Master's Thesis

Money, Sight and Term Deposits
A New Monetarist Approach

Chair of Economic Theory
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Abstract

The structure of financial flows can drastically affect the functioning and stability of the financial system. This thesis analyzes the mechanisms influencing the size and direction of financial flows in the credit system. Term and sight deposits are integrated into a model with financial intermediation and consumption uncertainty based on the framework of Lagos and Wright (2005). This approach captures the fundamental return-liquidity trade-off in credit markets and provides analytical information on the mechanics of deposit allocation and its economic implications. The interest spread of banks emerges as a central variable, whilst the impact of monetary policy is limited. The calibration to Australian, Swiss and US data for the period of 1984-2006 indicates that consumption uncertainty is a major factor in aggregate deposit allocation.

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Plagiatserklärung

Ich bezeuge mit meiner Unterschrift, dass meine Angaben über die bei der Abfassung meiner Arbeit benutzten Hilfsmittel sowie über die mir zuteil gewordene Hilfe in jeder Hinsicht der Wahrheit entsprechen und vollständig sind.
Ich habe das Merkblatt zu Plagiat und Betrug vom 22. Februar 2011 gelesen und bin mir der Konsequenzen eines solchen Handelns bewusst.

Füllinsdorf, July 19, 2016

Lukas Ziegler

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1 Introduction

A crucial role of the financial system is to link excess resources to credit needs. However, the financial system is not a homogenous entity connecting two parties. Instead, it is a complex system consisting of a variety of heterogeneous products. Financial innovation and the progress of information technologies increasingly intensify this heterogeneity. Characteristics of financial products affect the size and direction of financial streams, affecting the entirety of the financial system. This has manifested in the rise of the worldwide shadow banking sector over the last two decades and may occur again as a result of the vast changes in the regulatory environment in the wake of the Great Financial Crisis and the boom in the Fintech sector. Insights into these matters provide essential information for both commercial and institutional players concerning business strategies and the implementation of monetary and prudential policies. This thesis explores the allocation mechanisms in the credit market with respect to liquidity considerations and the economic implications. There will be emphasis on the allocation of financial streams across different products from the lenders' perspective.

Among the most important credit channels are bank loans funded through deposits. These comprise of sight deposits with constant access and term deposits where money is inaccessible for a predetermined duration in return for a higher yield. These differences in accessibility are generally irrelevant for the borrowing party, but pose a trade-off between the return and availability of funds for lenders. Therefore, sight and term deposits allow examining the objective of this thesis. By analyzing the allocation process of funds across these two deposits, certain conclusions can be drawn about the funds allocation across the whole credit system – both market and deposit based – and the factors affecting it.

This thesis adopts a New Monetarist approach, analyzing the allocation process by building a model wherein financial intermediaries provide loans by taking in sight and term deposits. Lagos and Wright (2005) [LW-model] provide a suitable framework for this, as the LW-model focuses on monetary aspects while analytically studying real output effects in an environment with differing market setups. Berentsen et al. (2007) introduce banks into the LW-model. The financial intermediaries in this thesis are modeled on this basis.

Liquidity aspects arise from introducing consumption uncertainty among depositors. Other studies adopt similar ideas of consumption uncertainty in LW-models. Faig and Jerez (2007) develop a model where agents with uncertain consumption preferences decide over holding an interest-bearing asset or cash. The results indicate that progress in information technology led to a reduction of consumption uncertainty in the recent decades. In that model, liquid balances come at the cost of foregone interest payments on illiquid investments. In contrast, this thesis introduces sight deposits that facilitate interest payments even on liquidity and it endogenizes returns by modeling both sides of the debt contracts. Telyukova and Wright (2008) analyze precautionary liquidity holdings. They model an environment where agents decide over getting a loan to pay for goods in the face of an uncertain consumption opportunity in an upcoming subperiod without access to the financial system. The model discussed in this thesis differs twofold. Firstly, it models both the creditor and debtor perspective. Secondly, it focuses on the deposit allocation decision whilst considering the investment's liquidity characteristics instead of having borrowers face changes in financial service availability.

This model allows for several interesting findings. Sight deposits are beneficial to society, as the positive return provides an optimal way of carrying liquidity that allows for a certain protection from inflation. Unsurprisingly, the interest rate spreads between illiquid and liquid deposits have a large impact on the allocation between the two types. Thus, a reduction in the spread between interest rates on sight deposits and those on less liquid assets results in a welfare gain, as the overall liquidity in the system increases. When spreads are sufficiently small, consumption uncertainty is large or agents are strongly risk averse, agents may engage in precautionary borrowing of additional sight deposit balances. Interestingly, if monetary policy has no direct impact on the spreads, it has only a limited effect on the allocations within the credit system compared to the return difference of sight and term deposits. However, if nominal interest rates fall below marginal bank costs, cash dominates sight deposits. Then, monetary policy greatly impacts the allocation of funds, as it directly affects the return difference of liquidity and term deposits, since cash offers no protection from inflation. Turning to the quantitative analysis, the model implies that most of the fluctuations in deposit allocation in Australia, Switzerland and the United States can be assigned to changes in aggregate uncertainty. More specifically, there are indicators suggesting that output volatility plays a large role.

The remainder of this thesis comprises of the following. Section 2 introduces the analytical model. A stationary monetary equilibrium is derived and its characteristics are presented by performing comparative statics over several parameters. In addition, the mathematical basis for the quantitative analysis is laid. By referring to the respective literature, assumptions for the model are discussed in section 3. It features explanations for the choice of exogenous features of the model and contains ideas on how these could be endogenized. In section 4, the model is calibrated to data of the US in order to analyze it quantitatively and comment on fundamental aspects driving financial allocation. Robustness checks are performed with comparable data from Australia and Switzerland. Implications and findings of this thesis are summarized in section 5.

2 Model

The model is based on Lagos and Wright (2005). Their framework indicates fiat money is valuable as a means of payment in decentralized and anonymous goods markets when lacking a double coincidence of wants. Agents without a buying opportunity hold on to their fiat money, as the model lacks a financial system. Thus, an extension is adopted from Berentsen et al. (2007) in order to include financial intermediaries. They introduce competitive institutions that take in deposits and make loans. This allows sellers with idle balances to transfer money holdings to buyers who have a use for money. By doing so, the financial sector provides sellers with a gain in the form of interest payments on excess money holdings. In the following model, loans are financed through term and sight deposits. Thereby, agents face a decision regarding the allocation of their funds, which enables the analysis of the allocation process and provides an instrument to assess the impact of different factors.

2.1 Environment

Time is discrete and continuous forever. There is a (0,1) continuum of infinitely lived agents, a general good that can be produced and consumed by all and a search good that can either be consumed or produced by the agents. The model features an intrinsically worthless item called fiat money issued by the monetary authority. For simplicity, this is the only means of payment in this model. Consequently, money in sight deposits needs to be withdrawn as cash in order to be used for payments. Money in term deposits cannot be used for payments. Table 1 summarizes the three financial assets and their characteristics.

Asset	**Yield**	**Liquidity**
Fiat Money	Zero yield	Means of payment
Sight Deposit	Low interest payment	Constantly accessible
Term Deposit	High interest payment	Illiquid, repayment at term

Table 1: Financial Assets in the Model

Repayment risks are neglected.[1] In general, intermediaries are assumed to face perfect competition from each other. However, the provision of liquid sight deposits is assumed to feature a positive cost spread. It captures elements like regulatory costs, contributions to a deposit insurance scheme, interbank market frictions and operational inefficiencies arising from potentially reduced competition. This spread will be taken as given exogenously. It is subject to the discussion in section 3.

[1]See section 3 for a discussion of this assumption.

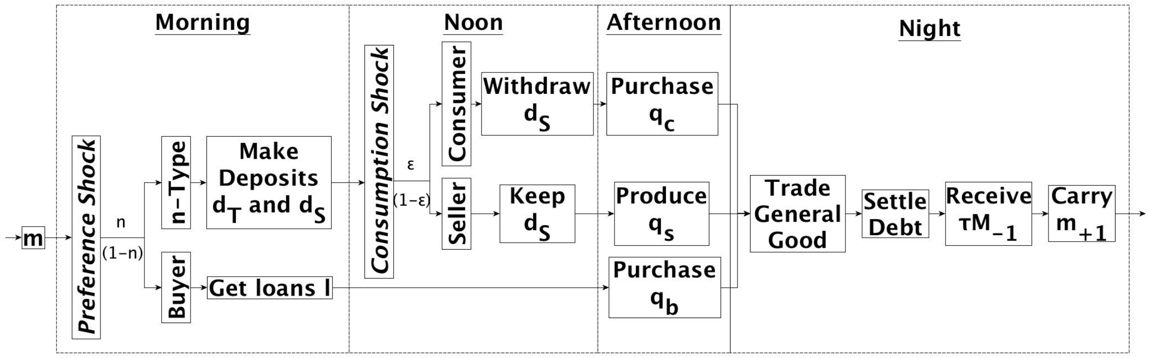

Figure 1: Model Environment

Each period is split into four subperiods that are shown in figure 1. Agents enter the morning market and receive an i.i.d. preference shock. With probability $1 - n$, it makes agents into *buyers* of the search good with certainty. With probability n, they become *n-type agents* who are likely to become *sellers*, but face some uncertainty with respect to their consumption behavior. A credit market opens, where two types of deposits are available. Sight deposits offer constant access at the variable cost μ and term deposits provide a higher interest rate at reduced accessibility of the funds. Buyers receive loans at an uniform interest rate.

After the closing of the credit market at noon, n-type agents receive a second shock that has a small probability $\epsilon \in [0, 0.5)$ turning them into *consumers*. These agents have the opportunity to withdraw their liquid sight deposits d_S in order to bring some money holdings into the afternoon market, as cash is the only accepted means of payment there.[2]

In the afternoon market, sellers produce the search good q at the disutility $c(q_s)$, where $c'(q_s) > 0$ and $c''(q_s) \geq 0$. Buyers and consumers purchase the search good quantities q_b and q_c from the sellers using their cash holdings, as trades occur anonymously. Pricing is assumed to be competitive, as sellers face *take it or leave it* offers. Consuming the

[2]It is assumed that payments can only be made with cash and not with bank balances. This assumption prevents the use of inside money that could be created at will by banks, which would undermine agents' necessity to bring money into each period. See section 3 for a discussion of this assumption.

search good yields utility $u(q)$, for which the Inada conditions[3] apply.

In the night market, all agents can produce and consume the general good x suffering disutility h and receiving utility $U(x)$. The monetary authority has the power to inject or withdraw fiat money and credit contracts are assumed to be perfectly enforceable.[4] Agents adjust money holdings for the next period and discount future periods at the discount rate β. Total welfare in this model is given by:

$$(1-\beta)W = (1-n)u(q_b) + n\epsilon u(q_c) - n(1-\epsilon)c(q_s) + U(x) - x \tag{1}$$

2.2 Social Optimum

As a benchmark, the model is derived from the perspective of a social planner who is able to enforce any amount of goods production and consumption. This planner maximizes the total welfare function (1) with respect to search good and general good quantities, facing the feasibility constraint.

$$\max_{q_b,q_c,q_s,x} \frac{(1-n)u(q_b) + n\epsilon u(q_c) - n(1-\epsilon)c(q_s) + U(x) - x}{1-\beta}$$

$$\text{s.t. } n(1-\epsilon)q_s = (1-n)q_b + n\epsilon q_c$$

The socially optimal quantities are determined by the first order conditions of this problem: $c'(q_s^*) = u'(q_b^*) = u'(q_c^*)$ and $U'(x^*) = 1$. In the social optimum, shocked consumers and buyers consume the same search good quantities $q_c^* = q_b^*$. Their marginal utility equals sellers' marginal disutility from producing it. Likewise, the optimal general good quantity x^* also equalizes marginal utility and marginal disutility.

[3] Inada conditions: u(q) is continuously differentiable and it holds that $u(0) = 0$, $u'(q) > 0$, $u''(q) < 0$, $\lim_{q\to 0} u'(q) = \infty$ and $\lim_{q\to\infty} u'(q) = 0$

[4] This is identical to actuarially fair default premiums and perfectly diversified intermediaries. In both scenarios, the expected cost of a loan in the night market is identical: $(1+i) = (1-\pi)(1+i+p)$, where π represents the probability of default and $p = \frac{1+i}{1-\pi}$ the respective risk premium.

2.3 Stationary Monetary Equilibrium

In the next step, a stationary symmetric equilibrium of this model in the absence of a social planner is derived. Agents decide autonomously over financial and goods quantities, but follow identical strategies. Real variables are time-invariant, thus only nominal quantities change over time. In a first step, the characteristics of financial intermediaries are derived. Then, the agents' problems are set up and solved backwards.

2.3.1 Financial Intermediation

Agents can acquire loans l or make sight and term deposits d_S and d_T through competitive financial intermediaries in the morning market. Since borrowers are indifferent between borrowing l_T from term deposit providers or l_S from sight deposit providers, borrowing occurs at the uniform interest rate i. Depositors in term deposits receive a one-period return of i_T and sight deposits yield i_S. Furthermore, the amount of loans cannot be larger than total deposits.[5] The profit function of term deposit providers comprises of the difference of total interest revenues on loans and total interest expenditures on deposits.

$$\Pi_T = (1-n)l_T i - n d_T i_T = 0, \text{ s.t. } (1-n)l_T = n d_T$$

The difference between interest rates charged by intermediaries on loans and those paid on deposits $i - i_T$ is the interest rate spread. The competition for depositors drives interest spreads on term deposits to zero $i = i_T$. Similarly, sight deposit providers' profit function consists of the revenue on loans minus deposit interest rates as well as the previously mentioned variable costs from providing sight deposits μ.

$$\Pi_S = (1-n)l_S i_{l_S} - n(1-\epsilon)d_S(i_{d_S} + \mu) = 0, \text{ s.t. } (1-n)l_S = n(1-\epsilon)d_S$$

[5] This condition does not rule out the ability of banks to create additional balances by extending their balance sheets. However, its potential is limited by the model's characteristic that money needs to be withdrawn as cash in order to be used as means of payment and to be brought into a subsequent period.

The uniformly offered interest rate on sight deposits is given by $i_S = i - \mu$. This shows that relatively large spreads could make the returns on banks' sight deposits negative $i - \mu < 0$. However, agents never choose to hold sight deposits at a negative return, as cash would be the clearly dominating option. Vice versa, n-type agents stop holding cash whenever sight deposits bear positive returns. One of the two assets always dominates the other due to the difference in returns. In order to derive and analyze the model in a general form, the following indicator function is introduced, canceling out sight deposits when applicable.

$$\mathbf{I}_S = \begin{cases} 1, & \text{if } i - \mu > 0 \\ 0, & \text{otherwise} \end{cases}$$

2.3.2 Second Subperiod: Night

The night features a centralized market, where the price of money in terms of the general good is ϕ. Agents finance general good consumption x and future money holdings m_{+1} by working h hours. Additionally, agents use the money holdings brought from the previous subperiod m and the money received from the monetary authority τM_{-1} to trade the general good. Intermediaries can perfectly enforce the repayment of loans l including interest. This gives lenders another source of income on sight and term deposits, whereas borrowers need to finance the credit repayment. The problem each agent faces when entering the night market is therefore:

$$W_2(m, l, d_S, d_T) = \max_{x,h,m_{+1}} [U(x) - h + \beta V_{+1}(m_{+1})] \tag{2}$$

$$\text{s.t. } x + \phi m_{+1} = h + \phi\{\tau M_{-1} + m + (1+i)(d_T - l) + [1 + \mathbf{I}_S(i - \mu)]d_S\} \tag{3}$$

Solving (2) gives agents' first order conditions in the night market.

$$x: \qquad U'(x) = 1 \tag{4}$$

$$m_{+1}: \qquad \phi = \beta V'_{+1}(m_{+1}) \tag{5}$$

The general goods quantities produced and consumed by agents achieve the social optimum, as (4) matches the social planner's target x^*. From (5) it follows that agents' decision over the amount of money holdings to bring into the next period is exclusively determined by the discount factor β, the price of money ϕ and the marginal value of money in the next period $V'_{+1}(m_{+1})$. Past variables are not considered, impyling that all agents bring the same amount of money holdings. The money holdings at the beginning of each period are thus degenerate. The envelope conditions of the second subperiod are given by:

$$W_{2m} = \phi \tag{6}$$

$$W_{2l} = -\phi(1+i) \tag{7}$$

$$W_{2d_T} = \phi(1+i) \tag{8}$$

$$W_{2d_S} = \phi[1 + \mathbf{I}_S(i-\mu)] \tag{9}$$

2.3.3 First Subperiod: Morning, Noon and Afternoon

As seen above, all agents enter the period with m money holdings. An initial preference shock divides agents into buyers and n-type agents. The latter group has a high chance of becoming a seller, but nevertheless faces the potential of experiencing a consumption shock at noon. With this information, agents trade in the morning on the competitive credit market with sight and term deposit providers. After the credit market has closed at noon, a second shock splits n-type agents into consumers with the probability ϵ and sellers with the probability $1-\epsilon$. Consumers can withdraw sight deposits before entering the afternoon market, where agents meet anonymously and trade the search good q competitively at price p. Agents move on to the night market. At the beginning of each period, agents have the following expected lifetime utility function.

$$\begin{aligned} V(m) = & n\epsilon[u(q_c) + W_2(m - d_T - pq_c, d_T)] \\ & + n(1-\epsilon)[-c(q_s) + W_2(m - d_T - d_S + pq_s, d_S, d_T)] \\ & + (1-n)[u(q_b) + W_2(m + l_S + l_T - pq_b, l_S + l_T)] \end{aligned} \tag{10}$$

Agents face the **buyers' problem** with probability $1-n$. It is given by:

$$\max_{l_S,l_T,q_b} u(q_b) + W_2(m + l_S + l_T - pq_b, l_S + l_T) \tag{11}$$

$$\text{s.t. } pq_b \leq m + l_S + l_T \text{ (Buyers' budget constraint: } \lambda_b) \tag{12}$$

$$\text{where } l_S + l_T = l \text{ (Buyers' borrowing indifference)}$$

Solving (11) with respect to the choice variables l and q_b and applying (6) and (7) gives the two first order conditions:

$$l: \qquad \phi i = \lambda_b \tag{13}$$

$$q_b: \qquad u'(q_b) = p\phi(1+i) \tag{14}$$

By (14) buyers purchase an amount of the search good so that marginal utility equals marginal costs of doing so. λ_b refers to the Lagrange multiplier of the buyers' budget constraint. From (13) it follows that it is binding for any positive nominal interest rate.

Agents face the **n-type agents' problem** with probability n. It features the split into sellers and consumers.

$$\begin{aligned}\max_{d_T,d_S,q_s,q_c} & \epsilon[u(q_c) + W_2(m - d_T - pq_c, d_T)] \\ & + (1-\epsilon)[-c(q_s) + W_2(m - d_T - d_S + pq_s, d_S, d_T)]\end{aligned} \tag{15}$$

$$\text{s.t. } d_T + d_S \leq m \text{ (Deposit constraint: } \lambda_s) \tag{16}$$

$$pq_c \leq m - d_T \text{ (Consumers' budget constraint: } \lambda_c) \tag{17}$$

Maximizing (15) with respect to the choice variables d_T, d_S, q_s and q_c and applying the envelope conditions (6), (8) and (9) gives the four first order conditions:

$$d_T: \qquad \phi i = \lambda_s + \lambda_c \tag{18}$$

$$d_S: \qquad (1-\epsilon)\phi(i-\mu)\mathbf{I}_S = \lambda_s \tag{19}$$

$$q_s: \qquad c'(q_s) = \phi p \tag{20}$$

$$q_c: \qquad \epsilon[u'(q_c) - p\phi] = p\lambda_c \tag{21}$$

Here, λ_s and λ_c are the Lagrange multipliers of the sellers' deposit and the consumers' budget constraint. By (18) and (19) the consumers' constraint is binding for any positive nominal interest rate, whereas the deposit constraint only binds if sight deposits have positive returns.

Furthermore, (20) indicates that sellers produce up to the point, where marginal disutility equals marginal benefit in terms of the general good consumption. By (21) deposits are made up to the point where expected marginal net benefit from bringing liquidity into the afternoon market equals the marginal opportunity cost in terms of foregone interest payments.

2.3.4 General Equilibrium

The search good consumption plans in the general equilibrium are given by the combination of the first order conditions from agents' problems in the first subperiod. Firstly, the combination of (14) and (20) determines the buyers' decision.

$$\frac{u'(q_b)}{c'(q_s)} = 1 + i \tag{22}$$

By (22) buyers wish to consume up to the point where marginal utility from consumption equals marginal costs. The nominal interest rate acts as a wedge between the buyers' consumption plan and the social optimum. Secondly, from (18)–(21) the n-type decision follows.

$$\frac{u'(q_c)}{c'(q_s)} = 1 + \frac{i}{\epsilon} - \mathbf{I}_S \left(\frac{1-\epsilon}{\epsilon} \right) (i - \mu) \tag{23}$$

(23) can be rewritten as $\epsilon \left[\frac{u'(q_c)}{c'(q_s)} - (1+i) \right] = (1-\epsilon)[i - \mathbf{I}_S(i-\mu)]$. This form shows that n-type agents allocate the money holdings with the aim of equalizing expected marginal net utility from consumption and expected marginal (opportunity) cost of not investing in term deposits. Since $\epsilon \in [0, 0.5)$ and $\mu > 0$ the consumption plans (22) and (23) imply $q_c \leq q_b \leq q^*$. Buyers never consume less than shocked n-type consumers and the socially optimal quantity q_b^* can only be achieved with an interest rate of zero.

Market Clearing Conditions: The total amount of search goods consumed must equal the total amount produced. In the credit market the sum of all loans must equal the deposits that are held until the night.

$$n(1-\epsilon)q_s = (1-n)q_b + n\epsilon q_c \tag{24}$$

$$n[(1-\epsilon)d_S + d_T] = (1-n)l \tag{25}$$

The left hand side of (25) stems from the fact that banks can perfectly anticipate the share of selling sight depositors who are not going to withdraw: $1-\epsilon$. Therefore, banks can lend out these funds while holding ϵd_S in cash to allow for withdrawals from consumers at noon.

2.3.5 Stationary Monetary Equilibrium

The monetary authority is assumed to have direct control over the total money stock M through lump-sum taxes τ. In a stationary equilibrium, all real variables are constant and only nominal variables adjust over time accordingly to the change in the total money stock: $\phi_{-1}M_{-1} = \phi M$. The gross inflation rate is therefore given by:

$$\gamma = \frac{\phi_{-1}}{\phi} = \frac{M}{M_{-1}} = \frac{p}{p_{-1}} \tag{26}$$

Differentiating agents' expected lifetime utility (10) with respect to money holdings gives the marginal value of money at the beginning of each period. The derivation can be found in the appendix.

$$V'(m) = \phi \left\{ n\epsilon \frac{u'(q_c)}{c'(q_s)} + n(1-\epsilon)[1 + \mathbf{I}_S(i-\mu)] + (1-n)\frac{u'(q_b)}{c'(q_s)} \right\} \tag{27}$$

The marginal value of money holdings consists of the sum of expected marginal utility from consuming the search good in the case of a buyer or consumer. Returns from term deposits do not appear, as the expenses to borrowers and revenues to lenders cancel each other out. However, the middle term of (27) features an additional gain for sellers in the case that bank deposits yield positive interest. This is because the decision to make sight deposits occurs under uncertainty, where n-type agents optimize their deposit holding with respect to (23). Sight deposits offer liquidity in case of a consumption shock, while providing some interest payments for n-type agents that turn out to be sellers. Therefore, sight deposits provide a cost efficient insurance against consumption shocks, which is reflected by its added value. As expected, banks' marginal costs μ have a negative effect on the marginal value of money holdings.

Combining agents' plan on future money holdings (5), the gross inflation rate (26) and the marginal value of money holdings (27) allows the derivation of the intertemporal Euler equation for money holdings.

$$\frac{\gamma}{\beta} = n\epsilon\frac{u'(q_c)}{c'(q_s)} + n(1-\epsilon)[1+\mathbf{I}_S(i-\mu)] + (1-n)\frac{u'(q_b)}{c'(q_s)} \tag{28}$$

The nominal interest rate i is therefore determined by the Fisher equation arising from (22), (23) and the Euler equation (28).

$$\frac{\gamma}{\beta} = 1 + i \tag{29}$$

Search Good Quantities: The policy rate of the monetary authority $\gamma \geq \beta$ affects the nominal interest rate level i directly. Figure 2 depicts the individual levels of buyers' and n-type consumers' search good quantity consumption as a function of the nominal interest rate.

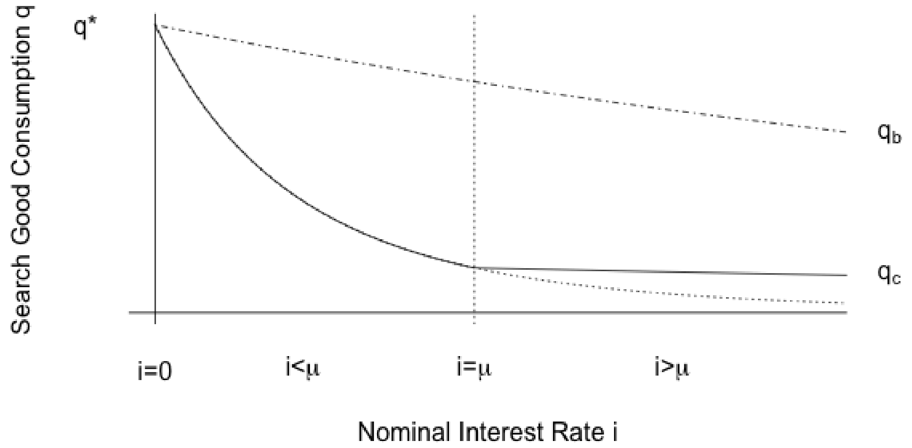

Figure 2: Search Good Levels in Equilibrium vs. Nominal Interest Rates

Proposition 1 *Depending on the monetary policy rate γ, there are three qualitatively different equilibrium types in the afternoon market: One leading to the social optimum $q_c = q_b = q^*$ (i) and two leading to inefficient equilibria $q_c < q_b < q^*$ once in the absence (ii) of sight deposits and once in the presence (iii) of sight deposits.*

Proof Under the Friedman rule (i) $\gamma = \beta$, carrying money is costless $i = 0$, since the present real value of money remains constant over time. By (13) buyers' budget constraint is slack. By (18) and (19) consumers are not constrained either, implying $\frac{u'(q_b)}{c'(q_s)} = \frac{u'(q_c)}{c'(q_s)} = 1$. Therefore, agents are able to bring sufficient money holdings into the next period in order to trade the socially optimal amounts of the search good $q_c = q_b = q^*$.

For positive nominal interest rates $i > 0$ at $\gamma > \beta$, carrying money holdings becomes costly, because the real value of money holdings in the subsequent period is less than the price of money in the current period. Therefore, agents bring too little real balances into subsequent periods to trade the socially optimal search good quantities. Depending on the interest rate spread on sight deposits μ, the case with positive nominal interest rates takes the two different forms (ii) and (iii).

For low nominal interest rates (ii) $i < \mu$, sight deposits are strictly dominated by cash holdings. This implies a slack deposit constraint for n-type agents by (19) and a binding budget constraint for consumers by (18):

$$m = pq_c + d_T \tag{30}$$

In the morning, n-type agents' slack deposit constraint implies the allocation of money holdings partially into cash and the rest into term deposits. By (23) n-type agents equalize the marginal benefit from depositing and the expected net marginal benefit from consuming $\epsilon \left[\frac{u'(q_b)}{c'(q_s)} - 1\right] = i$. An increase in the inflation rate raises the return difference between cash and term deposits, which increases the opportunity cost from holding liquidity. The uncertainty about the need for liquidity in the afternoon amplifies the expected cost from cash holdings away from the Friedman rule and results in the sharp decrease in the consumption level curve of n-type consumers q_c up to the point where $i = \mu$. Equivalently, by (13) buyers' budget constraint is also binding at positive interest rates:

$$m + l = pq_b \tag{31}$$

Thus, buyers borrow up to the point where marginal utility from borrowing equals marginal cost $\frac{u'(q_b)}{c'(q_s)} = 1 + i$. This leads to inefficient consumption quantities $q_b < q^*$. However, since buyers have no uncertainty about the opportunity to trade in the afternoon, the search good consumption quantities q_b do not decrease as steeply in inflation as those of n-type consumers. Since $\epsilon \in [0, 0.5)$, it follows that $\frac{i}{\epsilon} > i$ so that $q_c < q_b < q^*$.

For high nominal interest rates (iii) $i > \mu$ sight deposits bear positive returns. Thus, a more cost efficient insurance against consumption shocks than cash holdings exists, because n-type agents receive some return in the case of no consumption shock. As this favorable method of carrying liquidity becomes available to n-type agents, the choice is made for a higher liquidity ratio. This reflects in the flattening of the n-type consumption curve q_c after the point $i = \mu$, where sight deposits become relevant. Consequently, (18) and (19) imply that n-type agents deposit all their money holdings in the morning. Therefore, in addition to the budget constraint of consumers (30) and buyers (31), the sellers' deposit constraint binds as well:

$$m = d_S + d_T \tag{32}$$

The term deposit choice equalizes the expected net benefit from a consumption opportunity and the expected opportunity cost from a sight deposit $\epsilon \left[\frac{u'(q_c)}{c'(q_s)} - (1+i)\right] = (1-\epsilon)\mu$. Since $i + \mu(\frac{1-\epsilon}{\epsilon}) < \frac{i}{\epsilon}$, quantities traded by consumers are larger than without sight deposits. This can be seen in figure 2. The dotted curve represents the case where sight deposits are unavailable. Thus, the existence of sight deposits improves n-type consumers trading activities in the afternoon market.

For buyers, the existence of sight deposits has no direct impact, as both deposit types feature the same competitive borrowing rate. Bringing money balances has the same cost as borrowing in the morning market. As a result, buyers continue to borrow up to the point where marginal utility from borrowing equals marginal cost $\frac{u'(q_b)}{c'(q_s)} = 1 + i$. Again, real balances brought into the afternoon market are not sufficient in order to purchase the efficient amount $q_b < q^*$ due to the positive nominal interest rate. Buyers have the advantage of certainty when being on the credit market. Thus, it is again the case that buyers consume larger amounts than n-type consumers $q_c < q_b < q^*$, since $i + \mu(\frac{1-\epsilon}{\epsilon}) > i$.$\blacksquare$

Proposition 1 shows that the computation of search good quantities depends on the returns of sight deposits. The existence of positive returns on liquidity changes n-type agents' allocation decision. The traded search good quantities for the different equilibrium types can be derived explicitly by applying specific functional forms. Derivations are in the appendix. The functional forms used here are:

$$c(q) = q \text{ and } u(q) = \frac{q^{1-\alpha}}{1-\alpha}, \text{ where } \alpha \in (0,1)$$

At the Friedman rule (i) or for low nominal interest rates (ii) $i < \mu$, the combination of (22), (23), (24) and (29) yields:

$$q_b = \left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}} \tag{33}$$

$$q_c = \left(\frac{\beta\epsilon}{\gamma - \beta(1-\epsilon)}\right)^{\frac{1}{\alpha}} \tag{34}$$

$$q_s = \frac{1}{n(1-\epsilon)}\left[n\epsilon\left(\frac{\beta\epsilon}{\gamma - \beta(1-\epsilon)}\right)^{\frac{1}{\alpha}} + (1-n)\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}}\right] \tag{35}$$

In the case of high interest rates (iii) at $i > \mu$, where sight deposits have positive returns, the search good quantities are given by:

$$q_b = \left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}} \tag{36}$$

$$q_c = \left(\frac{1}{\frac{\gamma}{\beta} + \mu\frac{1-\epsilon}{\epsilon}}\right)^{\frac{1}{\alpha}} = \left(\frac{\beta\epsilon}{\epsilon\gamma + \mu\beta(1-\epsilon)}\right)^{\frac{1}{\alpha}} \tag{37}$$

$$q_s = \frac{1}{n(1-\epsilon)}\left[n\epsilon\left(\frac{\beta\epsilon}{\epsilon\gamma + \mu\beta(1-\epsilon)}\right)^{\frac{1}{\alpha}} + (1-n)\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}}\right] \tag{38}$$

As shown in figure 2, quantities traded are decreasing in the inflation rate γ, as the cost of holding money increases via the nominal interest rate i. Agents consume lower quantities when becoming more impatient for the same reason, higher discount rates lead ceteris paribus to higher nominal interest rates. Furthermore, the interest rate spread μ reduces the quantities traded by n-type consumers, as it directly increases the cost of sight deposits relative to term deposits. However, there is no effect on the quantities traded by buyers.

Financial quantities: Nominal financial quantities can be derived explicitly by utilizing the real search good quantities (33) – (38). (5) indicates that agents do not consider the past when deciding over the money holdings to be brought into the next period. As a result, the money holdings at the beginning of the morning market are degenerate. As a result, the total money stock from the previous period is evenly spread among agents at the beginning of the morning market $m = M_{-1}$.

At the Friedman rule (i) the credit market has no bearing in this model. The slack budget constraints of buyers and consumers as well as the slack deposit constraint of n-type agents at $i = 0$ indicate that agents bring sufficient amounts of money. The socially optimal quantities are traded, while deposit and credit quantities are consequently zero.

In the case (ii) of low nominal interest rates $0 < i < \mu$, the buyers' and consumers' budget constraints in the afternoon are binding, since carrying money balances is costly. Due to the strict dominance of cash over sight deposits, n-type agents hold part of the money holdings in cash to prepare for a consumption shock. There are no sight deposits $d_{S,i<\mu} = 0$, so that n-type agents' deposit constraint is not binding. The financial quantities follow from combining credit market clearing (25) with the binding budget constraints of n-type consumers (30) and buyers (31).

$$p_{i<\mu} = \frac{M_{-1} - n(1-\epsilon)(M_{-1} - d_T)}{(1-n)q_b + \epsilon n q_c} = \frac{M_{-1}}{(1-n)q_b + nq_c} \tag{39}$$

$$d_{T,i<\mu} = M_{-1}\frac{(1-n)(q_b - q_c)}{(1-n)q_b + nq_c} \tag{40}$$

$$l_{i<\mu} = M_{-1}\frac{n(q_b - q_c)}{(1-n)q_b + nq_c} \tag{41}$$

The sellers' optimal production plan (20) determines the price of money in terms of the general good. It balances disutility from producing the search good in the afternoon market and utility from consuming the general good in the following night market.

$$\phi_{i<\mu} = \frac{(1-n)q_b + nq_c}{M_{-1}} \tag{42}$$

High nominal interest rates in the case (iii) of $0 < \mu < i$ imply that sight deposits dominate cash holdings. Then, n-type agents deposit all their money holdings during the morning market. The buyers' and consumers' budget constraint and the sellers' deposit constraint in the afternoon are binding. The financial quantities follow from the sellers' optimal production plan (20) combined with the credit market clearing condition (25), n-type agents' binding deposit constraint (32) and the binding budget constraint of n-type consumers (30) and buyers (31):

$$p_{i>\mu} = \frac{M_{-1}}{(1-n)q_b + n\epsilon q_c} \tag{43}$$

$$d_{T,i>\mu} = M_{-1}\frac{(1-n)q_b - (1-n\epsilon)q_c}{(1-n)q_b + n\epsilon q_c} \tag{44}$$

$$d_{S,i>\mu} = M_{-1}\frac{q_c}{(1-n)q_b + n\epsilon q_c} \tag{45}$$

$$l_{i>\mu} = M_{-1}\frac{nq_b - n\epsilon q_c}{(1-n)q_b + n\epsilon q_c} \tag{46}$$

$$\phi_{i>\mu} = \frac{(1-n)q_b + n\epsilon q_c}{M_{-1}} \tag{47}$$

Monetary Aggregates: In order to assess the deposit allocation within the model, the individual financial quantities can be aggregated and put in relation to each other. Following a typical definition of the monetary aggregate M3, the total of broad money consists of the sum of the cash stock M_{-1}, total sight deposits[6] $D_S = n(1-\epsilon)d_S$ and total term deposits $D_T = nd_T$. The shares of term and sight deposits in M3 are given by:

$$\delta_T = \frac{D_T}{M3} = \frac{nd_T}{M_{-1} + nd_T + n(1-\epsilon)d_S} \tag{48}$$

$$\delta_S = \frac{D_S}{M3} = \frac{n(1-\epsilon)d_S}{M_{-1} + nd_T + n(1-\epsilon)d_S} \tag{49}$$

$$\delta = \delta_T + \delta_S = \frac{n[d_T + (1-\epsilon)d_S]}{M_{-1} + nd_T + n(1-\epsilon)d_S} \tag{50}$$

Figure 3 depicts the shares of term and sight deposits under different money growth rates and a constant discount factor. Since the Friedman

[6]The share of sight deposits withdrawn at noon $n\epsilon d_S$ appears only once in M3. This is because it is not lent out and withdrawn from the credit market before earning any interest, whereas term deposits and sellers' sight deposits are both an asset to lenders, while also being used as means of payment by borrowers during the day.

rule (i) implies no costs from carrying money holdings, agents always bring sufficient amounts of money into each period. In this situation, there is no use for financial intermediaries. As a consequence, there are no deposits, which implies that for $i = 0$ the deposit shares in M3 are zero.

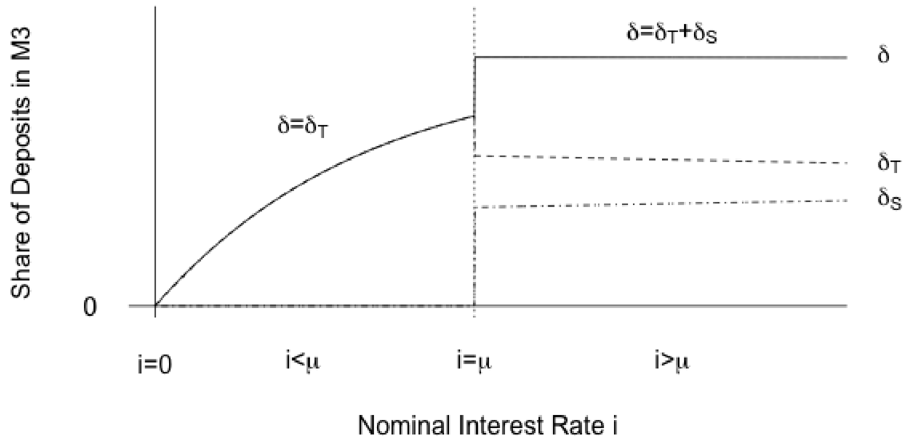

Figure 3: Share of Deposits in M3 under Different Monetary Regimes

For low nominal interest rates (ii) at $i < \mu$, n-type agents allocate an increasing share of money holdings into term deposits. The share of term deposits in M3 increases consequently. Since sight deposits are dominated by cash holdings, total deposits in this monetary regime consist exclusively of term deposits $\delta = \delta_T$. At the point $i = \mu$, where sight deposits become feasible, n-type agents allocate all money holdings to the two deposit types and do not hold any more cash. This results in a jump of the share of total deposits. Since this jump in sight deposits also increases M3, the relative share of term deposits δ_T features a sharp decrease.

For high nominal interest rates (iii) at $i > \mu$, the interest spread μ gets relatively smaller when inflation increases. This is why agents substitute some term deposits with sight deposits as a reaction to inflation. However, the effect of monetary policy on liquidity allocation in this area is rather small. As figure 4 shows, the difference in returns on the two deposit types μ is the main driver of the allocation for $\mu < i$.

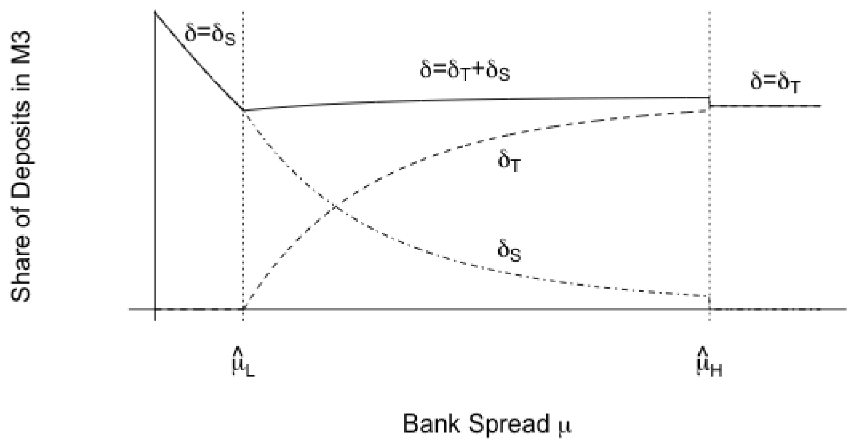

Figure 4: Share of Deposits in M3 vs. Bank Interest Rate Spread

Proposition 2 *There exist values for $\mu > \hat{\mu}_H$, for which agents abandon sight deposits in favor of cash and term deposits. Below that, agents allocate an increasing share to sight deposits. There exist values for $\mu < \hat{\mu}_L$, $\epsilon > \hat{\epsilon}$ or $\alpha > \hat{\alpha}$, where n-type agents exclusively hold sight deposits and even borrow additional sight deposit balances.*

Proof in the appendix.■

Proposition 2 indicates that for high interest rate spreads $\mu > \hat{\mu}_H = i$, agents switch to cash and do not hold sight deposits. Both deposit types are held when spreads are at moderate levels. The convergence of the two deposits' returns due to lower spreads corresponds to a flattening of the yield curve, where longer maturities becomes less attractive. At the lower critical value $\hat{\mu}_L$, the cost of sight deposits equals agents' endogenous willingness to pay for liquidity so that agents no longer deposit into term deposits. For lower spreads, n-type agents prefer to borrow additional funds from the banks in order to relax the liquidity constraint in the afternoon for a potential consumption opportunity. This materializes in the steep part of the overall deposit ratio in the left area of figure 4.

A necessary condition that borrowing from banks becomes interesting to n-type agents is that the interest rate spread lies below the cost of bringing additional money into the period $\mu < i$. The mechanism behind this phenomenon is depicted in figure 5. Banks provide an intertemporal clearing service by redistributing deposited cash from future sellers to n-type agents with a consumption shock at the banks' variable cost. However, there is no variable allowing simultaneous borrowing and depositing at sight deposit providers. Thus, the model captures the granting of loans to n-type agents technically by passing money from sight deposit providers through buyers and term deposit providers to n-type agents in the morning market.

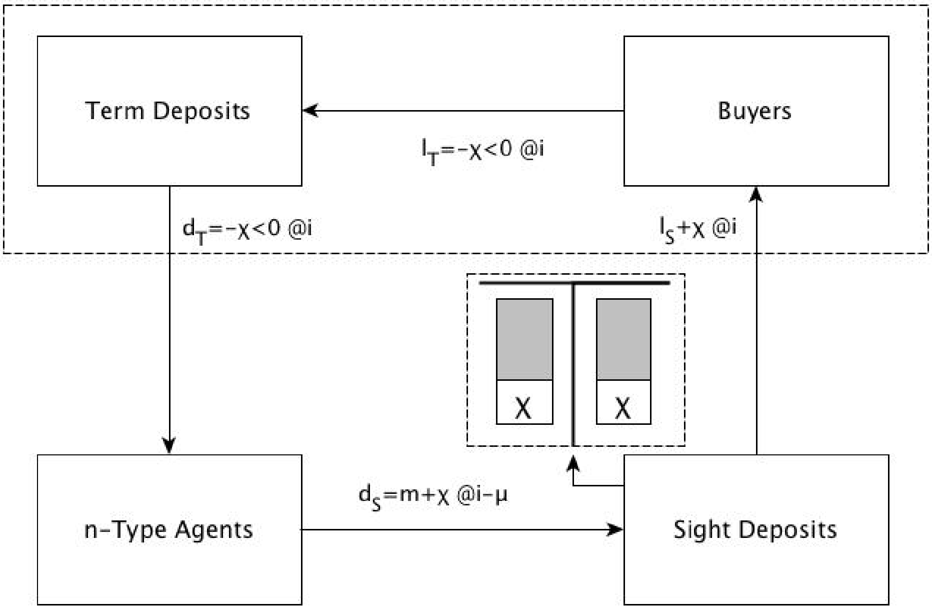

Figure 5: Model's Mechanism Allowing n-Type Agent Borrowing

The n-type loan χ is added to buyers' loans from banks. Buyers offset additional money at zero cost by depositing it in term deposits. This allows n-type agents to borrow from term deposits, which does not affect term deposit providers. Thereby n-type agents receive the loan χ from banks as if it had been borrowed directly through an extension in the banks' balance sheet. Buyers and term deposit providers only play a technical role in the creation of the new claims. This mechanism is fundamentally equivalent to the extension of bank balance sheets to make a new loan, as is shown in figure 15 in the appendix. It is noteworthy that, in this model, transactions in the afternoon are exclusively performed with cash. Therefore, bank deposits cannot be used as means of payment, which limits banks' ability to create money, as they cannot extend their balance sheet by more than what will be withdrawn at noon.

Borrowing by n-type agents occurs when expected benefits are higher relative to expected costs. This is the case when bank spreads are low, but also when risk aversion is high or consumption shocks are likely. The impact of the two latter parameters is illustrated in figures 6 and 7 showing the effect of ϵ and α on deposit allocation. The more likely a consumption shock is, the more money is allocated into sight deposits rather than term deposits. For values above $\hat{\epsilon}$, n-type agents begin to borrow from the bank, which increases δ_S. For even higher values, δ_S decreases again. This is because an increase in the number of n-type consumers implies a reduction of the sight deposits that are not withdrawn at noon, which restricts banks' ability to lend to n-type agents. Regarding the risk aversion α, low values indicate a lower preference for liquidity insurance so that agents allocate more money to term deposits. The benefit of sight deposits increases, as risk aversion gets higher. Above the point $\hat{\alpha}$, no term deposits are made and n-type agents borrow from banks in order to insure themselves against a consumption shock. Since the number of withdrawers does not change, δ_S keeps increasing in α, as n-type agents further expand the borrowing activities.

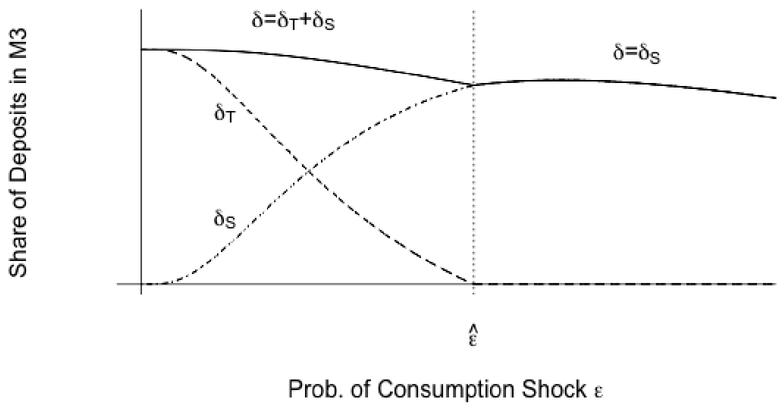

Figure 6: Share of Deposits in M3 vs. Consumption Shock Probability

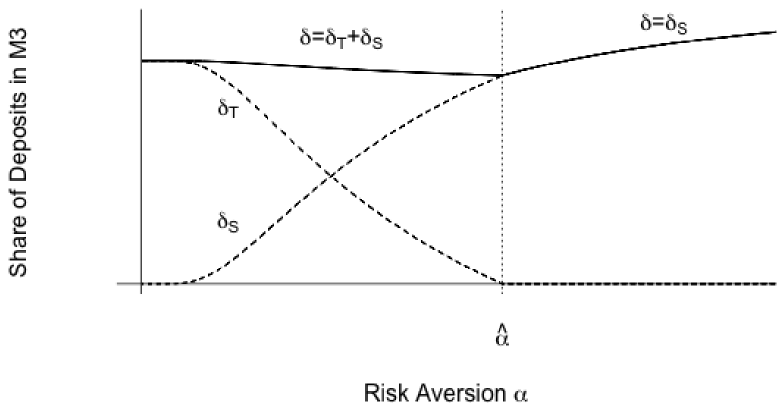

Figure 7: Share of Deposits in M3 vs. Risk Aversion Coefficient

General Goods Quantities: Agents' activities in the credit and search goods market during the day determine the activities at night. Agents enter the night market with heterogeneous money holdings. Buyers and n-type consumers do not hold money after purchasing search goods in the afternoon. At the beginning of the night market, sellers hold the total money stock in the economy M_{-1}. Agents' optimization plan (5) implies that the decision over money holdings to be brought into the subsequent period is independent of past variables. The money holding in the subsequent morning market can thus be expressed in terms of the monetary authorities' taxation policy:

$$m_{+1} = M = M_{-1}(1+\tau) \tag{51}$$

At the end of each period, the total money stock is therefore evenly distributed across all agents. From agents' budget constraint in the night market (3) and the next period money holding target (51) the hours worked in the night market can be derived for each type of agent. Trades aim at adjusting the money holdings and consuming the optimal level of the general good x^*. The individual derivations can be found in the appendix. The expected total hours worked are given by:

$$h = n\epsilon h_c + n(1-\epsilon)h_s + (1-n)h_b \tag{52}$$

Plugging in the individual hours worked (62), (63), (64) as well as the search goods and credit market clearing conditions (24) and (25) gives:

$$h = x^* + n(1-\epsilon)\phi\mu d_S = x^* + n(1-\epsilon)\mu q_c \tag{53}$$

Hence, on the aggregate level agents produce the socially optimal amount of the general good and recover the costs of sight deposits. Again, this result clearly shows that society has an interest in reducing the interest rate spread on sight deposits.

The real general goods output in the night market for the functional form of $U(x) = Alog(x)$ is given by $Y_C = A + n(1-\epsilon)\mu q_c$.[7] The real search goods output in the afternoon market equals $Y_D = n\epsilon q_c + (1-n)q_b$. Thus, the share of transactions taking place in the search goods market is:

$$s_G = \frac{Y_D}{Y_C + Y_D} \tag{54}$$

Money Demand: The theoretical money demand function in this model is given by the inverse money velocity $L = v^{-1}$. The quantity theory of money states that the product of the total money stock and the money velocity equals an economy's nominal GDP: $Mv = PY$. Utilizing this relationship, the money demand L and the elasticity of the money demand with respect to the nominal interest rate level are given by:

$$L = \frac{M}{PY} \tag{55}$$

$$\xi_L = \frac{\partial L}{\partial i}\frac{i}{L} \tag{56}$$

In this model, the narrow money stock M1 consists of the total amount of physical fiat currency M_{-1} plus total sight deposits $D_S = n(1-\epsilon)d_S$. The nominal GDP is determined by total real production in the afternoon market Y_D and night market Y_C multiplied by the price levels in each submarket. The general money demand function in this model is then:

$$L = \frac{M_{-1} + D_S}{pY_D + \phi^{-1}Y_C} = \frac{M_{-1} + n(1-\epsilon)d_S}{p[(1-n)q_b + n\epsilon q_c] + \phi^{-1}[A + n(1-\epsilon)\mu q_c]} \tag{57}$$

When plugging in the respective financial variables, the explicit money demand function in terms of the search good quantities can be derived for

[7] The night market's first order condition (4) implies $\frac{\partial Alog(x)}{\partial x} = 1 \Rightarrow x^* = A$.

the different monetary policy regimes. In the case of the Friedman rule (i) and a low nominal interest rate regime (ii) at $0 \leq i < \mu$, sight deposits have negative returns and play no role. Plugging in the search good price (39), the inverse price of money in terms of the general good (42) and $d_S = 0$, the money demand function (57) can be rewritten as:

$$L = \frac{(1-n)q_b + nq_c}{(1-n)q_b + n\epsilon q_c + A} \tag{58}$$

In the high nominal interest rate regime (iii) at $0 < \mu < i$, all money holdings are channeled towards buyers and consumers through sight and term deposits, since there are no frictions limiting these financial streams. As a consequence, the nominal output in the afternoon market amounts to M_{-1}, as the whole currency stock changes hands once in the search good trade. Plugging in the search good price (43) in the first term of the denominator of the money demand function (57) makes this clear.

$$pY_D = p[(1-n)q_b + n\epsilon q_c] = \frac{M_{-1}[(1-n)q_b + n\epsilon q_c]}{(1-n)q_b + n\epsilon q_c} = M_{-1}$$

Each unit of money is used once in the afternoon market and some is exchanged again when making interest payments and adjusting money holdings by trading the general good in the night market. However, this does not necessarily imply a money velocity of $v \geq 1$. Due to the sight deposits made in the morning, the monetary aggregate M1 grows from M_{-1} to $M_{-1} + n(1-\epsilon)d_S$. Plugging in the sight deposit function (45) and the inverse price of money in terms of the general good (47) gives the money demand function.

$$L = \frac{(1-n)q_b + nq_c}{(1-n)q_b + nq_c[\epsilon + \mu(1-\epsilon)] + A} \tag{59}$$

For certain parameterizations, this equation can produce values of $L \geq 1$. The presence or absence of sight deposits makes the credit systems fundamentally different. This reflects in the differences of the money demand functions (58) and (59). Therefore, the specific forms of the money demand elasticity need to be derived separately. This is done in the appendix and results in the equations (65) and (66).

2.4 Model Summary

All endogenous variables of the model are now explicitly derived. In summary, there are three qualitatively different stationary monetary equilibria. At the Friedman rule (i), goods traded in the afternoon and night market reach the socially optimal level. Since agents do not suffer any cost from carrying money holdings into the next period, they simply bring enough money to purchase these amounts. As a consequence, there is no need for any intermediation services.

When the money growth rate is above agents' discount rate, carrying money holdings into the next period becomes costly. Agents make use of the financial sector to transfer money holdings from n-type agents to buyers after having received a first preference shock. In the region of low nominal interest rates (ii), sight deposits are dominated by cash holdings due to the negative yield resulting from the bank cost spread. Due to the risk of a consumption shock, n-type agents carry some cash holdings into the afternoon, while depositing the rest of the money holdings into term deposits in order to receive interest payments from borrowing buyers. In this region, the money growth rate highly affects the deposit allocation.

When the monetary authority implements a policy rate leading to relatively high nominal interest rates (iii), banks are able to offer sight deposits with positive interest payments despite the cost spread. While this does not affect borrowers, n-type agents can henceforth carry liquidity into the afternoon market at more favorable conditions than those offered by cash. The returns on sight deposits partially absorb the negative effect of an increase in inflation on liquidity, which largely eliminates the effect of the monetary policy on deposit allocation. The share of term deposits in the economy is consequently smaller than in the case without sight deposits. The more important drivers of deposit allocations are then the cost spread, risk aversion and consumption risk probability.

In section 4, the model is calibrated to data from the United States. Two robustness checks are performed with Australian and Swiss data.

3 Discussion

This section discusses relevant aspects and assumptions of the model.

Interest Rate Spread on Sight Deposits: The cost spread on sight deposits has been taken as exogenously given, as there is a large theoretical and empirical body of literature supporting its existence. The fundamental reason for its existence can be seen in the underlying maturity transformation. Famously, Diamond and Dybvig (1983) show that sight deposit provision relies on the idea, that only a share of deposits is withdrawn at any point in time. This allows the holding of illiquid assets in order to generate interest. However, it can also lead to bank runs and is thus at the core of the cost spread, as the following factors show.

• *Interbank Market*: Banks experience fluctuations in the individual withdrawal rates. Bhattacharya and Gale (1985) and Allen et al. (2009) suggest that in the case that banks' individual withdrawal rates are uncertain, operating an interbank market for liquidity is beneficial. Thereby liquidity reserves can be shared among all banks, so that idiosyncratic withdrawals are perfectly insured. Nevertheless, it requires banks to maintain a costly infrastructure and to engage in a costly search for interbank trading partners.

• *Imperfect Competition*: Most measures to improve the stability of the banking system, also lead to adverse incentives. The typical example is the governmental deposit insurance as described in Diamond and Dybvig (1983) that can lead to excessive risk-taking. Bouwman (2013) and Calomiris et al. (2014) show that banks have the incentive to underinvest in liquidity and rely on the interbank market. This makes further regulations and the use of banking licenses necessary. Demirgüc-Kunt et al. (2003) show a significant effect of banking regulation on the market concentration among banks in 72 countries. Berger and Hannan (1998) postulate that when the market discipline decreases, banks enjoy a quiet life and services become inefficient. In a summary paper, Degryse and Ongena (2008) identify a decrease in interest rates on sight deposits as the main effect of banks' market power. Furthermore, regulation is found to be a direct driver of concentration in banking. Drechsler et al. (2016)

show empirically that banks raise their spreads when Fed fund rates increase, as cash does not challenge banks' market power in as high interest rate environment. This establishes a potential link how monetary policy could affect the allocation within the credit system.

• *Balance Sheet Costs*: Besides the reduction in competition, Martin et al. (2013) propose that the regulations in banking create direct compliance costs and indirect costs stemming from capital and liquidity requirements as well as deposit insurance funding. An extension of banks' balance sheets thus increases their regulatory burden.

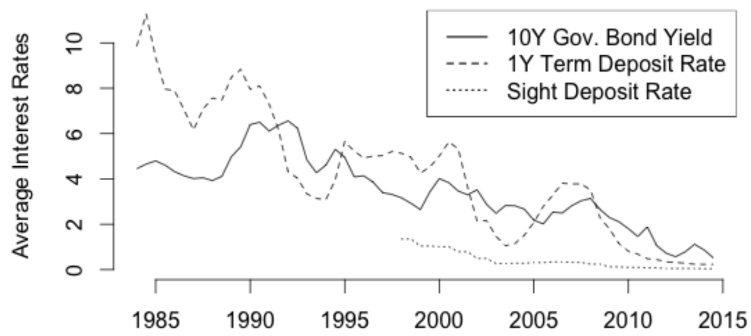

Figure 8: US Government Bond Yield and Average Deposit Rates (in %)

In the market for term deposits without maturity transformation, intermediaries face lower regulatory requirements. There is also a larger competitive pressure from non-bank institutions as well as securities markets, as Edwards and Mishkin (1995) point out. Consequently, term deposits must yield higher returns than sight deposits. This reflects in figure 8 showing US data on average sight and term deposit rates as well as government bond yields. It confirms that sight deposits yield significantly less return than one year term deposits. Average term deposit rates roughly track the government bond yield with a tendency of being higher during boom periods and lower during periods with slowing growth.

Other Credit Instruments: This thesis exclusively models bank deposits and cash to assess allocation mechanisms in the credit system. However, it can be argued that its findings hold generally for all types of debt-related products. In contrast to bank deposits, other debt instruments such as bonds or securitized debt obligations are traded on financial markets. Jacklin (1993) and von Thadden (1998, 1999) argue that the existence of a perfectly liquid and transaction cost-free secondary market would allow agents to replace sight deposits with investments and sell those when needed. Hellwig (1994) suggests that in reality, trading on those markets bears costs that limit its use for small deposits. In addition, more widely traded products also feature a liquidity premium in these markets. This shows that even though the financial system features a broad variety of debt-related assets, most fall within the range between sight and term deposits with respect to accessibility and return. In this range of products, sight deposits are arguably the most liquid and term deposits with fixed maturities are among the least liquid. Thus, the findings of this thesis should also hold more generally.

Default Risk: Throughout this thesis, debt contracts are assumed to be perfectly enforceable or that risk premiums reflect repayment probabilities and intermediaries perfectly pool these risks. These cases are identical if banks can assess agents' ability to walk away from obligations, since imposing fair risk premiums perfectly internalizes default risks. This is not the case under asymmetric information about the default risk of agents or deposit institutions. Then, the decision regarding the fixed commitment of funds for a longer period includes the inability to withdraw funds in the case that observable repayment probabilities worsen. This adds a dimension that is not captured in this model. Thus, it could be interesting to separate liquidity insurance objectives and long-term default risk aspects in an adjusted version of this model.

Inside Money: For simplicity, it is assumed that transactions are exclusively performed with cash. Fundamentally, this resembles a situation where banks have a 100% reserve requirement, since banks' ability to lend is clearly restricted compared to the real world. Only in the situation where n-type agents borrow, banks are able to go below that mark, since not all n-type agents withdraw the additionally created balances. However, allowing for the use of bank balances as means of payment would not affect the general purpose of this model that is tracking the allocation of funds by individuals. It would only change the channel through which money comes into the system and replace cash with bank balances. Interest rate levels would still be determined by discount rates and monetary policy. Still, modeling fractional reserve banking might be interesting when analyzing the factors affecting the size of the interest rate spreads, which falls outside the scope of this thesis.

4 Quantitative Analysis

The quantitative analysis of the model aims at identifying the country-specific effects on the deposit allocation from changing any of the exogenous parameters, the drivers of fluctuations in deposit data and the economic implications. For reasons of data availability and comparability, the period covered ranges from 1984 to 2006. The length of one model period is selected as one year. The parameters to be identified are the preference parameters (A, α, β), technology parameters (ϵ, n, μ) and the policy parameter (i). For simplicity, the functional forms are adopted from the analytical part so that $U(x) = Alog(x)$, $c(q) = q$ and $u(q) = \frac{q^{1-\alpha}}{1-\alpha}$ where $\alpha \in (0, 1)$. Following Kiyotaki and Wright (1993), the number of matches in the afternoon market is determined by $M(B, S) = BS/(B + S)$. In this model, the number of searching agents is given by the sum of buyers and n-type consumers $B = (1 - n) + n\epsilon$ and the number of selling agents $S = n(1 - \epsilon)$.[8] Maximizing $M(B, S)$ with respect to n implies:

$$n_{max} = \frac{1}{2(1-\epsilon)} \tag{60}$$

For $\epsilon \in [0, 0.5)$, the number of matches is maximized for a value of $0.5 < n_{max} \leq 1$, where the share of sellers reaches $n(1 - \epsilon) = 0.5$. The maximizing share of n-type agents is an increasing function of the consumption shock probability at noon. Respectively, increasing the exogenous variable n in the calibration leads to higher values for ϵ. Therefore, it represents a scenario with a higher consumption uncertainty.

[8]Implying a matching probability for sellers of $M(B, S)/S = 1 - n(1 - \epsilon)$.

4.1 Model Calibration: United States

The benchmark calibration of the model is based on quarterly data from the US for the period between the first quarter of 1984 and the last quarter of 2006.[9] The calibration targets for the US are shown in table 2. All data sources can be found in the appendix.

	Target Description	**Value**
A	Money Velocity	6.7472
α	Money Demand Elasticity	-0.3006 $(\sigma{=}0.038)$
ϵ	Ratio of Term Deposits in M3	0.2531
r	Real Interest Rate	0.0372
i	10Y-Government Bond Yield	0.0691
μ	Bank Interest Rate Spread	0.0403

Table 2: Calibration Targets for US Data 1984 – 2006

The parameters i, β and μ are set directly to match their targets. The nominal interest rate is set equal to the average 10-year government bond yield. According to the Fisher equation, the average real interest rate can be computed by dividing the average gross nominal interest rate by the average gross inflation rate measured by the change of the consumer price index $\frac{1+i}{1+\gamma} = 1 + r = \beta^{-1}$. The bank spread μ is set to banks' net interest margin measured by the standardized difference of average bank investment earnings (lending rates) and interest expenses (deposit rates).

The calibration of A, α and ϵ is based on the simultaneous matching of three targets by minimizing the sum of standardized squared errors between the calibration targets and the model generated values. The first two targets consist of the average velocity of money and the money demand elasticity with respect to the nominal interest rate level (obtained from a log-log specified OLS estimation). In the model, both depend on A, α and ϵ. The share of term deposits in M3 is the third target.[10] Its model equivalent is determined by α and ϵ.

[9] The Fed has discontinued data collection for M3 after 2006.

[10] Aggregate term deposit data also contains longer maturities. Thus, it does not perfectly represent 1-year term deposit behavior and adjusts slower.

The *baseline* calibration is run with $n = 0.55$, since (60) implies that the maximum number of matches for low values of ϵ is reached with a share of n-type agents slightly above a half. A robustness check is performed. The scenario *uncertainty* represents a more uncertain economic structure. It sets $n = 0.75$ so that a larger share of the population faces the uncertainty of a potential consumption opportunity. Table 3 lists the calibration results for the US.

	Baseline	Uncertainty
A	1.975	1.171
α	0.150	0.127
ϵ	0.097	0.104
$\hat{\mu}_L$	1.35 %	2.23 %
s_G	12.90%	11.52%
Δ_S	0.75 ‰	1.39 ‰
Δ_γ	6.21 ‰	7.24 ‰

Table 3: Calibration Results for US Data 1984 – 2006

The first three lines contain the internally calibrated parameter values. Whereas the increase of n-type agents affects the scaling factor A and risk aversion coefficient α negatively, the probability of the consumption shocks increases slightly. In the middle of the table, the critical value of the interest rate spread $\hat{\mu}_L$ is given, below which no term deposits would be made. The increase from 1.35% to 2.23% implies a larger willingness to pay for liquidity, when being in the *uncertainty* scenario. The share of the search goods market in total output (54) is given by s_G. The increase of n-type agents affects this ratio negatively.

The bottom part of the table contains information on the implied willingness to pay of agents with respect to factors of the monetary and financial framework. Δ_γ represents the share of total output that agents are willing to give up to be in equilibrium with nominal interest rates of 3% rather than 13%.[11] For the US, the cost of about ten percent

[11] This scenario and approach is adopted from Craig and Rocheteau (2008), finding for a LW-model without intermediation based on US data that the willingness to pay amounts to roughly 1.5% of total output.

inflation is found to be 0.62% of GDP. In this model, the return on unused money of n-type agents reduces the cost of inflation. At the same time, the consumption uncertainty induces additional frictions. These arise from the trade-off between the liquidity constraint in case of a consumption shock and the opportunity cost of liquidity holdings from not investing in term deposits. In the presence of sight deposits, this opportunity cost decreases, but it does not disappear due to the bank cost spread. When the probability of consumption shock ϵ increases, there are more constraint n-type consumers suffering from insufficient liquidity holdings. The higher value for Δ_γ in the *uncertainty* scenario with a larger consumption shock probability backs this statement.

By (22) the existence of sight deposits does not affect quantities traded by buyers. However, for n-type agents bringing liquidity into the afternoon market becomes less costly. The willingness to pay for the existence of sight deposits Δ_S thus represents the benefits from increased search good consumption of the small group of n-type consumer compared to a situation with prohibitively high spreads. This variable captures the benefit from optimal liquidity insurance offered by sight deposits. Other potential benefits of sight deposits such as transaction services are not included in this measure. While the *baseline* calibration leads to a value of about 0.8‰ of GDP, the increase of depositing n-type agents in *uncertainty* gives a higher value of nearly 1.4‰ of GDP.

Figures 9 and 10 show comparative statics for the model calibrated to US data with respect to the monetary policy parameter γ and the bank spread μ. As seen above, at the Friedman rule there would be no financial sector, since bringing money is costless. For low nominal interest rates, term deposits increase in the inflation rate above 30% of M3. When sight deposits have positive returns at $i > \mu$, the deposit ratios react significantly less to the inflation rate. The drop in the share of term deposits is due to the sudden increase of M3 when n-type agents put all cash holdings into sight deposits. In this area, monetary policy has no strong effect on the deposit allocation. A one percentage point increase in the nominal interest rate leads to a reduction in the share of term deposits of 0.17 percentage points. In the *uncertainty* scenario this reduction increases to 0.32 percentage points. Undoubtedly, when there are more n-type agents, the number of deposits increases accordingly so that the share of sight deposits in M3 is higher. Term deposit shares are similar in both scenarios, as it is a calibration target.

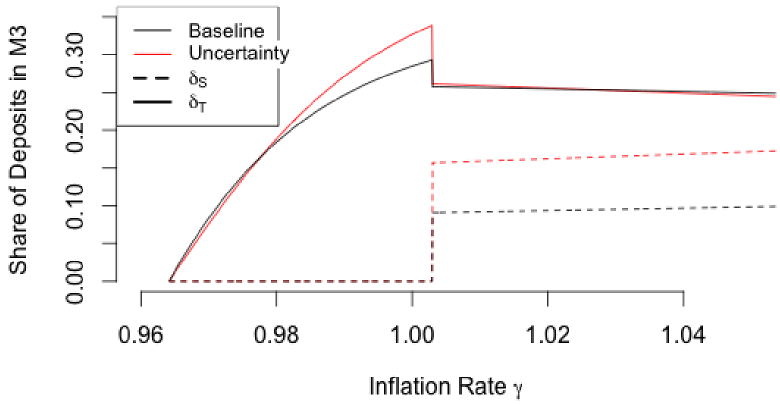

Figure 9: Share of Deposits in M3 vs. Inflation Rate, US Data

Banks' interest rate spreads on sight deposits have a strong impact on the US deposit allocation. At very high spreads $\mu > i$, sight deposits would not have positive returns so that only cash and term deposits would be held. Below that threshold, agents make sight and term deposits. Since higher spreads make sight deposits less attractive, the share falls whereas the term deposit share increases in μ. When sight deposits feature spreads that are lower than $\hat{\mu}_L$, term deposits would not be made. The critical value clearly depends on the economic structure underlying this model. The scenario *uncertainty* with more n-type agents leads to a higher cut-off value of 2.23% than the baseline calibration (1.35%), implying that agents accept higher spreads in the face of more uncertainty. For even lower spreads the opportunity cost from excess borrowing is relatively low, as only the spread needs to be paid if not using the loan. One could expect strong increases in the borrowing from banks in that area.

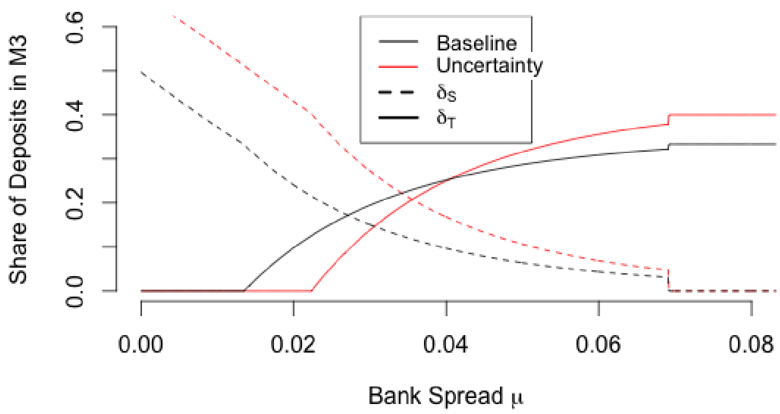

Figure 10: Share of Deposits in M3 vs. Bank Rate Spread, US Data

It is likely that there are other factors determining the share of term deposits in the data. This raises the question: how accurately can this model simulate deposit allocations? Figure 11 shows the attempt of tracking the US data of δ_T over time with the baseline calibration of this model. The quarterly time series of the nominal interest rates and the interest rate spreads are used to simulate the model. Average money velocity and money demand elasticity are held constant.

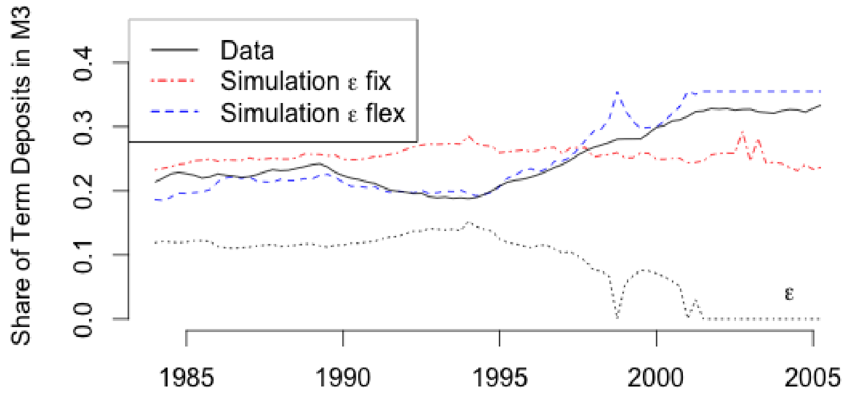

Figure 11: Term Deposit in M3, US Data and Simulation Results

The red line depicts the model's output for a fixed value of the consumption shock probability ϵ. It manages to track the data on average, but does a poor job in tracking its movements. With a floating ϵ, the model tracks the data much better, as can be seen by the blue line. The dotted line at the bottom of the plot shows the implied probability for a consumption shock ϵ after balancing its effect on average money demand and its elasticity. It is evident that most of the variation in the share of term deposits seems to be captured by changes in this probability, which has been stable until the mid 90s. After 2002, the data implies that the probability of a consumption shock dropped to zero, in which case this model collapses to the model of Berentsen et al. (2007). Fundamental changes must have occurred during this time. When comparing the standard deviations of GDP growth rates for the periods 1984-2001 and 2001-2006, there is a significant drop from around 0.55% to about 0.4%. This reduction in aggregate uncertainty could explain why the implied values for ϵ dropped. The stable development of the US economy even after the burst of the tech-bubble may have made consumption plans more predictable.

4.2 Robustness Check: Australia and Switzerland

Australia and Switzerland are chosen to recalibrate the model because these countries have different economic structures. Both countries also have detailed and methodologically consistent data material available.

	Target Description	**Australia**	**Switzerland**	**US**
A	Money Velocity	7.2492	2.5627	6.7472
α	Money Demand Elasticity	-0.6158 (σ=0.0553)	-0.3711 (σ=0.0275)	-0.3006 (σ=0.038)
ϵ	Term Deposits/M3	0.3116	0.2234	0.2531
r	Real Interest Rate	0.0493	0.0220	0.0372
i	10Y-Gov. Bond Yield	0.0860	0.0406	0.0691
μ	Bank Interest Rate Spread	0.0321	0.0203	0.0403

Table 4: Calibration Targets for Australian and Swiss Data 1984 - 2006
Additionally: US Data 1984 - 2006 from table 2 for comparability.

Table 4 shows the calibration targets. Swiss data features a relatively low money velocity. This implies lower values for α and A than in the other two countries. The lower money velocity in Switzerland could stem from its historically low average inflation rate. The share of term deposits in M3 δ_T is similar in Switzerland and the US. It is considerably higher in Australia that also has the highest inflation and nominal interest rates. Switzerland has the lowest nominal interest rate and average bank spread of 2%, followed by Australia with 3.2% and the US with 4%.

The calibration results for the *baseline* and *uncertainty* scenarios are shown in table 5. The lower money velocity in Switzerland implies a larger share of the search goods market in total output s_G. This makes inflation more costly compared to Australia and the US, as a larger share of total output is traded in the decentralized cash-requiring afternoon market. Furthermore, the calibrated probability of a consumption shock is approximately twice as high in Switzerland than in Australia or the US. Consequently, the willingness to pay for the existence of sight deposits Δ_S is higher too. The fact that Swiss sight deposits come with a lower cost spread adds to the value of its existence.

	Australia		**Switzerland**	
	Baseline	Uncertainty	Baseline	Uncertainty
A	1.278	0.603	0.517	0.532
α	0.095	0.066	0.039	0.042
ϵ	0.086	0.133	0.239	0.190
$\hat{\mu}_L$	0.75 %	1.48 %	0.84 %	1.29 %
s_G	12.94%	10.88%	25.00%	16.51%
Δ_S	0.41 ‰	1.10 ‰	1.45 ‰	1.70 ‰
Δ_γ	9.37 ‰	11.93‰	17.73‰	12.40‰

s_G is the share of the search goods market in total output. Δ_S represent the share of total consumption that agents are willing to give up for the access to sight deposits. Δ_γ represents the share of total consumption that agents are willing to give up to be in an equilibrium with nominal interest rates of 3% rather than 13%.

Table 5: Calibration Results for Australian and Swiss Data 1984 – 2006

In Australia, the impact of monetary policy in the presence of sight deposits is smaller than in Switzerland or the US. A one percentage point increase in Australian nominal interest rates results in a reduction in the term deposit share of 0.10 (*uncertainty*: 0.26) percentage points. In

Switzerland, the term deposit share decreases by 0.22 (0.39) percentage points. Figures 12 and 14 show the model fit to Australian and Swiss term deposits data over time. As above, the red line represents the simulation with a fixed value for ϵ and the blue line represents the simulation with a flexible ϵ. For both countries, the model with a fixed consumption shock probability matches the data only on average. Letting ϵ adjust allows for a better track of the data. This further indicates that fluctuation in the relative bank spread by itself is not the main driver of term deposit shares in M3. Instead, changes in the probability of a consumption shock account for most dynamics in the term deposit data.

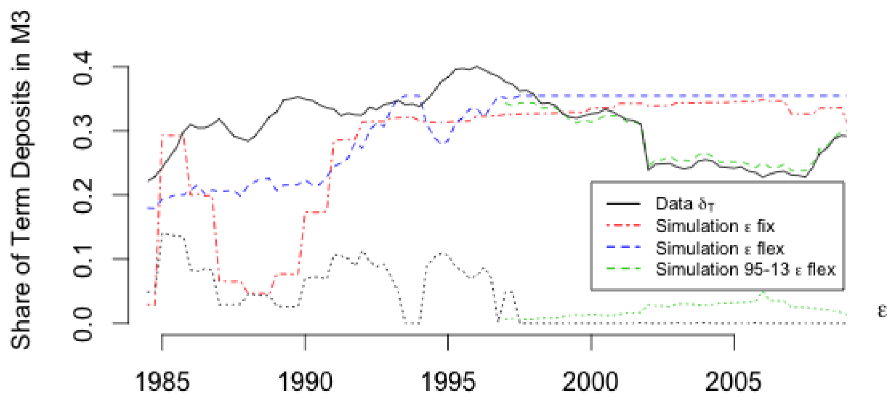

Figure 12: Term Deposit in M3, Australian Data and Simulation Results

The Australian simulation tracks the general behavior of term deposits up to 1998. Afterwards, the implied value for a consumption shock ϵ drops to zero. In Australia, the standard deviation of GDP growth rates from 1984-1998 was around 1.2%. However during 1998-2008, this value dropped to approximately 0.7%. As in the US, the decrease in output volatility coincides with the drop in ϵ to zero. However, there was another significant break around that time. The Australian central bank switched to an inflation targeting policy, inducing a monetary response to changes in the output growth. Thus, the calibration may not apply to the second half of the period, as the monetary regime began to respond to changes in aggregate uncertainty. When recalibrating the model for the period 1995-2013, the model with flexible ϵ is able to track the data well.

In the period until 1998, the model allows for interesting findings. The simulated aggregate consumption uncertainties match the volatility of Australian output growth surprisingly well. Notably, the output data has only been used to compute average money velocity and money demand elasticity, but has not been included as a time series. Data on term deposits seem to contain information on output growth volatility. The black line in figure 13 represents the moving 5-year standard deviation of GDP growth rates (right axis). The model-simulated values for the consumption shock probability ϵ are plotted in blue as the dotted line. It tracks the GDP growth volatility very well, but it breaks down around 1998. Even when recalibrating the period 1995-2013, the implied values for ϵ do not match the output growth volatility anymore. This suggests that the switch to an inflation targeting regime and potentially the strong increase in Australian external trade might have eliminated the nexus between GDP growth volatility and term deposits.

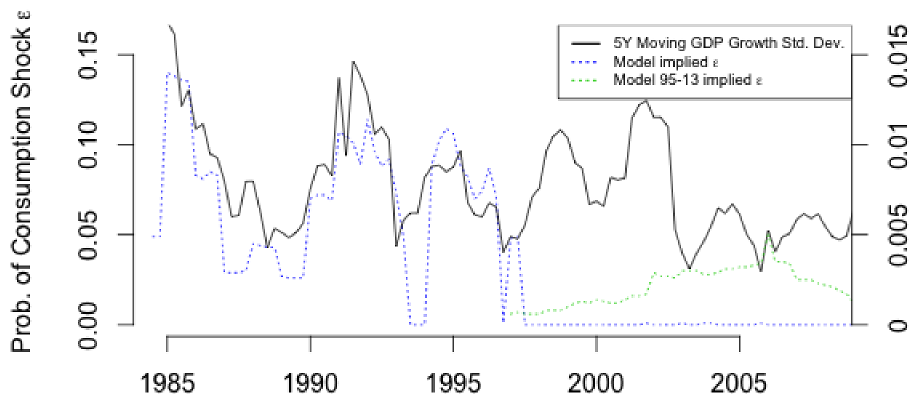

Figure 13: Model Implied Uncertainty and GDP Volatility in Australia

In comparison to the Australian and the US figures, the Swiss data on term deposit shares in M3 contains more volatility. Consequently, the simulations lead to jagged lines. Again, the floating ϵ allows for a better fit. In comparison to the Australian and US simulations, the Swiss simulation leads to implied values of ϵ that fluctuate strongly between zero and 0.5 (right axis). Particular fluctuations come from the relatively low bank spreads, as evidenced in the unsteady simulation with fixed values. Interestingly, the phenomenon of a break down of the model in the new millennium does not occur. The lack of any structural break in the output growth fluctuations in the Swiss data over the period 1984-2008 may provide an explanation for this difference. For any split of the series between the years 1990 and 2005, the difference in standard deviations is essentially zero. It lies at approximately 0.7%. Another conclusion drawn from these findings is deposit allocation in Switzerland seems to be greatly affected by external factors not directly related to domestic circumstances. This is a reasonable hypothesis, as Switzerland is a small and open economy with relatively large financial cross-border flows.

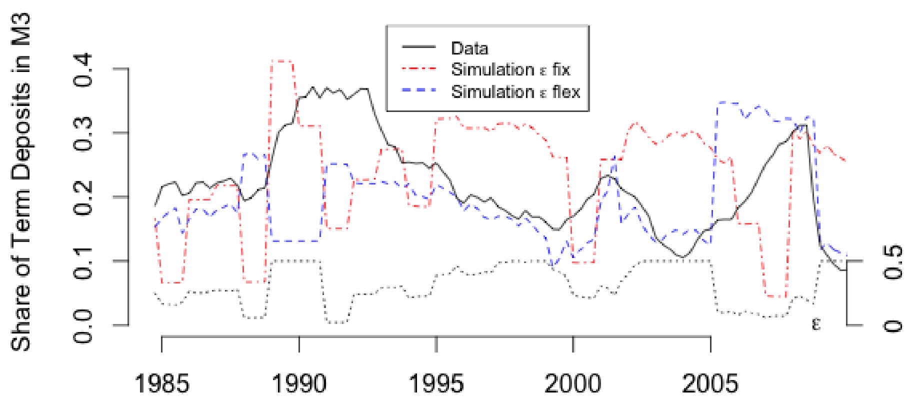

Figure 14: Term Deposit in M3, Swiss Data and Simulation Results

Interestingly, the Swiss values for the critical spread $\hat{\mu}_L$ below which no term deposits are made, are in the area of nominal interest rates after 2008 – somewhere around one percent. The recent drop in the Swiss data for term deposits in M3 to less than ten percent can be attributed at least partially to a domination of term deposits. The monetary expansion certainly contributed to this as well, but term deposits have even decreased in absolute terms. The explanation using this model is that the additional return from holding fixed term deposits has not been worth the associated liquidity risk anymore and people switched to sight deposits.

5 Concluding Remarks

This thesis sought to analyze the mechanism of funds allocation within the credit system. A New Monetarist approach has been adopted, allowing monetary variables to be tracked analytically. Fundamentally based on Lagos and Wright (2005) as well as Berentsen et al. (2007), a suitable model was derived. The model introduced consumption uncertainty in combination with sight and term deposits, which allowed modeling the endogenous allocation process of funds in an economy.

The model established that consumption uncertainty and agents' risk aversion are essential determinants in the allocation process. However, the central parameter is the interest rate spread between the uniform lending rate and the interest rate on sight deposits – the opportunity cost of liquidity. It is capped at 100% of the nominal lending rate, since cash replaces sight deposits if those come with negative returns. In the case that cash dominates sight deposits, the return difference of (term) depositing and (cash) liquidity is exclusively driven by the monetary policy. However, sight deposits yielding positive returns represent an optimal instrument to carry liquidity without facing the full effect of inflation. Any reduction of this spread thus improves welfare. In the presence of sight deposits, it was shown that the impact of monetary policy on deposit allocation is relatively small, since the yield difference of deposits remains constant in absolute terms. Only large changes in the nominal interest rate affect the relative spread in a significant way.

The first best policy in this model is the Friedman rule, as zero nominal interest rates make carrying cash balances costless. This allows agents to carry sufficient amounts in order to trade the socially optimal search good quantities. Consequently, there is no function for financial intermediation in this equilibrium. Away from the Friedman rule, there are equilibria with cash and term deposits or sight and term deposits. The model showed that there are also equilibria in which agents only hold sight deposits. When agents are relatively risk averse, probabilities for a consumption shock are large or interest rate spreads are relatively small, lending agents engage in precautionary borrowing from banks. This process can be described as liquidity insurance. Banks pool parts of uncertain agents' liquidity at a certain cost and redistribute liquidity to those agents that receive a consumption shock at noon. In these equilibria, term deposits have no function, except for a technical role in this specific model.

Calibrating this model to Australia, Switzerland and the United States evidenced that most of the fluctuation on term deposit allocation between 1984 and 2006 was a result of changes in the level of uncertainty. This uncertainty seems to have been reduced around 2000. The simulation for Australia and the US implied very low consumption shock probabilities, even when recalibrating the model to the second half of the time period. This coincides with a fall in output volatility. For Australia, the uncertainty level correlates with the output growth volatility for the first 15 years of the data. It is possible that as central bank policy started to respond to such volatilities, it eliminated the nexus of output volatility and deposit allocation. The simulation over Swiss data implied a wild fluctuation in the consumption uncertainty for the whole period. These fluctuations could be caused by relatively large financial streams from abroad that are largely determined by foreign events.

This thesis contributes to the better understanding of the structural composition of financial flows in the credit markets. The points addressed in the discussion section contain ideas for further research, which could draw on the findings of this thesis. The interest rate spreads of liquid assets are of central importance for the allocation of funds in the credit system. Establishing the determinants are thus of great interest. Further areas of study could be taken to determine how this spread could be affected as a potential policy tool. The separation of risk and liquidity objectives in the allocation process in credit markets is an equally interesting area. A better insight into these issues may assist financial firms to provide a more customized service. The better knowledge about policy impacts and regulatory needs will benefit public bodies, leading to overall improvements of the financial system.

A Appendices

A.1 Data Sources

Country	Description	Identifier	Period	Frequency
AUS[1]	10Y Gov. Bond Yield	IRLTLT01AUQ156N	84:Q1-13:Q1	quarterly
AUS[1]	Gross Domestic Product	AUSGDPNQDSMEI	84:Q1-13:Q1	quarterly
AUS[1]	Consumer Price Index	AUSCPIALLQINMEI	84:Q1-13:Q1	quarterly
AUS[1]	M1	MANMM101AUQ189S	84:Q1-13:Q1	quarterly
AUS[2]	Term Deposits	DMAODTEC	84:Q1-13:Q1	quarterly
AUS[2]	M3	DMAM3N	84:Q1-13:Q1	quarterly
AUS[3]	Interest Rate Spread	FR.INR.LNDP	84:Q1-13:Q1	quarterly
CH[1]	10Y Gov. Bond Yield	IRLTLT01CHM156N	84:Q1-13:Q1	quarterly
CH[1]	Gross Domestic Product	CHEGDPNQDSMEI	84:Q1-13:Q1	quarterly
CH[1]	Consumer Price Index	CHECPIALLQINMEI	84:Q1-13:Q1	quarterly
CH[1]	M1	MANMM101CHM189S	84:Q1-13:Q1	quarterly
CH[4]	Time Deposits	snbmonagg{B,T}	84:Q1-13:Q1	quarterly
CH[4]	M3	snbmonagg{B,GM3}	84:Q1-13:Q1	quarterly
CH[3]	Interest Rate Spread	FR.INR.LNDP	84:Q1-13:Q1	quarterly
US[1]	10Y Gov. Bond Yield	IRLTLT01USQ156N	84:Q1-06:Q4	quarterly
US[1]	Gross Domestic Product	GDP	84:Q1-06:Q4	quarterly
US[1]	Consumer Price Index	CPIAUCSL	84:Q1-06:Q4	quarterly
US[1]	M1 Retail Swipe Adj.	M1ADJ	84:Q1-06:Q4	quarterly
US[1]	M2	M2	84:Q1-06:Q4	quarterly
US[1]	M3=M2+Term Deposits	M3	84:Q1-06:Q4	quarterly
US[1]	Bank Net Int. Margin	USNIM	84:Q1-06:Q4	quarterly
US[5]	1Y Term Deposit Rate	1-year CD yield	84:Q1-14:Q4	quarterly
US[5]	Sight Deposit Rate	Checking Accounts	98:Q1-14:Q4	quarterly

1) St. Louis FRED Database
2) Reserve Bank of Australia
3) The World Bank
4) Swiss National Bank
5) Bankrate.com

Table 6: Data Sources

A.2 Illustration of Intertemporal Clearing

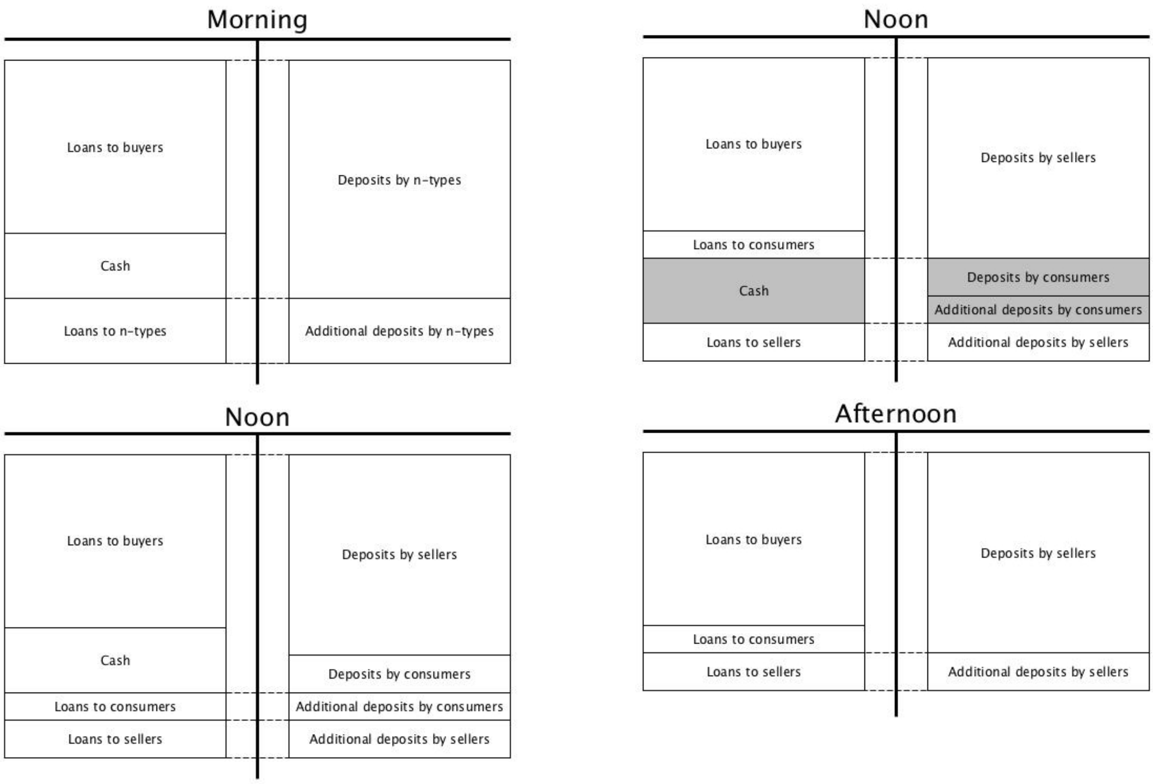

Figure 15: Bank Balance Sheet for n-Type Borrowing

Figure 15 shows an alternative explanation for the phenomenon of precautionary borrowing by n-type agents as shown in figure 5. It depicts the structure of the balance sheet of a sight deposit providing bank. Banks extend their balance sheet in the morning, allowing n-type agents to borrow additional balances. Banks keep enough deposits as cash reserves to pay out the original plus the additional deposits of shocked n-type agents at noon. Thereby they use some of the sellers' deposits to pay out n-type consumers additional loans. Those n-type agents that turn out to be sellers do not withdraw their money so that the additional deposits of sellers are carried until the night market, where sellers only pay the spread between borrowing and lending rates. This proofs that buyers and term deposits only play a technical role in the mechanism of precautionary borrowing in this model.

A.3 Proofs and Derivations

Derivation of Marginal value of money holdings (28)

The first differentiation of (10) with respect to money holdings is:

$V'(m) = n\epsilon[u'(q_c)\frac{\partial q_c}{\partial m} + \phi(1 - \frac{\partial d_T}{\partial m} - p\frac{\partial q_c}{\partial m}) + \phi(1+i)\frac{\partial d_T}{\partial m}] + n(1-\epsilon)[-c'(q_s)\frac{\partial q_s}{\partial m} + \phi(1 - \frac{\partial d_T}{\partial m} - \frac{\partial d_S}{\partial m} + p\frac{\partial q_s}{\partial m}) + \phi(1+i)\frac{\partial d_T}{\partial m} + \phi(1+\mathbf{I}_S(i-\mu))\frac{\partial d_S}{\partial m}] + (1-n)[u'(q_b)\frac{\partial q_b}{\partial m} + \phi(1 + \frac{\partial l}{\partial m} - p\frac{\partial q_b}{\partial m}) - \phi(1+i)\frac{\partial l}{\partial m}]$

It generally holds that $\frac{\partial q_s}{\partial m} = 0$. For i>0, the buyers' and consumers' budget constraint are binding so that: $\frac{\partial d_T}{\partial m} + p\frac{\partial q_c}{\partial m} = 1$ and $1 + \frac{\partial l}{\partial m} = p\frac{\partial q_b}{\partial m}$. Therefore:

$V'(m) = n\epsilon[u'(q_c)\frac{\partial q_c}{\partial m} + \phi(1+i)\frac{\partial d_T}{\partial m}] + n(1-\epsilon)[\phi(1 - \frac{\partial d_T}{\partial m} - \frac{\partial d_S}{\partial m}) + \phi(1+i)\frac{\partial d_T}{\partial m} + \phi(1+\mathbf{I}_S(i-\mu))\frac{\partial d_S}{\partial m}] + (1-n)[u'(q_b)\frac{\partial q_b}{\partial m} - \phi(1+i)\frac{\partial l}{\partial m}]$

By substituting $\frac{\partial l}{\partial m}$ and $\frac{\partial d_T}{\partial m}$, one gets to:

$V'(m) = n\epsilon[(u'(q_c) - p\phi(1+i))\frac{\partial q_c}{\partial m} + \phi(1+i)] + n(1-\epsilon)[\phi(1 - \frac{\partial d_T}{\partial m} - \frac{\partial d_S}{\partial m}) + \phi(1+i)\frac{\partial d_T}{\partial m} + \phi(1+\mathbf{I}_S(i-\mu))\frac{\partial d_S}{\partial m}] + (1-n)[(u'(q_b) - p\phi(1+i))\frac{\partial q_b}{\partial m} + \phi(1+i)]$

Applying (22) reduces this expression to:

$V'(m) = n\epsilon[(u'(q_c) - p\phi(1+i))\frac{\partial q_c}{\partial m} + \phi(1+i)] + n(1-\epsilon)[\phi(1 - \frac{\partial d_T}{\partial m} - \frac{\partial d_S}{\partial m}) + \phi(1+i)\frac{\partial d_T}{\partial m} + \phi(1+\mathbf{I}_S(i-\mu))\frac{\partial d_S}{\partial m}] + (1-n)[\frac{u'(q_b)}{p}]$

For $i - \mu > 0$, it holds that $\frac{\partial d_S}{\partial m} + \frac{\partial d_T}{\partial m} = 1$. As a consequence, the expression becomes:

$V'(m) = n\epsilon[(u'(q_c) - p\phi(1+i))\frac{\partial q_c}{\partial m} + \phi(1+i)] + n(1-\epsilon)[\phi(1+i-\mu) + \phi\mu\frac{\partial d_T}{\partial m}] + (1-n)[\frac{u'(q_b)}{p}]$

Replacing $\frac{\partial d_T}{\partial m}$ and rewriting gives:

$V'(m) = n\phi(1+i) + (n[\epsilon u'(q_c) - \epsilon p\phi(1+i) - (1-\epsilon)p\phi\mu]\frac{\partial q_c}{\partial m} + (1-n)[\frac{u'(q_b)}{p}]$

Applying (23) reduces this expression to

$$V'(m) = n\phi(1+i) + (1-n)\frac{u'(q_b)}{p} \qquad (61)$$

It can be shown that the same result arises for $i - \mu < 0$. As the index function becomes zero, the expression is:

$V'(m) = n\epsilon[(u'(q_c)-p\phi(1+i))\frac{\partial q_c}{\partial m}+\phi(1+i)]+n(1-\epsilon)[\phi+\phi i\frac{\partial d_T}{\partial m}]+(1-n)[\frac{u'(q_b)}{p}]$

Substituting $\frac{\partial d_T}{\partial m}$ leads to:

$V'(m) = n[\phi(1+i)] + n[\epsilon(u'(q_c) - \epsilon p\phi(1+i) - (1-\epsilon)p\phi i]\frac{\partial q_c}{\partial m} + (1-n)[\frac{u'(q_b)}{p}]$

Applying (23) for $i - \mu < 0$ reduces this expression and it becomes the same as (61).

Using (23) to replace $\phi(1+i)$ in (61) gives the expression for the marginal expected value of money holdings at the beginning of the morning market.

$V'(m) = n[\epsilon\frac{u'(q_c)}{p} + (1-\epsilon)\phi(1+\mathbf{I}_S(i-\mu))] + (1-n)[\frac{u'(q_b)}{p}]$

Rewriting gives (27).

Derivation of the Search Good Quantities (33) – (38)

The search good quantities are given by combining the agents' consumption plans (22) and (23), the goods market clearing condition (24) and the Fisher equation (29).

- Case (i) and (ii): $0 \le i \le \mu$

$\frac{u'(q_b)}{c'(q_s)} = 1+i \Rightarrow \frac{1}{q_b^\alpha} = \frac{\beta}{\gamma} \Rightarrow q_b = \left(\frac{\gamma}{\beta}\right)^{\frac{1}{\alpha}}$

$\frac{u'(q_c)}{c'(q_s)} = 1+\frac{i}{\epsilon} - \mathbf{I}_S\left(\frac{1-\epsilon}{\epsilon}\right)(i-\mu) \Rightarrow \frac{1}{q_c^\alpha} = 1+\frac{\gamma}{\beta\epsilon} - \frac{1}{\epsilon} \Rightarrow q_c = \left[\frac{\beta\epsilon}{\gamma-\beta(1-\epsilon)}\right]^{\frac{1}{\alpha}}$

$n(1-\epsilon)q_s = (1-n)q_b+n\epsilon q_c \Rightarrow q_s = \frac{(1-n)q_b+n\epsilon q_c}{n(1-\epsilon)} \Rightarrow q_s = \frac{(1-n)\left(\frac{\gamma}{\beta}\right)^{\frac{1}{\alpha}}+n\epsilon\left[\frac{\beta\epsilon}{\gamma-\beta(1-\epsilon)}\right]^{\frac{1}{\alpha}}}{n(1-\epsilon)}$

- Case (iii): $0 < mu < i$

$\frac{u'(q_b)}{c'(q_s)} = 1+i \Rightarrow \frac{1}{q_b^\alpha} = \frac{\beta}{\gamma} \Rightarrow q_b = \left(\frac{\gamma}{\beta}\right)^{\frac{1}{\alpha}}$

$\frac{u'(q_c)}{c'(q_s)} = 1+\frac{i}{\epsilon} - \mathbf{I}_S\left(\frac{1-\epsilon}{\epsilon}\right)(i-\mu) \Rightarrow \frac{1}{q_c^\alpha} = \frac{\gamma}{\beta} + \left(\frac{1-\epsilon}{\epsilon}\right)\mu \Rightarrow q_c = \left[\frac{1}{\frac{\gamma}{\beta}+\left(\frac{1-\epsilon}{\epsilon}\right)\mu}\right]^{\frac{1}{\alpha}}$

$n(1-\epsilon)q_s = (1-n)q_b+n\epsilon q_c \Rightarrow q_s = \frac{(1-n)q_b+n\epsilon q_c}{n(1-\epsilon)} \Rightarrow q_s = \frac{(1-n)\left(\frac{\gamma}{\beta}\right)^{\frac{1}{\alpha}}+n\epsilon\left[\frac{1}{\frac{\gamma}{\beta}+\left(\frac{1-\epsilon}{\epsilon}\right)\mu}\right]^{\frac{1}{\alpha}}}{n(1-\epsilon)}$

Proof of Proposition 2

• $\hat{\mu}_L$: Setting $d_{T,i>\mu}$ in equation (44) to zero and solving for μ

$d_{T,i>\mu} = M_{-1}\frac{(1-n)q_b-(1-n\epsilon)q_c}{(1-n)q_b+n\epsilon q_c} = 0 \Rightarrow (1-n)q_b - (1-n\epsilon)q_c = 0$

Plugging in the search good quantities (36) and (37) gives:

$(1-n)\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}} = (1-n\epsilon)\left[\frac{\beta\epsilon}{\epsilon\gamma+\mu\beta(1-\epsilon)}\right]^{\frac{1}{\alpha}} \Rightarrow \left(\frac{1-n\epsilon}{1-n}\right)^{\alpha} = \frac{\epsilon\gamma+\mu\beta(1-\epsilon)}{\epsilon\gamma}$

$\Rightarrow \hat{\mu}_L = \frac{\epsilon\gamma\left[\left(\frac{1-n\epsilon}{1-n}\right)^{\alpha}-1\right]}{\beta(1-\epsilon)} \geq 0$, since $\left[\frac{(1-n\epsilon)}{1-n}\right]^{\alpha} \leq 1$ for $\alpha \in (0,1)$ and $\epsilon > 0$

• $\hat{\alpha}$: Setting $d_{T,i>\mu}$ in equation (44) to zero and solving for α

$(1-n)\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}} = (1-n\epsilon)\left[\frac{\beta\epsilon}{\epsilon\gamma+\mu\beta(1-\epsilon)}\right]^{\frac{1}{\alpha}} \Rightarrow \left(\frac{1-n\epsilon}{1-n}\right)^{\alpha} = \frac{\epsilon\gamma+\mu\beta(1-\epsilon)}{\epsilon\gamma}$

$\Rightarrow \hat{\alpha} = \frac{ln\left[\frac{\epsilon\gamma+\mu\beta(1-\epsilon)}{\epsilon\gamma}\right]}{ln\left(\frac{1-n\epsilon}{1-n}\right)} \geq 0$, since $ln\left(\frac{1-n\epsilon}{1-n}\right) > 0$ for $\epsilon > 0$
and $ln\left[\frac{\epsilon\gamma+\mu\beta(1-\epsilon)}{\epsilon\gamma}\right] \geq 0$

• $\hat{\epsilon}$: It is not possible to solve explicitly for $\hat{\epsilon} \in [0, 0.5)$. But it is possible to set $d_{T,i>\mu}$ in equation (44) to zero and show that there exist positive values of ϵ fulfilling this equation:

$(1-n)\left(\frac{\beta}{\gamma}\right)^{\frac{1}{\alpha}} = (1-n\epsilon)\left[\frac{\beta\epsilon}{\epsilon\gamma+\mu\beta(1-\epsilon)}\right]^{\frac{1}{\alpha}} \Rightarrow \left(\frac{1-n\epsilon}{1-n}\right)^{\alpha} = \frac{\epsilon\gamma+\mu\beta(1-\epsilon)}{\epsilon\gamma} = 1+\frac{\mu\beta}{\gamma}\left(\frac{1-\epsilon}{\epsilon}\right)$

$$\Rightarrow \frac{\epsilon}{1-\epsilon}\left[\left(\frac{1-n\epsilon}{1-n}\right)^{\alpha}-1\right] = \frac{\mu\beta}{\gamma}$$

The right hand side of this equation is constant and positive: $0 < \frac{\mu\beta}{\gamma} < 1$

The left hand side of this equation has the following limits:

$\lim_{\epsilon\to 0}\frac{\epsilon}{1-\epsilon}\left[\left(\frac{1-n\epsilon}{1-n}\right)^{\alpha}-1\right] = 0$

$\lim_{\epsilon\to 1}\frac{\epsilon}{1-\epsilon}\left[\left(\frac{1-n\epsilon}{1-n}\right)^{\alpha}-1\right] = \frac{\alpha n}{1-n}$

This shows that $\hat{\epsilon} \in [0, 0.5)$, but only if $\frac{\mu\beta}{\gamma} < \frac{\alpha n}{1-n}$.

• $\hat{\mu}_H = \frac{\gamma}{\beta} - 1$ is given by the definition that sight deposits are not used when yielding negative returns, which triggers the indicator function $\mathbf{I}_S$.

Derivation of Night Market Hours Worked (62)**,** (63) **and** (64)

Buyers work the amount of hours required to produce the optimal amount of the general good consumption for themselves x^*, to recover the real balances used to purchase the search good and to fulfill interest payments on their loans.

$$h_b = x^* + c'(q_s)q_b + \phi il \tag{62}$$

Consumers work the amount of hours required to produce the optimal amount of the general good consumption for themselves x^* and to recover the real balances spent on the search good in the afternoon. As they receive interest payments on their term deposits, their hours worked are reduced equivalently.

$$h_c = x^* + c'(q_s)q_c - \phi id_T \tag{63}$$

Sellers use the interest payments on their sight and term deposits as well as the real balances acquired from selling the search good in the afternoon market to purchase the general good from other agents. The hours worked by sellers are determined by the difference between the optimal amount of general good consumption x^* and the amount of general goods purchased from other agents.

$$h_s = x^* - c'(q_s)q_s - \phi id_T - \phi(i-\mu)d_S \tag{64}$$

In order to make sure that the equilibrium exists, $U(x)$ needs to be scaled according to $U'^{-1}(1) = x^* \geq c'(q_s)q_s + \phi id_T + \phi(i-\mu)d_S$, so that sellers would not work negative hours $h_s \geq 0$.

Starting off from (3) rewriting gives:

$$h_\chi = x^* + \phi(m_{+1} - \tau M_{-1} - m - (1+i)d_T - (1 + \mathbf{I}_S(i-\mu))d_S + (1+i)l$$

Plugging in (51) leads to:

$$h_\chi = x^* + \phi(M_{-1} - m - (1+i)d_T - (1 + \mathbf{I}_S(i-\mu))d_S + (1+i)l$$

In the next step, variables are set zero where this is the case. This allows analyzing the equation for each type of agent for $i > 0$.

Buyer: $h_b = x^* + \phi(M_{-1} + (1+i)l)$
Buyers' budget constraint (31) can be rewritten as $c'(q_s)q_b = \phi(M_{-1} + l)$ and plugged in, so that (62) arises.

Consumers: $h_c = x^* + \phi(M_{-1} - (1+i)d_T)$
Consumers' budget constraint (30) can be rewritten as $c'(q_s)q_c = \phi(M_{-1} - d_T)$ and plugged in so that (63) arises.

Sellers: $h_s = x^* + \phi(M_{-1} - pq_s - (1 - \mathbf{I}_S)(M_{-1} - d_T) - (1+i)d_T - (1 + \mathbf{I}_S(i - \mu))d_S$
Depending on whether $i - \mu$ is positive or not, it is either the case that the sellers' deposit constraint (32) holds so that $M_{-1} = d_T + d_S$ or that no money is invested in bank deposits so that $d_S = 0$ and thus $M_{-1} - d_T > 0$. In both cases, the final equation (64) arises.

Derivation Money Demand Functions (58) **and** (59) **and Money Demand Elasticites**

- Case (i) and (ii): $0 \le i \le \mu$

Applying $d_S = 0$ and the prices (39) and (42) to (57)

$$L = \frac{M_{-1}}{\frac{M_{-1}}{(1-n)q_b + nq_c}[(1-n)q_b + n\epsilon q_c] + \frac{M_{-1}}{(1-n)q_b + nq_c}A} = \frac{(1-n)q_b + nq_c}{(1-n)q_b + n\epsilon q_c + A}$$

The elasticity is given by $\xi_L = \frac{\partial L}{\partial i}\frac{i}{L}$, where:

$$\frac{\partial L}{\partial i} = \frac{[(1-n)\frac{\partial q_b}{\partial i} + n\frac{\partial q_c}{\partial i}][(1-n)q_b + n\epsilon q_c + A] - [(1-n)\frac{\partial q_b}{\partial i} + n\epsilon\frac{\partial q_c}{\partial i}][(1-n)q_b + nq_c]}{[(1-n)q_b + n\epsilon q_c + A]^2}$$

This reduces to:

$$\frac{\partial L}{\partial i} = \frac{(1-n)\frac{\partial q_b}{\partial i}[A - n(1-\epsilon)q_c] + n\frac{\partial q_c}{\partial i}[A + (1-n)(1-\epsilon)q_b]}{[(1-n)q_b + n\epsilon q_c + A]^2}$$

(29) allows substituting the nominal interest in the consumed search good quantities (33) and (34)[12] so that:

$$\frac{\partial L}{\partial i} = \frac{-\left\{A\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1+\alpha}{\alpha}} + n\frac{1}{i+\epsilon}\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\right] + n(1-n)(1-\epsilon)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\frac{(1-\epsilon)}{(i+\epsilon)(1+i)}\right\}}{\alpha\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}} + n\epsilon\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}} + A\right]^2}$$

This can be rewritten as:

[12] For $\beta \le \gamma \le \beta(1+\mu)$, replacing $\gamma = \beta(1+i)$ gives $q_b = \left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}$ and $q_c = \left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}$

$$\frac{\partial L}{\partial i} = \frac{-\left\{A\left[(1-n)(i+\epsilon)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n(1+i)\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\right]+n(1-n)(1-\epsilon)^2\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\right\}}{\alpha(1+i)(i+\epsilon)\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\epsilon\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}+A\right]^2} < 0$$

The elasticity of money demand is therefore given by:

$$\xi_L = \frac{-i\left\{n(1-n)(1-\epsilon)^2\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}+A\left[(1-n)(i+\epsilon)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n(1+i)\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\right]\right\}}{\alpha(1+i)(i+\epsilon)\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}\right]\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\epsilon\left(\frac{\epsilon}{i+\epsilon}\right)^{\frac{1}{\alpha}}+A\right]} < 0 \tag{65}$$

- Case (iii): $0 < \mu < i$

$$L = \frac{M_{-1}\left[1+\frac{n(1-\epsilon)q_c}{(1-n)q_b+n\epsilon q_c}\right]}{\frac{M_{-1}}{(1-n)q_b+n\epsilon q_c}[(1-n)q_b+n\epsilon q_c]+\frac{M_{-1}}{(1-n)q_b+n\epsilon q_c}[A+n(1-\epsilon)\mu q_c]} = \frac{(1-n)q_b+nq_c}{(1-n)q_b+nq_c[\epsilon+\mu(1-\epsilon)]+A}$$

$$\frac{\partial L}{\partial i} = \frac{(1-n)\frac{\partial q_b}{\partial i}\{A-nq_c[1-\epsilon-\mu(1-\epsilon)]\}+n\frac{\partial q_c}{\partial i}\{A+(1-n)q_b[1-\epsilon-\mu(1-\epsilon)]\}}{[(1-n)q_b+nq_c[\epsilon+\mu(1-\epsilon)]+A]^2}$$

(29) allows substituting the nominal interest in the consumed search good quantities (33) and (34)[13] so that:

$$\frac{\partial L}{\partial i} = \frac{-\left\{A\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1+\alpha}{\alpha}}+n\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1+\alpha}{\alpha}}\right]+n(1-n)[1-\epsilon-\mu(1-\epsilon)]\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\left(\frac{\mu(1-\epsilon)}{(1+i)[\epsilon(1+i)+\mu(1-\epsilon)]}\right)\right\}}{\alpha\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n[\epsilon+\mu(1-\epsilon)]\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}+A\right]^2}$$

This can be rewritten as:

$$\frac{\partial L}{\partial i} = \frac{-\left\{A\left[(1-n)[\epsilon(1+i)+\mu(1-\epsilon)]\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\epsilon(1+i)\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\right]+n(1-n)[1-\epsilon-\mu(1-\epsilon)]\mu(1-\epsilon)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\right\}}{\alpha(1+i)[\epsilon(1+i)+\mu(1-\epsilon)]\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n[\epsilon+\mu(1-\epsilon)]\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}+A\right]^2}$$

The elasticity of money demand is therefore given by:

$$\xi_L = \frac{-i\left\{A\left[(1-n)[\epsilon(1+i)+\mu(1-\epsilon)]\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\epsilon(1+i)\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\right]+n(1-n)[1-\epsilon-\mu(1-\epsilon)]\mu(1-\epsilon)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\right\}}{\alpha(1+i)[\epsilon(1+i)+\mu(1-\epsilon)]\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}\right]\left[(1-n)\left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}+n[\epsilon+\mu(1-\epsilon)]\left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}+A\right]}$$

$$< 0 \tag{66}$$

[13] For $\beta(1+\mu) < \gamma$, replacing $\gamma = \beta(1+i)$ gives $q_b = \left(\frac{1}{1+i}\right)^{\frac{1}{\alpha}}$ and $q_c = \left(\frac{\epsilon}{\epsilon(1+i)+\mu(1-\epsilon)}\right)^{\frac{1}{\alpha}}$

A.4 Source Codes

The following source codes in *R* have been used throughout the quantitative analysis of this thesis.

• ***computation*-func.**: Computation of financial and searchgood quantities

```
computation <- function(alpha,beta,gamma,epsilon,mu,n)
{ c <- gamma/beta # compute value for the nominal gross interest rate
  bankyield <- c - mu # Gross return on bank deposits
  nomint <- c-1 # Nominal interest rate

   # case 1 or 2: 0<=i<=mu
  if (c>=1 && bankyield<=1)
  {# Compute search good quantities
    qb <- (beta/gamma)^(1/alpha)
    qc <- (beta*epsilon/(gamma-beta*(1-epsilon)))^(1/alpha)
    qs <- (1/(n*(1-epsilon)))*(n*epsilon*qc+(1-n)*qb)

    # Compute credit market quantities
    dbs <- 0
    dM <- ((1-n)*(qb-qc)/((1-n)*qb+n*qc)) #*M
    l <- (n*(qb-qc)/((1-n)*qb+n*qc))  #*M

    # Price of money in terms of the general good
    phi <- ((1-n)*qb+n*qc) #/M

    # Price of search good
    p <- 1/((1-n)*qb+n*qc)#*M
  }
  # case 3: 0<mu<i
  if (c>1 && bankyield>1)
  {# Compute search good quantities
    qb <- (beta/gamma)^(1/alpha)
    qc <- (1/(gamma/beta+mu*(1-epsilon)/epsilon))^(1/alpha)
    qs <- (1/(n*(1-epsilon)))*(n*epsilon*qc+(1-n)*qb)

    # Compute credit market quantities
    dbs <- (qc/((1-n)*qb+epsilon*n*qc)) #*M
    l <- ((n*qb-n*epsilon*qc)/((1-n)*qb+n*epsilon*qc)) #*M
    dM <- (((1-n)*qb-(1-n*epsilon)*qc)/((1-n)*qb+n*epsilon*qc)) #*M

    # Price of money in terms of the general good
    phi <- ((1-n)*qb+n*epsilon*qc) #/M

    # Price of search good
    p <- 1/((1-n)*qb+n*epsilon*qc)#*M
   }
  # Compute Welfare contribution of search good
  Ws <- (n*(1-epsilon)*(-qs)+n*epsilon*(qc)^(1-alpha)/(1-alpha)
  +(1-n)*(qb)^(1-alpha)/(1-alpha))/(1-beta)
```

```
  return(list(nomint,qs,qb,qc,Ws,dbs,l,dM,phi,p,alpha,beta,gamma,epsilon,mu,n))}
```

- ***calibratemodel*-func.**: Model calibration

```
calibratemodel <- function(amd,r,nomint,elasticity,Dm,mu,n)
{# Compute Gamma and Beta
  beta <- 1/(1+r)
  gamma <- (nomint+1)*beta

  # Initiate checking Variable
  counter <- -1
  x <- 999

  # Case 1 and 2
  if(nomint<mu || nomint==mu)
  {# There has been no case where the data implied dominated sight deposits.
  # The source code has thus been omitted.
   }
  # Case 3
  if(nomint>mu)
  {# Calibrate A and alpha
    # i: A loop
    for(i in seq(0.5,0.8,0.001))
    {# Progress Message
      counter <- counter+1
      if(counter==10)
      {cat("*** Checking for A=",i," ***\n")
        counter <- 0
      }
      # j: alpha loop
      for(j in seq(0.001,0.999,0.001))
      {# k: epsilon loop
        for(k in seq(0.001,0.5,0.001))
        {# Compute estimate for money demand
          qb <- (beta/gamma)^(1/j)
          qc <- (1/(gamma/beta+mu*(1-k)/k))^(1/j)
          qs <- (1/(n*(1-k)))*(n*k*qc+(1-n)*qb)
          p <- 1/((1-n)*qb+n*k*qc) #*M
          phi <- ((1-n)*qb+n*k*qc) #/M

          # Agrregate money demand estimate
          amdhat <- ((1-n)*qb+n*qc)/((1-n)*qb+n*k*qc+i) # M1 with sight deposit

          # Money demand elasticity estimate
           elasticityhat <- (-nomint*i*((1-n)*(k*(1+nomint)+mu*(1-k))*(1/(1+nomint))^(1/j)+n
           *(1+nomint)*k*(k/(k*(1+nomint)+mu*(1-k)))^(1/j))+n*(1-n)*(1-k)^2
           *mu*(1/1+nomint)^(1/j)*(k/(k*(1+nomint)+mu*(1-k)))^(1/j))/(j*(1+nomint)*(k*(1+nomint)
           +mu*(1-k))*((1-n)*(1/(1+nomint))^(1/j)+n*(k/(k*(1+nomint)+mu*(1-k)))^(1/j))
           *((1-n)*(1/(1+nomint))^(1/j)+n*k*(k/(k*(1+nomint)+mu*(1-k)))^(1/j)+i))

          # Compute estimate for time deposit ratio
```

```
        modelvector <- computation(j,beta,gamma,k,mu,n)
        Dmhat <- as.numeric(modelvector[8])*n/(1+as.numeric(modelvector[8])
        *n+n*(1-k)*as.numeric(modelvector[6]))

        # Compute standardized sum of squared errors
        SE1 <- (amd - amdhat)^2/amd
        SE2 <- -(elasticity - elasticityhat)^2/elasticity
        SE3 <- (Dm - Dmhat)^2/Dm
        SSE <- SE1+SE2+SE3

        # Compare fitting of model values
        if(SSE < x)
        {# Compute goods market share
          Qs <- Qs <- as.numeric(modelvector[2])*n*(1-k)
          sg <- Qs/(i+Qs)

          A <- i
          alpha <- j
          epsilon <- k
          x <- SSE
        }}}}}
  # Return Output
  return(list(A,alpha,beta,gamma,epsilon,mu,n))}
```

- ***WTP_numeric*-func.**: Numerical computation of willingness to pay

```
WTP_numeric <- function(A,alpha,beta,gamma,epsilon,mu,n)
{# Induce Checking Variables
  x <- 9999
  y <- 9999
  z <- 9999
  # Compute quantities
  gammared <- 1.03*beta # Gamma at nominal interest rates of 3 percent
  gammaele <- 1.13*beta # Gamma at nominal interest rates of 13 percent

  model1 <- computation(alpha,beta,gamma,epsilon,mu,n) # Baseline model
  model2 <- computation(alpha,beta,gammared,epsilon,mu,n) # Reduced Gamma
  model5 <- computation(alpha,beta,gamma,epsilon,10,n) # Sight deposits dominated
  model6 <- computation(alpha,beta,gammaele,epsilon,mu,n) # Elevated Gamma

  # WTP Gamma
  rhs <- n*epsilon*as.numeric(model6[4])^(1-alpha)/(1-alpha)
  +(1-n)*as.numeric(model6[3])^(1-alpha)/(1-alpha)-n*(1-epsilon)*as.numeric(model6[2])
  for(i in seq(0,0.05,0.00001))
  {delta <- 1-i
    lhs <- n*epsilon*(as.numeric(model2[4])*delta)^(1-alpha)/(1-alpha)+(1-n)
    *(as.numeric(model2[3])*delta)^(1-alpha)/(1-alpha)-n*(1-epsilon)
    *as.numeric(model2[2])-i*A
    SE <- (rhs-lhs)^2
    if(SE<x)
    {x<-SE
      WTPinflation <-i
```

```
    #cat("SE: ",SE,"\n")
    #cat("WTP Inflation: ",i,"\n")
  }}
# WTP Sight Deposits
rhs <- n*epsilon*as.numeric(model5[4])^(1-alpha)/(1-alpha)+(1-n)
*as.numeric(model5[3])^(1-alpha)/(1-alpha)-n*(1-epsilon)*as.numeric(model5[2])
for(i in seq(0,0.05,0.00001))
{delta <- 1-i
  lhs <- n*epsilon*(as.numeric(model1[4])*delta)^(1-alpha)/(1-alpha)+(1-n)
  *(as.numeric(model1[3])*delta)^(1-alpha)/(1-alpha)-n*(1-epsilon)
  *as.numeric(model1[2])-i*A
  SE <- (rhs-lhs)^2
  if(SE<z)
  {z<-SE
    Delta_sight <-i
  }}
# Return Output
return(list(WTPinflation,WTPmu))}
```

• ***Modelsimulation*-script**: Simulation using time series data

```
# Import and Convert Data
calibration_data_values <- read.csv("~/simulationdata.csv", sep=";")
values <- as.matrix(calibration_data_values)
datasize <- nrow(values)
result <- vector(,27)
check <- 10

# Running Loop
for(i in seq(1,datasize,1))
{beta <- values[i,"Beta"]
  gamma <- values[i,"Gamma"]
  mu <- values[i,"Mu"]
  for(j in seq(0,0.5,0.001))
  {epsilon <- j
  x <- computation(alpha,beta,gamma,epsilon,mu,n)

  # Total amounts traded in the credit market
  L <- as.numeric(x[7])*(1-as.numeric(x[16]))
  DM <- sqrt((as.numeric(x[8])*as.numeric(x[16]))^2)
  Db <- as.numeric(x[6])*as.numeric(x[16])*(1-as.numeric(x[14]))

  # Total amounts traded in the search good market
  Qb <- as.numeric(x[3])*(1-as.numeric(x[16]))
  Qc <- as.numeric(x[4])*as.numeric(x[16])*as.numeric(x[14])
  Qs <- as.numeric(x[2])*as.numeric(x[16])*(1-as.numeric(x[14]))

  # Deposit Shares in M3
  timedepshare <- DM/(1+DM+Db)
  sightdepshare <- Db/(1+DM+Db)
  totaldepshare <- timedepshare+sightdepshare
```

```
# Agrregate money demand estimate
amdhat <- ((1-n)*as.numeric(x[3])+n*as.numeric(x[4]))/((1-n)*as.numeric(x[3])
+n*as.numeric(x[4])*(j+(1-j)*mu)+A) # M1 with sight deposit

# Money demand elasticity estimate
elasticityhat <- (-as.numeric(x[1])*A*((1-n)*(j*(1+as.numeric(x[1]))+mu*(1-j))
*(1/(1+as.numeric(x[1])))^(1/as.numeric(x[11]))+n*(1+as.numeric(x[1]))*j
*(j/(j*(1+as.numeric(x[1]))+mu*(1-j)))^(1/as.numeric(x[11])))+n*(1-n)*(1-j)
*(1-j-mu*(1-j))*mu*(1/1+as.numeric(x[1]))^(1/as.numeric(x[11]))
*(j/(j*(1+as.numeric(x[1]))+mu*(1-j)))^(1/as.numeric(x[11])))/(as.numeric(x[11])
*(1+as.numeric(x[1]))*(j*(1+as.numeric(x[1]))+mu*(1-j))*((1-n)
*(1/(1+as.numeric(x[1])))^(1/as.numeric(x[11]))+n*(j/(j*(1+as.numeric(x[1]))
+mu*(1-j)))^(1/as.numeric(x[11])))*((1-n)*(1/(1+as.numeric(x[1])))^(1/as.numeric(x[11]))
+n*(j+mu*(1-j))*(j/(j*(1+as.numeric(x[1]))+mu*(1-j)))^(1/as.numeric(x[11]))+A))

# Compute sum of squared errors
SE1 <- (amd - amdhat)^2
SE2 <- (elasticity - elasticityhat)^2
SE3 <- (timedepshare - values[i,"TD_Data"])^2
SSE <- SE1+SE2+SE3
if(SSE<check){
  check<-SSE
  result[26]<-j
  result[18] <- timedepshare
  cat("SE3: ",SE3,"\n")
  } }
  # Bank Efficiency Loss to Society (in Terms of General Goods)
muloss <- as.numeric(x[15])*Db/as.numeric(x[9])

# Willingness to pay
WTPx <- WTP_numeric(A,as.numeric(x[11]),as.numeric(x[12]),
as.numeric(x[13]),as.numeric(x[14]),as.numeric(x[15]),as.numeric(x[16]))
WTPinflation <- WTPx[1]
WTPmu <- WTPx[2]

# Collect output
result[1] <- x[1];result[2] <- x[2];result[3] <- x[3];result[4] <- x[4];result[5] <- x[5]
result[6] <- x[6];result[7] <- x[7];result[8] <- x[8];result[9] <- x[9];result[10] <- x[10]
result[11] <- i;result[12] <- L;result[13] <- DM;result[14] <- Db;result[15] <- Qb
result[16] <- Qc;result[17] <- Qs;result[27] <- values[i,"Vola"]*10
result[19] <- sightdepshare;result[20] <- totaldepshare;result[21] <- muloss
result[22] <- WTPmu;result[23] <- WTPinflation;result[24] <- values[i,"TD_Data"]
result[25] <- values[i,"Date"]
mat <- rbind(mat,result)}
```

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