THE DEMAND FOR MONEY MARKET MUTUAL FUNDS

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This paper presents a model on the demand for money market funds (MMFs). These funds are a very close substitute for M1 deposits, except that MMFs do not satisfy immediate transaction needs. The demand for MMFs strengthens when the intended volume of transactions is low. A high interest rate level makes it expensive to hold M1 deposits. High interest rate volatility increases the risk related to M1 deposits more than the risk related to MMFs, boosting the demand of the latter. The results are largely corroborated by data.

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EXECUTIVE SUMMARY

Money market mutual funds (MMFs) have become an essential component of the total stock of monetary assets held by both business undertakings and households. In the Euro area, these funds total 600 billion euros, and they account for nearly 10% of the M3, the widest monetary aggregate. The number of empirical papers analyzing the determinants of the stock of MMFs is very limited, and the existing research is extremely focused on the U.S. market. It may not be obvious that these results are relevant to Europe. To make things worse, there seems to be almost no theorizing on the determinants of the demand for money market funds.

This paper presents a relatively simple theoretical framework to analyse the demand for MMFs. It is based on the idea that transaction accounts and MMFs are very close substitutes. Both types of monetary assets can be used for speculative and precautionary motives. However, MMFs cannot be used for immediate transaction needs. This difference implies that when the intended volume of transactions is high, banks’ customers prefer to hold transaction account deposits rather than MMFs.

The second important difference between MMFs and transaction accounts is the rate of return. Transaction accounts always earn the same relatively low fixed interest rate, or no rate of return at all. This rate is invariant to changes in the money market rate whereas the yield of MMFs generally follows the market rate. The conclusion is straightforward; whenever interest rates are high, the difference between the returns on these two assets widens, implying that customers reduce their holdings of transaction account deposits and increase their holdings of MMFs.
Because of the extremely short duration of securities held by MMFs, the one-off capital gains and losses caused by changes in interest rates are negligible. Instead, the return equals the money market rate. If the cost of holding monetary assets equals the money market rate, the situation is very paradoxical. Because the gross return on MMFs always follows the gross cost of holding them, there is no risk related to the net cost of MMFs. In the case of transaction accounts, instead, nothing but the cost varies. Hence, the net interest rate risk of deposits exceeds the risk of holding variable rate MMFs. Therefore risk averse customers avoid transaction account deposits and prefer to hold MMFs when interest rates are volatile.

Finnish monthly data is particularly well suited for testing the theory. Finland is one of the smallest countries of the Euro area, implying that it is relatively realistic to believe that interest rate developments are exogenously given. The payment system is largely based on transfers between accounts, implying that transaction account data reflects the stock of payment media better than in many other countries. All the predictions concerning the demand for MMFs are corroborated by the results, and the development of MMFs seems to surprisingly predictable. The impact of interest rate volatility on the demand for MMFs is particularly strong; investments in MMFs increase during interest rate turbulence. Intense economic activity in the near future, proxied by the GDP indicator of the following month, weakens the demand for MMFs. The demand for MMFs is stronger if interest rates are high. If anything, the growth of MMFs has been accelerating during the observation period.

The results with the demand for transaction account deposits are somewhat weaker. Low interest rates and low volatility strengthen the growth of deposits. However, rather surprisingly, deposit growth does not seem to be related to the volume of economic activity.
1 Introduction

The scope of analysis

Money market mutual funds (MMFs) invest in nothing but short maturity debt securities, such as treasury bills and certificates of deposit. These funds typically prefer securities issued by low-risk debtors, such as the government. In Euro area monetary statistics these funds are classified as a component of the widest monetary aggregate M3. According to ECB statistics, they accounted for 9% of M3, the outstanding stock totalling more than 600 billion euros in July 2005. Despite their relatively central role in the monetary system it is extremely difficult to find any analysis on the determinants of the size of this asset class. No theory of money market fund demand seems to exist. This paper is a preliminary attempt to shed some light on this neglected topic.

The scarcity of research might pose problems to policy makers. As long as monetary aggregates play any role in monetary policy making, the logic behind the development of this component of M3 should not be ignored; as will be seen in the following sections, the reaction of MMFs to interest rate changes is completely different from the reaction of M1 deposits. The supply of cheap deposits is essential to banks' net interest income, and customers' choice between MMFs and M1 deposits might be of relevance to financial institutions' profitability.

From a legal point of view, MMFs can be classified in the same category with other mutual funds. However, from an economic point of view, these funds have little in common with, say, equity funds characterised by high volatility and high potential returns. According to
the empirical results of Syriopoulos (2002), MMFs might be complements to other types of mutual funds, not substitutes for them.

MMFs are a very close substitute for transaction accounts. Both types of assets are characterised by low risk, high liquidity and low rate of return, even though the return on MMFs has been higher than the rate of return on transaction accounts. MMFs are almost as liquid as M1 deposits; they can be sold any time within a couple of days, in most cases with no fees. Basically, MMFs serve all the purposes M1 deposits do, with the exception that in most countries they cannot be used for immediate transaction needs.

It is difficult to mention other assets characterised by such a combination of low risk and high liquidity, except notes and coins. Equities and equity funds bear a much higher market risk. Interest rate volatility affects the value of bonds and bond funds much stronger than the value of money market funds, implying a significantly higher level of interest rate risk. Time deposits are illiquid because of their fixed maturity. It may be possible to withdraw the money before the original maturity date, but not without costs, making time deposits a relatively poor substitute for M1 deposits.

Because transaction accounts and MMFs are close substitutes, it is meaningful to analyse the choice between them as a separate question. The second section of this paper presents a model on the choice between these two monetary assets. The model is based on the idea that there are two differences between transaction accounts and MMFs; unlike M1 deposits, MMFs cannot be used for immediate transaction needs. Moreover, the return on MMFs is higher and it almost equals the money market rate. Paradoxically, it turns out that the overall interest rate risk of MMFs characterised by a very short maturity is lower than the interest rate risk of transaction deposits.
The third section presents some empirical analysis on the stock of these two monetary assets with Finnish monthly data. Most of the empirical predictions of the model are corroborated by the data. The demand for MMFs is strong when money market rates are volatile, economic activity is abating and interest rates are increasing. The fourth section concludes the main findings.

Previous literature on MMFs

There is surprisingly little systematic research on the demand for MMFs. The existing empirical evidence focuses almost exclusively on the U.S. market, and it was published mainly in the 1990s. It is difficult to identify in this literature any established schools or research traditions. Neither are there controversies. Instead, there seems to be a relatively small number of almost non-related contributions.

There is hardly any research on the demand for MMFs in Europe. One of the extremely few contributions was presented by Syriopoulos (2002) who used Greek data. The paper has an approach that has some analogies with the following model because it analyses the choice between MMFs and other assets. In the contribution by Syriopoulos, the choice is made between different types of mutual funds, not between mutual funds and M1 accounts. It was found that MMFs are a complement to other mutual fund categories rather than a substitute for equity and bond funds.

A particularly detailed contribution has been presented by Farinella and Koch (1999); they analysed the impact of taxation and changes in regulations on the demand for different types of MMFs in the U.S. in 1984-1995. The demand for these funds was negatively related to the yields of government debt securities but positively related to the return on the
funds themselves. The demand for MMFs does also depend on fund maturity, but the sign of this effect depends on the investor category.

Dow and Elmendorf (1998) studied the impact of stock price changes on the stock of MMFs. The results were somewhat surprising; both increases and decreases in stock prices intensified the demand for these funds, when compared to stable stock prices. The authors explain this observation by arguing that MMFs serve as a gateway between different asset classes. The argumentation may lack clarity, but the empirical results were rather clear. Goetzmann, Massa and Rouwenhorst (1999), instead, found that flows to equity funds are negatively correlated with flows to MMFs. Lam, Deb and Fomby (1989) concluded that deregulation of bank deposit rates in the U.S. in 1982 weakened the demand for MMFs because substitutes with nearly similar return properties became available.

As to the supply side, Maggs (1991) estimated how the number of different MMFs offered to the public reacted to interest rate changes. It seemed that financial intermediaries’ decision to launch new mutual funds reacted strongly to the highest treasury bill rate observed during the previous quarters.

There is some empirical research on the ability of money market fund managers to forecast changes in interest rates. Fund managers do not seem to be able to adjust portfolio maturities according to future changes in interest rates; in fact, portfolio maturities follow rather than anticipate interest rate changes. (Domian 1992) At least among large funds net returns to investors are driven almost exclusively by two factors, namely differences in expenses and the policy of the fund to invest or not to invest in commercial paper (Domian & Reichenstein 1997).
All the above mentioned contributions have taken a highly empirical approach. It seems to be completely impossible to find formal, theoretical models on the demand for money market funds.

2 The model

Assumptions

This model analyses the demand for two different monetary assets, namely M1 deposits and their close substitute, MMFs. This model describes customers' choice between these two assets. In line with money demand literature, companies in the financial industry are no active players in this model, and no attention is paid to their optimal behaviour. Instead, they do nothing but offer different services with exogenously given characteristics.

The model is a simple version of the money in utility function approach; holding money is costly, but agents prefer to keep a certain part of their assets as money because of the services provided by monetary assets. M1 deposits provide agents with liquidity services, whereas MMFs do not. Money held for other motives, such as precautionary and speculative purposes, does also yield utility. In these other uses M1 deposits and MMFs are perfect substitutes.

All the agents incur a cost if they hold these monetary assets. The gross cost equals the money market rate \( r, 0 < r < 1 \) multiplied by the amount of assets. The opportunity cost of holding monetary assets is the same irrespective of which kind of assets are being held. It would also be possible to assume that the cost must be somewhat higher than the mere money market rate because agents cannot borrow directly from the market, but as long as
the margin between the cost and the market rate is constant, this would have basically no impact on the empirical predictions of the model.

No interest is paid on M1 deposits. The investments of MMFs, instead, earn the market rate, but there is a constant management fee \( f, 0<f<r \) charged by the mutual fund company, implying that the net cost of holding MMFs equals \( f \) times the amount of MMFs being held. This assumption is consistent with the above mentioned observations by Domian (1992) and Domian & Reichenstein (1997); MMF return is largely determined by the market rate, and active fund management plays no significant role. To keep things simple, it is assumed that the duration of the money market fund portfolio is 0, and there are neither immediate capital losses nor gains when interest rates change.

The objective function of each agent is

\[
U = a \ln [m_1^*(c-z)] + \ln [m_1 + m_f] \tag{1}
\]

where \( c \) is expenditure on consumption, \( m_1 \) is the amount of M1 deposits, \( m_f \) is the amount of money market funds and \( z \) \((0<z<1)\) is an exogenously given minimum amount of consumption, such as the minimum level of subsistence. The parameter \( a \) describes agents’ preference for immediate consumption. The first part of the expression describes utility from consumption and consumption related liquidity services, the latter part describes the utility from holding monetary assets for any purpose not related to immediate transaction needs.

The sequential order is the following.

1) Agents observe the interest rate \( (r, 0<r<1) \). They do also observe their preferences concerning consumption, ie. the parameter \( a \).
2) Agents borrow money at the money market rate. They decide how much to borrow and how to divide these funds between M1 deposits \( (m_1) \) and money market funds \( (m_f) \).

3) Transactions are made. Utility from consumption and services provided by monetary assets is accrued.

4) Agents get their exogenously given income. The income equals +1. In addition, agents get the interest income from their MMFs. Agents have to repay their debts and to pay their interest and fee expenditures to lenders and mutual fund companies.

This is a static model, and the above mentioned stages are repeated only once.

Consumption at stage (3) equals the difference between income and the net cost of holding monetary assets. Not being able to repay debts at the stage four causes serious disutility, and it cannot be optimal to default. By definition

\[
c = 1 - r m_1 - f m_f
\]  

(2)

Solving the model

Substituting (2) for \( c \) in the equation (1), and differentiating with respect to \( m_1 \) and \( m_f \) yields the optimisation conditions \( \partial U / \partial m_f = 0 \) and \( \partial U / \partial m_1 = 0 \), and the following unique equilibrium\(^1\)

\[
\frac{\partial^2 U}{\partial m_1^2} = -\frac{1}{(m_1 + m_f)^2} - \frac{af^2}{(1 - fm_f - m_1 r - z)^2} < 0
\]

\(^1\) Second order conditions
\[ m_1 = \frac{a(1-z)}{(r-f)(2a+1)} \]  

(3)

\[ m_f = \frac{(1-z)(r-f(1+a))}{(2a+1)f(r-f)} \]

As can be seen, it is not possible to construct examples where agents would prefer to hold no M1 deposits at all. Instead, it is entirely possible to construct examples where there is no demand for money market funds. Such cases are likely if market rates are low, which narrows the cost differential between money market funds and M1 deposits, the fees charged by mutual fund companies \( f \) are high and the preference for consumption is strong \( a >> 0 \). Especially the latter factor might vary between agents of the real world. In the following, the analysis is restricted to cases where the optimal holdings of money market funds are positive \( r - f(1+a) > 0 \).

The formulae (3) imply that consumption expenditure equals

\[ c = \frac{(a+z +az)}{(1+2a)} \]  

(4)

With the formulae (3) it is possible to calculate how the optimal holdings of the two monetary assets react to changes in interest rates.

\[ \frac{\partial m_1}{\partial r} = -\frac{a(1-z)}{(2a+1)(r-f)^2} < 0 \]  

(5)

\[ \frac{\partial m_f}{\partial r} = \frac{a(1-z)}{(2a+1)(r-f)^2} > 0 \]

\[ \frac{\partial^2 U}{\partial m_1^2} = \frac{-a}{m_1^2} - \frac{1}{(m_1 + m_f)^2} - \frac{ar^2}{(1-fm_r - m_1 r - z)^2} < 0 \]
Unsurprisingly, the demand for money market funds increases and the demand for M1 deposits decreases when interest rates increase. The net cost of holding M1 accounts increases, whereas the cost of holding money market funds remains constant in net terms, implying that it is rational to substitute money market funds for M1 deposits. Interestingly, the formula (4) implies that interest rates have no impact on consumption, and the only consequence is a reallocation between the two types of monetary assets. This is partly due to the lack of long-term saving decisions in a one period model.

It is equally easy to calculate how changes in the preference parameter $a$ affect the demand for the two monetary assets.

$$\frac{\partial m_1}{\partial a} = \frac{(1-z)/((2a+1)^2(r-f))}{(2a+1)^2(r-f)} > 0$$ (6)

$$\frac{\partial m_f}{\partial a} = -\frac{(1-z)(2r-f)/((2a+1)^2(r-f)f)}{(2a+1)^2(r-f)f} < 0$$

This result is not particularly surprising. When agents' preferences for consumption strengthen, they shift monetary assets from money market funds to transaction accounts. Needless to say, such a change in preferences will also strengthen consumption.

$$\frac{\partial c}{\partial a} = \frac{(1-z)/(1+2a)^2}{(1+2a)^2} > 0$$ (7)

**Interest rate volatility and the demand for monetary assets**

Now, the assumptions of the model are changed in the following way. At stage 1, agents observe nothing but the expected value of future interest rates ($r_e$). There are two possible interest rate realisations, $r_e+v$ and $r_e-v$ ($0<v<r_e-f$). These outcomes are equally likely. The actual level of interest rates is observed between stages 2 and 3; agents do not have this information when they decide how much M1 deposits and MMFs to hold, but they know how...
When the interest rate level is observed, agents realise that the amount of consumption they can afford equals

\[ c = 1 - f \, m_f - m_1 \, (r_e \pm v) \]  \hspace{1cm} (8)

Agents maximise the expected value of utility \( W \).

\[ W = \ln[m_1 + m_f] + \frac{1}{2} a \left\{ \ln[m_1(1-fm_f-m_1(r_e-v)-z)] + \ln[m_1(1-fm_f-m_1(r_e+v)-z)] \right\} \]  \hspace{1cm} (9)

Agents' optimisation problem is\(^2\)

\[ \frac{\partial^2 W}{\partial m_1^2} = \frac{1}{2} \left[ \frac{-2}{m_1 + m_f} \right]^2 - \frac{a f^2}{(1-fm_f-m_1(r-v)-z)^2} - \frac{a f^2}{(1-fm_f-m_1(r+v)-z)^2} \leq 0 \]

The expression for \( \frac{\partial^2 W}{\partial m_1^2} \) is extremely complicated, but the extreme value must be a maximum of utility because \( \frac{\partial W}{\partial m_1} \) is a continuous function with meaningful values of \( m_1 \) because the extreme value is unique and because of the following two reasons:

1) \( \lim_{m_1 \to 0} \frac{\partial W}{\partial m_1} = \infty \)

2) When \( m_1 \) approaches its theoretical maximum where nothing but the minimum sum \( z \) is spent on consumption with the high interest rate realisation (which implies infinite marginal utility of consumption)

\[ \lim_{m_1 \to (1-m_f f - z)/(r+v)} W = - \infty \]

Therefore, the utility maximising value of \( m_1 \) must lie between the two extremes.

\( ^2 \) The second order condition of money market funds is satisfied.
$$\frac{\partial W}{\partial m_i} = 0 \quad (10)$$

$$\frac{\partial W}{\partial m_1} = 0$$

These conditions yield the following optimal combination

$$m_1 = \frac{a \{ 3(r_e-f)-\sqrt{[(r_e-f)^2+8v^2]} \} (1-z)}{2(1+2a)((r_e-f)^2-v^2)} \quad (11)$$

$$m_f = \frac{\{ (2+3a)f^2+2(r_e^2-v^2) +f\{a\sqrt{[(r_e-f)^2+8v^2]} -r_e(4+3a)\} \} (1-z)}{2(1+2a)((r_e-f)^2-v^2)} \quad (12)$$

Unsurprisingly, if there is no interest rate uncertainty ($v = 0$), the formulae (11) and (12) reduce to the formulae (3).

**PROPOSITION:** When interest rate uncertainty increases, agents prefer to hold more money market funds and less M1 deposits. ($\frac{\partial m_1}{\partial v} < 0; \frac{\partial m_f}{\partial v} > 0$)

**PROOF:** Appendix 1

This result has a simple intuition. Because agents are risk averse, ($\frac{\partial^2 U}{\partial c^2} < 0$), they become unwilling to hold risk bearing assets when the uncertainty related to them increases. Paradoxically, the overall interest rate risk of M1 deposits is higher than the risk of MMFs. The gross return on MMFs is volatile whereas the return on transaction accounts is not, but, on the other hand, agents' willingness to hold different kinds of monetary assets depends on the net costs. Because there is a perfect correlation between the return on MMFs and the cost of holding them, MMFs paradoxically turn out to be a safer investment than transaction deposits.
3 Testing the model

The data

The following analyses are based on monthly statistics on Finnish contribution to Euro area monetary aggregates. MMFs are measured with the respective component in Finnish MFI's contribution to the Euro area M3, and transaction accounts are measured by the respective contribution to Euro area M1. All the data are from the period January 2000 – March 2005, containing 63 monthly observations.

As to testing the model, Finnish data are nearly ideal. The role of notes, coins and cheques as payment media is limited. Instead, debit cards and giro transfers are widely used. Hence, consistently with the model, transfers between M1 accounts are the dominant payment medium. Secondly, in a typical Finnish money market mutual fund, there are no fees related to subscription and redemption, which is consistent with the model, but not the case in every country. Thirdly, it is reasonable to test the model with data from one of the smallest Euro area countries; the theory is based on the idea that both the level and the volatility of interest rates are exogenous; if one used, say, combined French, German and Italian data, it could be meaningful to assume that Euribor rates would be at least partly endogenous.

The growth of MMFs has been extremely strong in Finland in the last few years. The average annual growth rate has been about 50% since January 2000.

There is one clear seasonal pattern in the money market fund data. The stock of funds decreases sharply in December but recovers in January and February. This regularity has an obvious explanation, namely the wealth tax. Individuals' wealth exceeding a certain rela-
tively large sum was subject to a specific tax that was determined by the end of year situation. Not all the assets were taxable. Mutual fund shares were liable to taxation, but bank deposits were not. Hence, many wealthy individuals used to dispose of their mutual fund shares in December and reinvest in them in January or February. The wealth tax was abolished in 2005, but it was applicable during all the December observations of the data. The seasonal regularity can be dealt with in two different ways. Neither of them is fully satisfactory, but because of the extremely limited number of years in the data no good solution is available.

- First, the time series can be filtered with seasonal decomposition. The problem with this approach is the limited number of years in the data. One has to derive 12 scaling factors, one for each month. Each scaling factor is calculated as the average of differences of the variable from its centered moving average. This moving average cannot be calculated for the first six and the last six observations of the sample. Thus, the scaling factor is calculated as an average of very few observations.

- The second possibility is to use a specific dummy variable for December, and possibly two or three of its lagged values. On the positive side, observations for most months of the year are not affected by the unreliable estimate for the monthly factor. On the negative side, this method ignores any other potential seasonal regularity. And as to Decembers, there are only five observations in the data, implying that it is still difficult to separate random variation from seasonal regularities.

The results of preliminary estimations were fairly similar, irrespective of how the seasonal regularity of the explained variable was treated. There seemed to be more diagnostic problems, such as residual autocorrelation, when the raw data with a December dummy and its lagged values were used. Thus, the analyses to be presented in the following are based on MMF data which was deseasonalised with the additive method. All the observations were
divided by the consumer price index and transformed by taking the logarithm before deseasonalisation. ³

Transaction account deposits held by the public are measured by M1 deposits. These data were logarithmic and transformed by dividing them with the consumer price index before taking the logarithm and deseasonalising. There does also seem to be some seasonal variation in M1 deposits. Fortunately, these data are available for a much longer period, and the deseasonalisation was done with monthly data for the period January 1990 – March 2005.

The three main explanatory variables suggested by the above model are included in the analysis.

• The Monthly Indicator of real GDP is used to measure economic activity. Even these data are real and deseasonalised. The deseasonalisation was done with logarithmic data for the period January 1990 – March 2005.

• The data set does also include the three months Euribor rates. The observation refers to the last bank day of the month.

• The daily volatility of the three months Euribor rate during each month is used as a measure for volatility.

In addition, the difference between the six months and three months Euribor rate (YSLOP) is used as a proxy for interest rate expectations. If the yield curve is steep, the market expects interest rates to rise. Rate changes in the Euro money market seem to have been relatively predictable (Bernoth & von Hagen 2004), implying that market expectations contain relevant information and rational agents react to them. How would agents react to anticipations about rising interest rates? There are two different possibilities. If the duration of the

³ Scaling factors: Jan +0.023; Feb +0.008; March +0.018; Apr -0.012; May -0.018; June -0.021; July -0.041; Aug -0.031; Sept -0.025; -Oct 0.045; Nov -0.025; Dec +0.168;
MMF portfolio is 0, the situation is straightforward; higher future interest rates mean nothing but higher future revenue, and it is fully rational to invest more in MMFs. On the other hand, rising interest rates would also imply one-off capital losses because the duration of the portfolio is at least a few weeks. This latter effect, however, would be of no importance in an efficient market because there should be no anticipated market rate changes that would enable investors to benefit from abnormal capital gains; whenever a rate change becomes evident, it is reflected in the prices of all the securities that will arrive at maturity after the anticipated rate change.

The return on stock investments is used as a control variable in the equation for MMFs. As Dow and Elmendorf (1998) did in their paper on MMFs, changes in stock returns are split into two variables. The first one (HEXUP) is the percent change of the Helsinki Stock Exchange HEX portfolio return index, if the return is positive, zero otherwise. The second one (HEXDNW) is the absolute value of the percent change if the change is negative, zero otherwise.

The impact of interest rate volatility on money demand has been studied in previous research. Slovin and Sushka (1983) suggested that agents may hold less debt securities and more narrowly defined money if the return on securities is uncertain because of interest rate volatility. On the other hand, the results of Choudhry (1999) imply that interest rate volatility weakens rather than strengthens the demand for money. Roughly the same result was valid irrespective of whether the tests were made with short or long rate variability, even though the impact of short rate volatility on M1 demand was stronger. Hence, in the following, the long rate volatility, measured by the daily bond rate volatility during the month, is used as an additional control variable. The bond rate is the quotation of a domestic government bond with 10 years of remaining maturity.
The appropriate method to be used in testing the model depends on the time series properties of the key variables. In the table I, the unit root test results of the variables to be used in the estimations are presented. As we can see, the only variables that clearly violate the unit root hypothesis are the volatilities. Perhaps surprisingly, even interest rates seem to have been a unit root processes during the observation period.

![TABLE I HERE](image)

There seemed to be no seasonal regularities in the volatility variables. When their logarithmic values were explained with their lagged values and dummy variables for each month, none of the monthly factors seemed to be close to statistical significance.

**Results**

The following two equations (table II) have been estimated with OLS. Because most of the variables are unit root processes rather than stationary variables, most of them are used as first differences in the analysis. First, all the above discussed variables were included as explanatory variables, but non-significant variables not central to the above model were dropped off. Moreover, lagged values of differences of the explained variable were also included as explanatory variables. The resulting equations are presented in the Appendix 2. As a second step all the clearly non-significant variables not central to the model described in the second section were dropped off. The resulting equations are presented in the table II.

![TABLE II HERE](image)
The correlation between regression residuals of the two equations is -0.26, which is statistically significant at the 5% level. This negative correlation is probably an indicator of the mutual substitutability of these two monetary assets. Because of this correlation it is reasonable to use the SUR estimation technique instead of OLS. The results are presented in the table III. Unsurprisingly, the results are fairly similar to the OLS results.

**TABLE III HERE**

As can be seen in the appendix 3, there is no sign of obvious diagnostic problems in the estimations, such as residual autocorrelation, heteroscedasticity or non-normality.

Most empirical predictions of the model are consistent with estimation results.

1) Short rate volatility increases the demand for MMFs but decreases the demand for M1 deposits. The effect is surprisingly strong in the case of MMFs.

2) The demand for MMFs depends negatively on economic activity of the near future. Past volume of economic activity is less relevant than future activity, which is consistent with the idea that liquidity is invested in MMFs when it is not intended to be used for transaction purposes in the near future.

3) High money market rates decrease the demand for M1 deposits and anticipations of high future interest rates strengthen the demand for MMFs, which is consistent with the model.

When agents decide about their investments in MMFs, their decisions seem to be forward looking. They react to planned or expected volumes of activity and to interest rate expectations rather than past developments. In the case of M1 deposits, instead, the past seems to be at least as relevant as the future. This may reflect differences between agents who invest
in these assets. The relative share of unsophisticated agents, such as poorly informed households, is probably larger among depositors than among MMF investors.

Perhaps surprisingly, the only empirical prediction of the model that finds no support in these results is the positive relationship between M1 deposits and the economic activity. However, there is previous empirical evidence in favour of the positive relationship between these two variables (see Ripatti 1998 for analysis with Finnish data), and it is possible that the lack of evidence is simply due to the limited number of observations and the strong focus on very short-term developments.

One surprising finding related to money demand is the very strong negative impact of past changes in the stock of M1 deposits; it seems that almost 70% of any short-term change in the stock of M1 deposits is eliminated within three months. There is a similar yet much weaker negative autocorrelation in the changes of the MMF stock.

The very strong statistical evidence of the trend variable in the MMF equation indicates that, if anything, the growth rate of MMFs has been accelerating during the observation period, and there is no evidence that the stock of MMFs would already be stabilising at an equilibrium level.

Because most key variables of the model are unit root processes, it might be interesting to analyse the existence of co-integrating relationships between them. However, in the light of preliminary experiments, it does not seem to be possible to find such relationships, at least not if the trend variable is omitted. If the trend variable is included, the Johansen procedure finds a relationship between the 3 months Euribor rate and the stock of MMFs, but there is little or no evidence on the relationship between MMFs and other interesting variables, such as the GDP series and the stock of M1 deposits. This may not be surprising because
the extreme growth rate of MMFs probably indicates that this variable is still converging towards an equilibrium level to be found in the future.

4 Conclusions

This paper presents a simple model to analyse the demand for M1 deposits and MMFs. MMFs are a close substitute for M1 deposits because they are highly liquid and bear a very low risk. However, MMFs cannot be used for immediate transaction needs as a payment medium. Instead, the return on MMFs is somewhat higher. Agents prefer to hold more MMFs instead of transaction deposits if the intended volume of transactions is low and if the cost of holding monetary assets, i.e. the money market rate, is high and volatile. Perhaps surprisingly, MMFs with variable rate of return bear a lower overall risk than fixed rate deposits. This paradoxical result is valid if the cost of holding monetary assets equals the money market rate, which is also the rate of return on the investments of the typical MMF.

Most of the empirical predictions of the model find support in both OLS and SUR analysis with first differences of the key variables. Interestingly, anticipations about future money market rates seem to affect the demand for MMFs, but there is little evidence that past changes would have much effect. This finding is consistent with the statement that changes in the short market rate have been predictable and agents have often reacted to changes in interest rates before they have taken place. Short rate volatility and slowing economic activity intensify the demand for MMFs. The results of Dow and Elmendorf (1998) were partly corroborated; positive stock returns strengthen the demand for MMFs. On the other hand, there seems to be no evidence of the impact of negative returns.
Perhaps surprisingly, previous results on the impact of economic activity on the demand for M1 deposits are not corroborated by the analysis.
APPENDIX 1: PROOF OF THE PROPOSITION

When \( m_f \) is determined according to \((12)\)

\[
\frac{\partial m_f}{\partial v} = \frac{av\{5(r_e-f)^2 + 4v^2 - 3(r_e-f)v\sqrt{(r_e-f)^2 + 8v^2}\} (1-z)}{(1+2a)((r_e-f)^2 - v^2)^2} \tag{i}
\]

\( (i) \) is positive iff \( \{5(r_e-f)^2 + 4v^2 - 3(r_e-f)v\sqrt{(r_e-f)^2 + 8v^2}\} > 0 \)

\[
\Leftrightarrow 25(r_e-f)^4 + 40v^2(r_e-f)^2 + 16v^4 > 9(r_e-f)^4 + 72(r_e-f)^2v^2 \]

\[
\Leftrightarrow 16(r_e-f)^4 + 16v^4 - 32(r_e-f)^2v^2 > 0 \tag{ii}
\]

If \( v = (r_e-f) \), the left hand side of \((ii)\) equals 0.

When the expression on the left side of the inequality sign of \((ii)\) is differentiated with respect to \( v \), one gets \( 64v^3 - 64(r_e-f)^2v \). Iff \( v < (r_e-f) \), as assumed, this derivative is negative, implying that the left hand side of \((ii)\) is positive and \( \frac{\partial m_f}{\partial v} > 0 \). 4

When \( m_1 \) is determined according to \((12)\), the impact of \( v \) on \( m_1 \) is

\[
\frac{\partial m_1}{\partial v} = -\frac{av\left[-3(r_e-f) + 4\left\{(r_e-f)^2 - v^2\right\}/\sqrt{(r_e-f)^2 + 8v^2}\right] + \sqrt{(r_e-f)^2 + 8v^2}}{(1+2a)((r_e-f)^2 - v^2)^2} \tag{iii}
\]

If \( v = (r_e-f) \), the expression \((iii)\) equals 0.

The expression \((iii)\) is negative iff

\[
-3(r_e-f) + 4\left\{(r_e-f)^2 - v^2\right\}/\sqrt{(r_e-f)^2 + 8v^2} + \sqrt{(r_e-f)^2 + 8v^2} > 0 \tag{iv}
\]

4 In fact, the inequality \((ii)\) would hold even when \( v > r_e-f \) because beyond the point where \( v = r_e-f \) the left hand side of \((ii)\) is an increasing function of \( v \). When \( v = r_e-f \), the left hand side of \((ii)\) reaches its extreme (minimum) value because the derivative with respect to \( v \) equals zero.
If \( v = (r_e - f) \), the left hand side of (iv) equals 0.

When the left hand side of (iv) is differentiated with respect to \( v \), one gets

\[
\frac{32v [(r_e-f)^2 - v^2]}{[(r_e-f)^2 + 8v^2]^{(3/2)}}
\]  

(v)

This is negative because by assumption \( v < r_e - f \), implying that (iv) is a declining function of the parameter \( v \) and the inequality (iv) is satisfied always when \( v < r_e - f \). If follows that (iii) is negative.\(^5\)

\(^5\) In fact, the inequality (iv) would hold even when \( v > r_e - f \) because beyond the point where \( v = r_e - f \) the left hand side of (iv) is an increasing function of \( v \). When \( v = r_e - f \), the left hand side of (iv) reaches its minimum value because the derivative with respect to \( v \) equals zero.
APPENDIX 2: ALL THE EXPLANATORY VARIABLES INCLUDED

Estimation Method: Least Squares
Sample: 2000M03 2005M02
Included observations: 60
Total system (unbalanced) observations 120

Included observations: 60

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob.</th>
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<tr>
<td>C</td>
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<td>LNYS-LNYS(-1)</td>
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<td>LOG(VOLA)</td>
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<td>-0.8210</td>
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<td>LOG(BVOLA)</td>
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<td>1.0303</td>
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<td>LNRM1S(-4)-LNRM1S(-5)</td>
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<td>HEXUP</td>
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<td>-0.4299</td>
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<td>RB-RB(-1)</td>
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<td>1.5216</td>
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<td>TREND</td>
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<td>1.5412</td>
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R-squared 0.567339 Mean dependent var 0.00221
Adjusted R-squared 0.445066 S.D. dependent var 0.03663
S.E. of regression 0.017628 Sum squared resid 0.014294

Explained variable: LNRM1S-LNRM1S(-1)

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<tr>
<th>Coefficient</th>
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<th>Prob.</th>
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<tbody>
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<td>-2.806767</td>
</tr>
<tr>
<td>(LNYS-LNYS(-1))</td>
<td>-0.264143</td>
<td>-0.978362</td>
</tr>
<tr>
<td>LOG(VOLA)</td>
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<td>3.976311</td>
</tr>
<tr>
<td>LOG(BVOLA)</td>
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<td>1.313046</td>
</tr>
<tr>
<td>(YSLOP-YSLOP(-1))</td>
<td>0.127509</td>
<td>2.007006</td>
</tr>
<tr>
<td>HEXDWN</td>
<td>0.538145</td>
<td>3.011615</td>
</tr>
<tr>
<td>HEXUP</td>
<td>0.0386</td>
<td>0.240808</td>
</tr>
<tr>
<td>RB-RB(-1)</td>
<td>-0.081241</td>
<td>-2.501961</td>
</tr>
<tr>
<td>EURIB3-EURIB3(-1)</td>
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<td>1.544957</td>
</tr>
<tr>
<td>EURIB3(-1)-EURIB3(-2)</td>
<td>-0.072557</td>
<td>-1.313968</td>
</tr>
<tr>
<td>LNRM1S(-1)-LNRM1S(-2)</td>
<td>-0.415018</td>
<td>-3.510427</td>
</tr>
<tr>
<td>TREND</td>
<td>0.001092</td>
<td>3.029493</td>
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<tr>
<td>LNRM1S(-1)-LNRM1S(-2)</td>
<td>-0.309393</td>
<td>-1.261561</td>
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</table>

R-squared 0.558811 Mean dependent var 0.029965
Adjusted R-squared 0.434127 S.D. dependent var 0.044677
S.E. of regression 0.033608 Sum squared resid 0.014294

Explained variable: LNRMMF1S-LNRMMF1S(-1)

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<tr>
<th>Coefficient</th>
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<th>Prob.</th>
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<td>-2.806767</td>
</tr>
<tr>
<td>(LNYS-LNYS(-1))</td>
<td>-0.264143</td>
<td>-0.978362</td>
</tr>
<tr>
<td>LOG(VOLA)</td>
<td>0.04992</td>
<td>3.976311</td>
</tr>
<tr>
<td>LOG(BVOLA)</td>
<td>0.025899</td>
<td>1.313046</td>
</tr>
<tr>
<td>(YSLOP-YSLOP(-1))</td>
<td>0.127509</td>
<td>2.007006</td>
</tr>
<tr>
<td>HEXDWN</td>
<td>0.538145</td>
<td>3.011615</td>
</tr>
<tr>
<td>HEXUP</td>
<td>0.0386</td>
<td>0.240808</td>
</tr>
<tr>
<td>RB-RB(-1)</td>
<td>-0.081241</td>
<td>-2.501961</td>
</tr>
<tr>
<td>EURIB3-EURIB3(-1)</td>
<td>0.095862</td>
<td>1.544957</td>
</tr>
<tr>
<td>EURIB3(-1)-EURIB3(-2)</td>
<td>-0.072557</td>
<td>-1.313968</td>
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<tr>
<td>LNRM1S(-1)-LNRM1S(-2)</td>
<td>-0.415018</td>
<td>-3.510427</td>
</tr>
<tr>
<td>TREND</td>
<td>0.001092</td>
<td>3.029493</td>
</tr>
<tr>
<td>LNRM1S(-1)-LNRM1S(-2)</td>
<td>-0.309393</td>
<td>-1.261561</td>
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</table>

R-squared 0.558811 Mean dependent var 0.029965
Adjusted R-squared 0.434127 S.D. dependent var 0.044677
S.E. of regression 0.033608 Sum squared resid 0.014294
## APPENDIX 3; RESIDUAL TESTS

<table>
<thead>
<tr>
<th></th>
<th>OLS estimation, basic diagnostic statistics</th>
<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td>M1 residuals</td>
<td>Market Fund residuals</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>ARCH Test; Squared residual regressed on four lagged squared residuals; R²*Nr of observations</td>
<td>5.908</td>
<td>5.154</td>
</tr>
<tr>
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<td></td>
<td>Prob, based on chi squared</td>
<td>0.206</td>
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<tr>
<td>Autocorrelation</td>
<td>Breusch-Godfrey Serial Correlation LM Test: Residual regressed on four lagged residuals and explanatory variables of original regression; R²*Nr of observations</td>
<td>5.880</td>
<td>4.092</td>
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<td></td>
<td>Prob, based on chi squared</td>
<td>0.208</td>
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<td>Residual normality</td>
<td>Jarque-Bera</td>
<td>1.132</td>
<td>0.657</td>
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<tr>
<td></td>
<td></td>
<td>Prob</td>
<td>0.568</td>
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</tbody>
</table>

|                                | SUR estimation, basic diagnostic statistics |                     |                     |
|                                |                                            | M1 residuals        | Market Fund residuals |
| Heteroscedasticity             | ARCH Test; Squared residual regressed on four lagged squared residuals; R²*Nr of observations | 3.294               | 5.215               |
|                                |                                            | Prob, based on chi squared | 0.510               | 0.266               |
| Autocorrelation                | Breusch-Godfrey Serial Correlation LM Test: Residual regressed on four lagged residuals and explanatory variables of original regression; R²*Nr of observations | 4.313               | 7.704               |
|                                |                                            | Prob, based on chi squared | 0.365               | 0.103               |
| Residual normality             | Jarque-Bera                                | 1.030               | 0.403               |
|                                |                                            | Prob                 | 0.598               | 0.817               |
REFERENCES


**TABLE I: UNIT ROOT TESTS**

<table>
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<th>Lag length</th>
<th>t-Statistic</th>
<th>Prob.*</th>
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<tr>
<td>0</td>
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<tr>
<td>3</td>
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<td>0.973</td>
</tr>
<tr>
<td>1</td>
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<td>0.011</td>
</tr>
<tr>
<td>1</td>
<td>-0.897</td>
<td>0.784</td>
</tr>
<tr>
<td>1</td>
<td>-4.744</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
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<td>0.687</td>
</tr>
<tr>
<td>0</td>
<td>-7.182</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
<td>-5.615</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
<td>-4.350</td>
<td>0.001</td>
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<tr>
<td>0</td>
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<td>0.051</td>
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<tr>
<td>0</td>
<td>-10.994</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>-0.828</td>
<td>0.805</td>
</tr>
<tr>
<td>1</td>
<td>-13.204</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*Augmented Dickey-Fuller test statistics*

Unit root tests of key variables and their differences; LNRMFS = Ln[(Stock of MMFs, end of month)/(consumer price index)], deseasonalised; LNRMIS = Ln (M1 deposits, end of month/consumer price index), deseasonalised; EURIB3 = 3 months Euribor rate, last bank day of the month; RB = 10 years govnmnt bond yield, last bank day of the month; LN(VOLA) = Ln (standard deviation of the daily returns on a 3 month money market investment during the month ); LN(BVOLA) =Ln(standard deviation during the month of the daily returns on a govnmnt bond with 10 years of remaining maturity) ; LNYS = Ln(Monthly series of real GDP), deseasonalised; YSLOP = the difference between the 6 and 3 months Euribor rates, last bank day of the month.
### TABLE II: OLS RESULTS

**Estimation Method:** OLS  
**Sample:** 2000M03 2005M02  
**Included observations:** 60

#### EQUATION FOR LNRM1S-

<table>
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<tr>
<th>Coefficient</th>
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<td>LNYS(1)-LNYS</td>
<td>0.1687</td>
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<tr>
<td>LNYS-LNYS(-1)</td>
<td>0.0541</td>
<td>0.3731</td>
</tr>
<tr>
<td>LN(VOLA)</td>
<td>-0.0089</td>
<td>-1.7958</td>
</tr>
<tr>
<td>LN(BVOLA)</td>
<td>0.0168</td>
<td>1.8738</td>
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<tr>
<td>EURIB3-EURIB3(-1)</td>
<td>-0.0387</td>
<td>-1.9561</td>
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<tr>
<td>LNRM1S(-1)-LNRM1S(-2)</td>
<td>-0.5363</td>
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</tr>
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#### R-squared 0.512264  
Mean dependent var 0.00221

#### Adjusted R-squared 0.435757  
S.D. dependent var 0.023663

#### S.E. of regression 0.017775  
Sum squared resid 0.016113

#### EQUATION FOR LNRMMFS-

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<th>Coefficient</th>
<th>t-Statistic</th>
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<tr>
<td>LN(VOLA)</td>
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<tr>
<td>YSLOP-YSLOP(-1)</td>
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<td>LNRMMFS(-1)-LNRMMFS(-2)</td>
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#### R-squared 0.521798  
Mean dependent var 0.029965

#### Adjusted R-squared 0.435722  
S.D. dependent var 0.044677

#### S.E. of regression 0.003561  
Sum squared resid 0.056316
### TABLE III: SUR RESULTS

**Estimation Method:** Seemingly Unrelated Regression  
**Sample:** 2000M03 2005M02  
**Included observations:** 60  
**Total system (balanced) observations 120**  
**Linear estimation after one-step weighting matrix**

**EQUATION FOR LNRM1S-LNRM1S(-1)**

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<thead>
<tr>
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<td>EURIB3-EURIB3(-1)</td>
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**R-squared** 0.510086  
**Mean dependent var** 0.00221  
**S.D. dependent var** 0.023663  
**S.E. of regression** 0.017814  
**Sum squared resid** 0.016185

**EQUATION FOR LNRMMFS-LNRMMFS(-1)**

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<tr>
<td>TREND</td>
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</table>

**R-squared** 0.517094  
**Mean dependent var** 0.029965  
**S.D. dependent var** 0.044677  
**S.E. of regression** 0.033725  
**Sum squared resid** 0.056878

**Determinant residual covariance** 2.30E-07