$

If we assume that dr/dr_m and $d\lambda/dr_m$ are smaller than 1 then the covariance term is also certainly positive. In all, we have the result that the sum of elasticities (3) is positive.

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