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Excess Liquidity and the Usefulness of the Money Multiplier

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Abstract

We model the behaviour of banks as a main driver of the changing components of the money multiplier (MM). So we provide behavioural underpinnings for the supply and demand for inside and outside money. We illustrate how the creation of large outside money balances by central banks induces behavioural changes, creating an environment characterised by a low MM and low market interest rates. The low regime reflects a state in which the functioning of the financial system changes fundamentally due to excess supply of reserves. This so-called excess liquidity trap has adverse economic consequences, is persistent, and cannot be solved by monetary policy alone. We argue that government and supervisory measures taken during the pandemic provide an example of supporting policies that are effective in escaping the excess liquidity trap.

JEL classification: E51, E52

Keywords: monetary policy; interest rates; money multipliers

I. Introduction

The balance sheet policies of central banks in recent years have been aimed at lowering market interest rates in the face of a binding effective lower bound on policy rates. The resulting large excess reserves on banks' balance sheets supported bank funding and liquidity in financial markets, but did not translate into a concomitant rise in bank credit and deposit creation. The latter is a thorny issue since it questions the use of central bank policies to stimulate the economy and increase inflation and increase inflation by balance sheet measures through removing frictions for financial intermediation by banks and other financial market participants.

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Against this background our paper investigates how the interactions between banks, non-bank agents and the central bank can lead to an environment characterised by risk-return profiles that increase demand for central bank reserves and other safe assets. In this state the extended central bank liquidity does not reach the real economy. The questions how this excess liquidity trap has been brought about and how it can be solved are analysed through the lens of the money multiplier (henceforth MM), applied to the US and the euro area. A main empirical outcome of our approach is that it clearly shows a regime with very low interest rates and excess reserves and hence a low MM. We also show that behaviour of banks and non-bank agents can reinforce such a tendency and that other actors than the central bank, for instance governments, can help to escape from the excess liquidity trap. They can contribute to reduce frictions, which can be an impediment besides other factors for the creation of inside money.

We illustrate our findings by the a-typical dynamics of inside and outside money in the pandemic. In the pandemic both base money and broader monetary aggregates displayed vigorous growth. This is a-typical in a crisis, because monetary transmission – inter alia depending on banks and financial markets – is then usually strained, leading to lackluster broad money growth. We will discuss the mechanisms behind the a-typical correlation between outside and inside money by showing that policy measures of governments and supervisors have been a determining factor for keeping monetary dynamics away from the trapped regime.

Our MM framework is inspired by *Goodhart* (1989, 2009, 2010), Disyatat (2008) and *Stella* et al. (2021) who stress that the lack of behavioural content robs the MM of its (policy) usefulness. However, we show that the concept of the MM is useful to reveal the key behavioural underpinnings that link inside and outside money. We provide these underpinnings by modelling the market of reserves balances and the bank loan and deposit market, following earlier work by e.g. *Tobin* (1969), *Brunner* (1994), *Bernanke* and *Mihov* (1998) and *Afonso* et al. (2020). Our model explicitly allows for the costs for the banking sector emanating from financial frictions due to, inter alia, asymmetric information. This builds on the seminal works on the credit view of monetary transmission, see *Bernanke* and *Gertler* (1995) for an overview. Monetary policy in our model affects the banking sector both via the conditions in the reserve market and via financial frictions. Our analysis allows for both a regime with scarce reserves (which was more or less the relevant one until the Global Financial Crisis (GFC) of 2007) and one with large excess reserves (more or less applicable since the GFC). We trace how the latter regime changes the functioning of the financial system.

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The rest of this paper is structured as follows. In the next section we define the money multiplier and its components. Section III describes the model framework that links inside to outside money. Section IV describes the development of the MM over four decades in the US and the euro area, which puts the MM dynamics during the pandemic into perspective. Section V discusses policy implications and section VI concludes.

II. Money Concepts

In essence, the money multiplier is an identity that describes the relationship between outside and inside money, see *Lagos* (2010). Outside money is money that is either of a fiat nature (unbacked) or backed by some asset that is not in zero net supply within the private sector, e.g. gold. More formally, outside money, also called base money or high powered money (H), is defined as the sum of banknotes circulating in the economy (C) and reserves that banks hold at the central bank (reserve balances, R)[1]:

$$H \equiv C + R \tag{1}$$

Inside money is defined as an asset representing, or backed by, forms of private credit. So the price of inside money is determined by the interest rate in the private credit market. For an asset to qualify as money, the underlying credit should be extended by the money issuing sector – i.e. the banks. They create deposits by lending to or buying assets from non-banks, whose deposit accounts (i.e. the asset of the money holding sector) are credited. Deutsche Bundesbank (2017) provides an overview of the role of banks, non-banks and the central bank in the money creation process.

Inside money, or the money stock (M), is defined as the sum of C and bank deposits (D_i) held by non-bank private agents. The subscript i reflects the fact that there are various forms of bank deposits, and that these various forms are the distinguishing feature of the various measures of money supply (M1, M2 or M3):

$$M_i \equiv C + D_i \text{, with } i = 1,\ 2,\ 3 \tag{2}$$

In addition, reserves that banks are required to hold at the central bank (required reserves, RR) are distinguished from reserves that banks hold voluntarily at the central bank (excess reserves, ER):

$$R \equiv RR + ER \tag{3}$$

[1] Vault cash of the banks – an empirically insignificant part of base money – is included in bank reserves, for ease of exposition.

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RR are set by a regulator (either for monetary control or for prudential reasons), and *ER* are determined by banks on the individual bank level. On the aggregate level, (opportunity) costs of holding ER, which are created by the central bank and end up at the asset side of the banking sector, will adjust in order for banks to absorb *ER*.[2] In between there can be a flow of transactions depending on portfolio choices of banks and transactions between non-bank agents with accounts at different banks. *ER* is made up of an autonomous component (working balances of reserves that banks use to pay the central bank for cash withdrawals of customers) and a non-autonomous component that is for instance related to banks' preferences to hold reserves as safe and liquid assets. We will specify both components and elaborate on the behavioural factors behind *ER* in the next section. There we will illustrate why the distinction between autonomous (*AR*) and non-autonomous reserves (*NAR*) is useful to describe the post-GFC market situation. So, $R = AR + NAR$ with $AR = RR + AF$ where *AF* stands for working reserve balances. Clearly, $NAR = ER - AF$.

After some simple manipulation of (1) – (3) we get the following equation:

$$M_i \equiv \frac{1+c}{c+e+r} H \cdot \quad (4)$$

with $c \equiv C / D_i$, $e \equiv ER / D_i$ and $r \equiv RR / D_i$.

Eq. (4) implicitly defines the money multiplier $\frac{1+c}{c+e+r}$.[3] As an identity, it obviously has to hold at all times and by itself does not imply any causal relationship. It can, however, be used to decompose the supply of inside money into three factors: (i) changes in the amount of outside money *H*, holding the parameters *r*, *c*, *e* constant. (ii) changes in one or more of these behavioural parameters, assuming a constant amount of outside money and (iii) the interaction between (i) and (ii).

Figure 1 illustrates, using monthly data for the euro area and the US during 1981 – 2021, this decomposition. The graph illustrates that none of the components of the MM remain constant over time. In addition, it seems to be the case that the movements in outside money and behavioural parameters are inversely related. Finally, these factors were much more stable in the period before the GFC.

Figure 2 presents the behavioural parameters *c*, *e*, *r*, for the US and the euro area. The parameters reflect the behaviour of the policy maker, the public (mon-

[2] Tobin (1963) in his classic paper refers to the "hot potato" analogy (p.12). This in contrast to inside money, where an economic mechanism exists for both its creation and extinction.

[3] From now on, we will drop the subscript for ease of exposition. In our empirical work below, we will use M3 for the euro area and M2 for the US, and the scope of the deposits used is consistent with the statistical definitions of the money stock variable.

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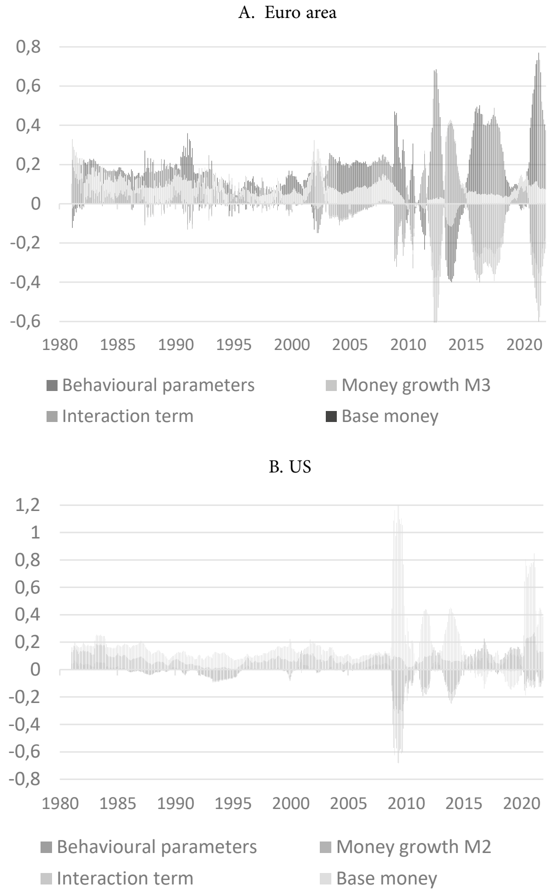

Figure 1. Decomposition of inside money M (year-on-year growth rate in decimals)

ey holding sector) and the banks (money issuing sector). The parameter levels in both the US and euro area a priori differ due to differences in financial regulation (r), financial structures and preferences of economic agents (c, e). Since the GFC, it is primarily the increased holdings of excess reserves by banks (relative to bank deposits) that changed the MM. The excess reserves are determined by the central bank on the aggregate level, based on monetary policy considerations.[4] In particular since the GFC central banks have expanded ER, partly as a result of Quantitative Easing (QE).

[4] Interbank transactions or transactions by clients of different banks can shift reserves from one bank to another.

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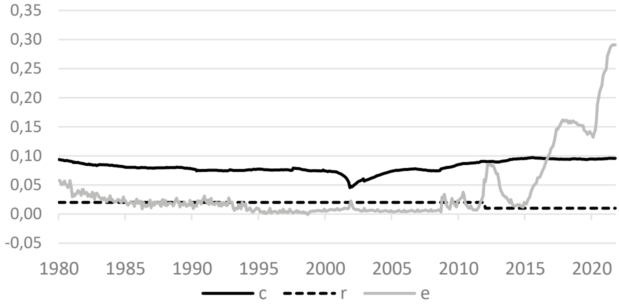
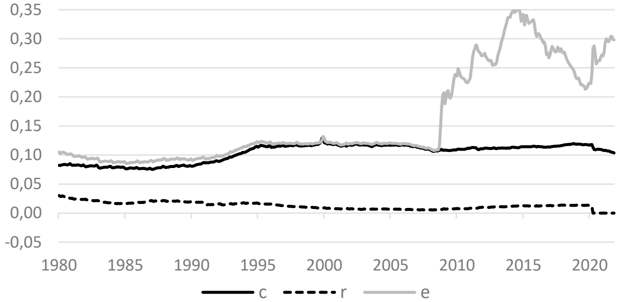
A. Euro area



B. US



Note: c = C/D; r=RR/D. e=ER/D, with D = M3 – repos (euro area); D = M2 (US).

Figure 2. Money multiplier parameters

We define the first factor of the abovementioned decomposition as the marginal MM:

$$\Delta M \equiv \frac{1+c}{c+e+r}\Delta H \tag{5}$$

This is a useful concept, given that the behavioural factors behind movements of inside and outside money usually relate to dynamic interactions between agents' (portfolio) responses and economic conditions, such as low interest rates. The marginal MM more closely reflects such dynamics than the MM defined in eq. (4), since it also captures temporary deviations from longer-term movements in the MM. We will return to the marginal MM in section IV.

III. Model Framework

In this section we provide the mechanistic MM with behavioural underpinnings by modelling the supply and demand for outside and inside money. We

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model the behaviour of different sectors in the economy, while indicating when individual bank responses are a distinguishing factor. The model allows for two states: a regime where reserves are scarce ("normal MM regime") and the regime with excess reserve supply ("low MM regime"). In both regimes the MM is the outcome of a set of behavioural equations, for two markets that determine inside and outside money: the market for reserve balances and the market for bank loans (implictly taking into account the bank deposit market as explained below). Given the objective of the paper our focus is on explaining (the interaction of) behavour of banks in three financial market segments: the reserves, loan and deposit markets. Tracing the macroeconomic effects of (un-)conventional monetary policy measures is outside our scope.

1. *Market for Reserve Balances*

Demand and supply for outside money, i. e. reserve balances, are settled in the money market (assuming C is determined outside the model). In this market, banks' demand for reserves (R_d) and the supply of reserves (R_s) by the central bank come together. Based on existing models of the money market (e. g. *Brunner*, 1994; *Bernanke* and *Mihov*, 1998; *Afonso* et al., 2020), we derive the supply and demand for reserves as

(6) $$R_d = -\lambda\left(i_R - i_{ER}\right) + \bar{\nu}^d + \nu^d$$

(7) $$R_s = \bar{\nu}^s + \nu^s$$

Reserve demand first and foremost depends on the opportunity cost for banks of holding them, ie the costs if they borrow from the central banks and hold the liquidity as a central bank deposit. This is represented by the differential between the money market rate (i_R) and the central bank deposit rate (i_{ER}). Reserve demand is reflected in the downward sloping curve in Figure 3, panel C.

Two additional demand components that we identify – both not primarily driven by movements in opportunity costs – are fixed autonomous reserve demand ($\bar{\nu}^d$) and the demand for excess reserves (ν^d).The former includes demand for required reserves (RR) and autonomous factors (demand for working balances of reserves (AF), related to banknotes in circulation and government balances at the central bank). Whether there is a demand for excess reserves as working balances depends on institutional factors. In the euro area for example, reserve requirements must be met on average over the reserve maintenance period, implying that required reserves can under certain conditions also serve as working balances. Excess reserve demand is determined by the preferences of banks (and the yield they implicitly attach) to hold central bank reserves as liquid and safe assets for precautionary reasons or for regulatory reasons. It is

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treated as an exogenous preference shock. Parameter λ (with $\lambda > 0$) is the elasticity of reserve demand related to the opportunity costs of holding reserves. This parameter depends on the terms and conditions at which the central bank supplies reserves (*Åberg* et al., 2021). If the allottment of reserves is more generous, for instance by extended refinancing operations, λ is lower. This then will be reflected in a flatter reserve demand curve.[5]

Reserve supply consists of two components: a fixed autonomous reserve supply ($\bar{\nu}^s$) and a monetary policy, or supply shock (ν^s). The former includes the supply of reserves to accommodate *RR* and reserve demand related to autonomous factors. While the central bank can adjust the reserve requirement for monetary policy purposes it will always provide sufficient reserves to banks to allow them to satisfy *RR* and to balance demand stemming from autonomous factors (*AF*), since it will not let shocks in those factors influence the market interest rate. This implies that $\bar{\nu}^s = \bar{\nu}^d$.

Total reserve supply R_s is represented by the vertical supply curve in Figures 3 and 4, panel C. The balance between ν^d and ν^s determines the MM regimes:

Normal regime (reserve scarcity):	$\nu^s < \nu^d$
Low regime (excess reserve supply)	$\nu^s \geq \nu^d$
Both regimes:	$\bar{\nu}^s = \bar{\nu}^d$

When the money market is in equilibrium it holds that,

$$R_d = R_s$$

$$-\lambda\left(i_R - i_{ER}\right) + \bar{\nu}^d + \nu^d = \bar{\nu}^s + \nu^s$$, and after rearranging terms, given $\bar{\nu}^s = \bar{\nu}^d$

$$(8) \quad i_R = i_{ER} + \frac{1}{\lambda}\left(\nu^d - \nu^s\right)$$

The distinguishing feature between the two regimes (normal versus low) is the sign of the opportunity cost component ($i_R - i_{ER}$). An imbalance in the reserves market will, in equilibrium, be reflected in the opportunity cost variable. Eq. (8) yields i_R as a function of supply and demand for *ER,* and policy parameter i_{ER}. It implies that in the normal regime equilibrium, when excess reserve demand is higher than supply a positive opportunity cost is needed to align demand with this lower level of supply, hence $i_R > i_{ER}$ (Figure 3, panel C).

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[5] The ECB currently applies the "fixed rate full allotment" procedure. That implies satisfying the demand of banks for excess reserves by full allotment in refinancing operations and a loosening of collateral requirements. This regime is more similar to our normal regime as the increase in excess reserves is driven by demand and not by supply but differs from the normal regime by making reserves not a scarce asset.

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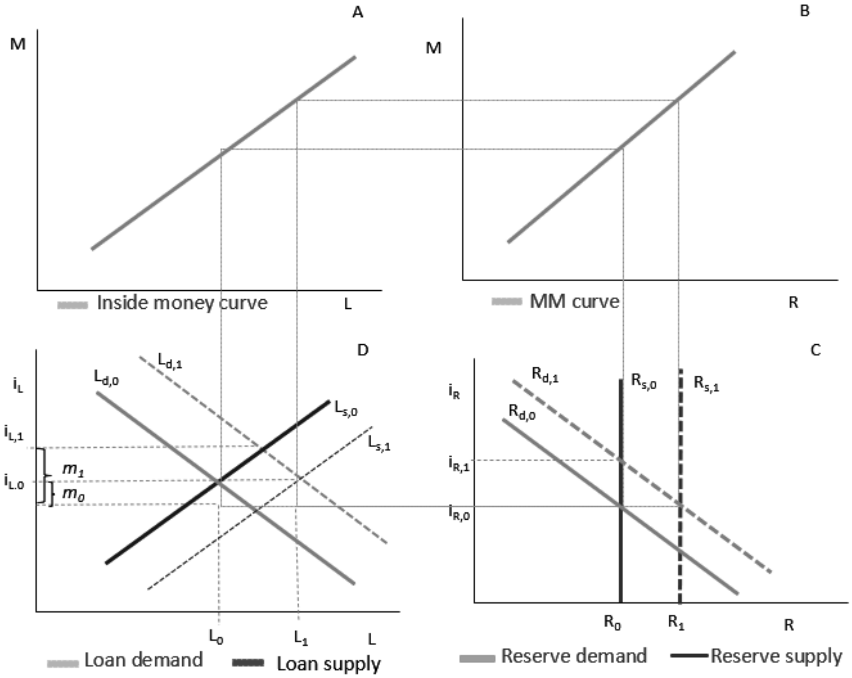

Figure 3. Money multiplier diagram (credit demand shock in normal regime)

In the low regime equilibrium, the market for reserve balances will clear as the (negative) opportunity cost ("opportunity benefit") will ensure that the marginal bank absorbs the additional reserves. The negative opportunity incentivises banks to hold large reserves and as a result the reserve demand curve is flat, ie demand is infinitely elastic to the interest rate at the level of i_{ER} (Figure 4, panel C).The absorption of reserves occurs via changes in bank behaviour, for example induced by a decrease in their profits from financial intermediation. With the resulting excess reserve supply ($v^s > v^d$), the MM is lower than in the normal regime when reserves are scarce, ceteris paribus.

The MM curve in Figures 3–4, panel B links the market of reserve balances (outside money) and the market of deposits (inside money created by bank lending). If an additional supply of reserves increases bank lending and so deposits, the MM curve is upward sloping as in Figure 3 panel B. If an increased supply of reserves does not lead to a change in bank lending and deposits, the MM curve is kinked at the dashed lines as Figure 4, panel B shows. The upper dashed line is a situation where an increase of reserve supply does not change the equilibrium in the bank loan market ($L_{d,0} = L_{s,0}$). The lower dashed line is a

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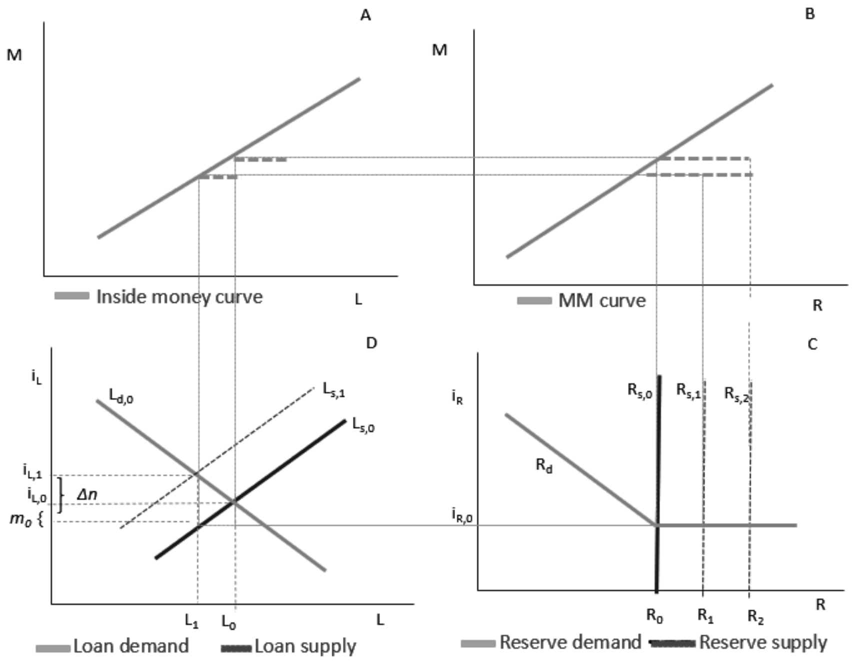

Figure 4. Money multiplier diagram (QE in low regime)

situation where bank loan supply has contracted (from $L_{s,0}$ to $L_{s,1}$ in Figure 4, panel B) and where the response of the central bank to this contraction, ic supplying additional reserves, is not able to resuscitate bank lending. In section III.7 we further explore these situations.

2. Bank Loan Market

Lending is determined by supply and demand in the bank loan market, as in Figure 3, panel D. The loan supply and demand curves are modelled as

$$L_d = -\gamma\, i_L + \overline{L}_d \tag{9}$$

$$L_s = \varphi\, m + \overline{L}_s \tag{10}$$

$$m = (i_L - i_R) - n \tag{11}$$

$$n = q\sigma_L + g\kappa_b + h\tau_m + jv^s \tag{12}$$

With q positive and g, h and j negative.

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Loan demand is a function of lending rate i_L in eq. (9), with parameter γ the interest rate elasticity coefficient ($\gamma > 0$). This coefficient for instance depends on the share of variable rate loans in the economy (determining the interest rate sensitivity of loan demand). $\overline{L}_d$, $\overline{L}_s$ are the loan amounts determined by factors outside the model. Eq (10) states that the supply of loans positively depends on the profitability of loan provision (margin m, with $\varphi > 0$). The margin equals the profits that banks gain from intermediation, which depend on the competition in the banking sector amongst other factors.[6] Following eq. (11), profitability equals the margin between the lending rate i_L and the money market rate i_R net of the banks' costs (n) related to financial frictions. Margin $i_L - i_R$ reflects the compensation for banks' maturity transformation (or interest rate risk), which will generally be positive, since loans usually have a longer maturity than money market liabilities. It is assumed that the compensation for credit risk is part of n, the parameter which captures the costs of financial frictions.

The equilibrium lending rate i_L is determined as,

$$L_D = L_S$$

$$-\gamma\, i_L + \overline{L}_d = \varphi\,(i_L - i_R - n) + \overline{L}_s$$, and after rearranging terms,

$$i_L = \frac{(\overline{L}_d - \overline{L}_s) + \varphi(i_R + n)}{\varphi + \gamma} \tag{13}$$

The model represented by equations (6), (7) and (9)–(12) can be closed by adding the equilibium conditions $L_D = L_s$ and $R_D = R_s$. The model determines prices and quantities in the reserve and bank loan markets as well as the profit margin and cost of frictions in the bank loan market, given the exogenous variables. Simultaneous equilibrium in both the reserve and bank loan markets can be obtained by inserting (8) into (13). The linear nature of the model and the parameter restrictions made ensure the existence of an unique and stable equilibrium, see the Annex.

We can now trace the impact of shocks in the bank loan market. We discuss the effects of a conventional monetary policy shock in i_R (by changing i_{ER}) and an unconventional monetary policy shock in v^s which affects the costs of frictions n. Given the partial equilibrium nature of our model the ceteris paribus assumption holds in the discussion below. [7]

[6] Put differently, the margin reflects the premium that compensates banks for various risks mainly interest rate risk, credit risk and market risk, which can relate to financial frictions.

[7] Macroeconomic variables such as output could be included in our partial equilibrium model as exogenous variables (for example by making $\overline{L}_d$ and $\overline{L}_s$ a function of output), without changing the results presented qualitatively. Of course, the model cannot be used to trace the macroeconomic effects of (un) conventional monetary policy measures

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- A monetary policy rate cut lowers i_R (as determined in eq. (8)) and thereby reduces lending rate i_L to a lower new equilibrium level. This follows from eq. (11), which – after rearranging terms – determines i_L as a function of i_R (i.e. $i_L = i_R + n + \mathrm{m}$). Margin m increases in the new equilibrium, given the negative sign of the derivative of m with respect to i_R (see the Annex). Lending L increases by both a positive credit demand (through lower i_L) and supply effect (through higher m) following a monetary loosening through a decline in i_R.
- An unconventional monetary policy shock through an increase of v^s reduces risk premia in financial markets and thereby lowers the costs of frictions (n). This raises margin m, given the negative sign of the derivative of m with respect to n (see the Annex). As a result, banks respond by expanding credit supply, which supports the creation of inside money. The lower costs of frictions (n) also reduce lending rate i_L, given the positive sign of the derivative of i_L with respect to n (see Annex). This boosts lending also by a positive demand effect. In the model, financial frictions is used as on encompassing concept which binds most specific channels of unconventional monetary policy; see Deutsche Bundesbank (2016, 2017) for an overview. The central bank can alleviate financial frictions by intervening directly in financial markets by balance sheet measures.

To summarise, a conventional monetary policy shock through i_R and an unconventional monetary shock through v^s (influencing frictions) both affect credit supply and demand. In the model, the effects of both shocks on lending rate i_L and margin m are equal, due to the linearity assumption of eq. (9) – (12), and illustrated by the expressions for the partial derivatives of i_L and m with respect to i_R and n (see Annex). The relative impact of both monetary policy shocks is determined by parameter λ in eq. (6). A lower value of λ (i.c. higher elasticity of reserve demand) increases the likelihood that bank credit is affected by changes in n (through the supply of reserves v^s) than by changes the monetary policy rate reflected in i_R (and vice versa if λ is higher).

3. *Deposit Market*

As defined in section II, inside money (M) is partly made up by bank deposits held by non-bank private agents. We subscribe to Schumpeter's famous statement "that it is much more realistic to say that banks create credit, i.e. that they create deposits in their act of lending, than to say that they lend the deposits that have been entrusted to them" (*Schumpeter*, 1954, p. 1114) by postulating

as it lacks a real economic sector, and therefore an endogenous response of real economic variables to monetary policy measures. This is beyond the scope of this paper.

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that deposits are created by bank lending. The statement that loan origination creates deposits implies that the money supply is endogenous, a function of the loan generation process determined by the supply and demand for credit as modelled in the previous section.[8]

Following from that, inside money is created by bank loans (L) extended to non-bank agents and by assets (F) purchased by banks from non-banks. In a closed economy (abstracting from money creation and destruction from abroad) this defines inside money creation as,

$$M = C + D = \bar{C} + \bar{D} + \beta_t \left(L + F\right) \tag{14}$$

It states that inside money (M) rises in proportion β_t to bank loans and bank asset purchases (t denoting the time dimension), as plotted by the inside money curve in Figure 3 panel A. The inside money curve relates lending to deposit creation, as in eq. (14), with β_t the slope of the inside money curve. It is assumed that variables C and $\bar{D}$ are determined outside the model; $\bar{D}$ is the deposit amount determined by factors other than bank lending, such as government transfers to households or firms who keep these funds in a bank deposit. Deposit creation can also originate from a QE transaction, in case the central bank purchases assets (F) from (domestic) non-bank agents (Figure 5.A). Such a transaction is settled by banks, who credit the deposits (D) of the non-bank agents in return for the assets, which banks then pass to the central bank in return for central bank reserves. So inside money M is created by central bank purchases of assets F from non-banks settled by banks. This makes F a function of monetary policy, in particular of the reserve supply shock (v^s) specified in eq. (7). Our approach differs from *Acharya* and *Rajan* (2022), who assume that banks pro-actively issue deposits to finance the increase of central bank reserves on their asset side.

Central bank	
F ↑	ER ↑

Bank	
ER ↑	D ↑

Non-bank agent	
D ↑ F ↓	

Figure 5.A. Assets purchased in QE programme from non-banks

[8] The relationship (direction of causality) between loans and deposits is of course a variant of the core issue in monetary economics, ie the relationship between money and credit. A history of the academic work on this topic can be found in *Schumpeter* (1954), see also *McLeay* et al., (2014) and *Goodhart* and *Jensen* (2015) for a recent exposition of its macro-economic dimensions and *Werner* (2016) for the equivalent in the field of finance and banking.

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It is instructive to distinguish between the creation and the (re)distribution of deposits. At the moment of origination (say $t = 0$) of a loan or the purchase of an asset by the marginal bank the deposit account of the money holding sector will always be credited. This implies $\beta_{t=0} = 1$. Eq. (14) can then also be written as deposit supply equation,

$$D_{s,t=0} = \beta_{t=0}(L + F) + \bar{D} \tag{15}$$

which determines the supply of deposits D_s at the moment of loan origination or asset purchases ($t = 0$) as a function of bank lending L and asset purchases F. It implies that the extension of loans or purchases of assets by banks from non-bank private agents create deposits. Vice versa, the deposit supply decreases if loans are redeemed or banks sell assets to non-banks. It assumes a fixed relationship between banks' assets ($L + F$) and the composition of their liabilities, more specifically, the quantity of liabilities that are defined as money. This becomes obvious if one solves eq. (14) for D. Indirectly, deposit supply $D_{s,t=0}$ is driven by bank profitability and regulatory constraints, which determine bank lending (L_s in eq. 10). Since loans create deposits, these factors also have an effect on deposit supply. In that sense $D_{s,t=0}$ is driven by bank behaviour.

In contrast to the situation at the moment of origination (where the above-mentioned statement of Schumpeter refers to), the process of deposit (re)distribution is governed by portfolio decisions by non-bank deposit holders and banks. These decisions will change the relation between L, F and D, M (and hence β) over time. Depositors can substitute deposits D for assets that do not count as inside money (such as long-term bonds issued by banks or the central government[9], or banknotes (C). Such portfolio decisions of depositors are driven by the risk (σ_D) and return (i_D) of deposits relative to those of alternative bank liabilities, government bonds or banknotes. So the deposit demand can be expressed as a function f of these determinants:

$$D_d = f(y,\, i_D - i_P\,,\, i_F\,,\, \sigma_D) \tag{16}$$

$$\frac{\partial D_d}{\partial y} > 0;\; \frac{\partial D_d}{\partial i_D} > 0;\; \frac{\partial D_d}{\partial i_F} < 0;\; \frac{\partial D_d}{\partial \sigma_D} < 0$$

[9] If banks or the central government issue a bond, the liquidity proceeds they receive do not count as inside money, since banks and central governments are non-money holding sectors. Therefore the substitution of D for bank or governments bonds reduces inside money M (expect in case of short-term bank bonds, which count as money in the euro area). However, if non-bank private agents trade assets amongst each other, M does

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This determines deposit demand, in line with *Goodhart* (2010), as a function of output y, the spread between the deposit rate and the central bank policy rate, the returns on alternative assets and deposit risk σ_D. The latter is part of banks' own risk (κ_b, i.e. the financial soundness of a bank. While κ_b determines the portfolio allocation across bank (like deposits) and non-bank liabilities (e.g. government bonds), σ_D also determines the allocation across bank liabilities. This implies that σ_D also determines the allocation across inside money (ic. bank deposits) and bank liabilities that do not count as money (like long-term bank bonds). Changes in output y (which determine income and wealth of non-bank agents) and in the relative asset returns drive portfolio adjustments by non-bank agents so that their deposit demand meets their budget constraint.

The relative risk and return (σ_D and i_D) are endogenous to the funding strategy of banks, who might decide to offer an deposit spread ($i_D - i_p$) to ensure that customers supply a sufficient amount of deposits instead of substituting to alternative savings vehicles like bonds (the positive partial of i_D reflects that an increasing deposit rate attracts deposits).[10] Vice versa, a bank could substitute deposits for alternative funding sources if the risk and return of such sources fit with banks' liability management. Such a substitution of funding sources consequently changes a banks' liquidity risk profile and thereby σ_D (the negative partial of σ_D reflects that deposit demand declines if the risk profile of deposits increases).

Banks' asset management determines the composition of L, F and ER on their individual balance sheets. In addition to the equation for reserves and loans specified earlier, banks' holdings of assets are described by a Tobin (1969)-type portfolio function f, similar to (16):

(17) $$F_d = f\left(y,\, i_F\,,\, i_L\,, i_{ER}\,, \sigma_F\,, v^s\right)$$

$$\frac{\partial F_d}{\partial y} > 0;\ \frac{\partial F_d}{\partial i_F} > 0;\ \frac{\partial F_d}{\partial i_L} < 0; \frac{\partial F_d}{\partial i_{ER}} < 0;\ \frac{\partial F_d}{\partial \sigma_F} < 0;\ \frac{\partial F_d}{\partial v^s} > 0$$

Assuming bank holdings of financial assets comprise of (sovereign) bonds, bond yield i_F can be decomposed in the expected short-term interest rate, a term premium and residual, with the term premium linked to QE policies of the central bank. The supply of assets (F_s) is assumed to be exogenous, given that it is determined by the debt issuance of agents outside the model, like the government and non-financial corporations.

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not change, because the trade only leads to a shift of a bank deposit from the buyer of the asset to the seller.

[10] So the interest rate on deposits is an instrument that banks use to compete for funding to finance loans, and in this respect is connected to the description of the bank loan market in the previous section.

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4. Regimes in the Reserves Market

In the normal reserve regime the central bank aims to clear the money market at a certain level of the interest rate, that it chooses as the operational target variable of monetary policy. In order to achieve this, it maintains a liquidity shortage to keep the money market interest rate i_R above i_{ER}. The central bank then determines the marginal price of reserve balances (money market rate i_R). Maintaining a scarcity of liquidity implies discouraging banks to hold reserves (over-and-above the autonomous component $\bar{v}^d$) via the opportunity costs for holding them. The central bank then balances the supply and demand for reserves in order to keep the money market rate i_R in line with the policy rate i_P. The latter is set by the central bank based on macroeconomic considerations (and often formalised using a policy rule such as the famous *Taylor* (1993) interest rate rule, see *Woodford* (2003) for an extensive discussion) and is not determined by the supply of reserve balances.

In our low reserve regime the central bank implements monetary policy not by maintaining an excess demand but an excess supply of liquidity, implying having a level of reserve supply as the operational target. In these so-called floor systems (already used by some central banks prior to the GFC) the central bank structurally supplies an excess of reserves. As in the normal regime, the market for reserve balances will clear via adjustment of the opportunity cost of holding reserves. That is, market rates will decrease until the (negative) opportunity costs will make it attractive for the marginal bank to absorb the reserves.[11] Note that in both the normal and the low regimes it is an interest rate *differential* that is pivotal for the central bank for its policy implementation (management of liquidity); it is quite independent of the *level* of any specific interest rate.

In the low regime equilibrium, the central bank satiates the market with excess reserves and equilibrium requires a commensurate negative interest rate spread to ensure that banks absorb these excess reserves. This equilibrium is the point at the flat part of the demand curve in Figure 4 panel C, where the preferred demand for *ER* is fully accommodated by central bank reserve supply ($v^s \geq v^d$). As a result, $i_R \leq i_{ER}$. In that case banks receive a premium for depositing their funds at the central bank (at i_{ER}) vis-a-vis the money market rate i_R. Banks borrow from money market participants without recourse to central bank facilities and deposit the funds at the central bank, paying i_R and receiving the higher i_{ER}). So arbitrage ensures that the money market interest rate aligns with the policy rate (i.c. the central bank deposit rate which becomes the de facto policy rate in the low regime). So in the low regime, banks' opportunity cost of holding reserve balances is negative. This implies that reserve demand is deter-

[11] Not all market participants (usually non-banks) have direct recourse to central bank liquidity facilities. Market rates can therefore decline below the central bank deposit rate.

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mined by the fixed autonomous component ($\bar{V}^d$), which predominantly consists of working balances of reserves, and demand for excess reserves (v^d), which can be related to the preference to hold safe and liquid assets.

The low regime can also be shaped by the creation of excess reserves (v^s) exogenous to reserve demand, for instance by QE or extended central bank refinancing operations. Such unconventional monetary policy is associated with a structural excess supply of reserves and a binding lower bound on the *level* of interest rates available for implementing monetary policy. In this low regime, the policy rate i_{ER} is stuck at the effective lower bound just above $i_{R,0}$ (which reflects the lower bound in Figure 4, panel C). The choice variable of the central bank is the supply of reserves (R_s), which is not just accommodating the demand for base money in order to steer i_R, but acually a policy instrument, represented by v^s in eq. (7). Balance sheet instruments have effectively been used by central banks since the GFC. With the policy rate at the effective lower bound, central banks have applied balance sheet policies such as QE to influence term premia and other risk premia in bond yields. The aim is that, by reducing such premia, the cost of frictions are reduced, the profitability of loan supply increases, stimulating bank lending and inside money growth.

5. *Frictions in the Bank Loan Market*

Frictions in the bank loan market are usualy micro-founded, being related to asymmetric information, adverse selection and moral hazard (*Brunnermeier* et al., 2012). They make it harder for a bank to ascertain the creditworthiness of a borrower and give rise to agency costs and default risk, which requires provisions. So n is a function of loan risk σ_L (eq. (12)), which depends on the strength of borrowers' balance sheets. The positive sign of the derivative of n with respect to σ_L reflects that the cost of frictions increases (decreases) if loan risk rises (falls). This refers to the balance sheet channel (*Gertler* and *Gilchrist*, 1993).

Banks themselves may also be subject to frictions, for instance due to a lack of liquidity or capital (i. e. banks' own risk). This refers to the bank lending channel of monetary transmission (*Bernanke* and *Gertler*, 1995). This channel implies that a bank that is better capitalized and/or more liquid (i. e. higher κ_b) faces less frictions, for instance if valuation gains on the bank's assets improves its capital position and thereby market access. This reduces n, as reflected in the negative partial of κ_b in eq. (12). In other words, a bank that becomes more (less) financially sound faces lower (higher) costs of frictions. The economic rationale for this is that an increasing financial strength of a bank lowers its funding and capital costs and so increases its capacity to lend (and vice versa). An important channel for this effect are bank bond yields, which may decrease as a result of extended liquidity supply by the central bank through asset purchases.

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Empirical research confirms that an increasing capital surplus raises banks' loan growth (e.g. *Berrospide* and *Edge*, 2010). The reverse also holds. The loss absorption characteristics (size of equity cushion) and length of banks balance sheets (leverage ratio) will be important in determining the extent to which an increase in excess reserve supply will crowd out bank lending or increase it, see *Diamond* et al. (2021). The former is much more likely to happen when banks are confronted with binding regulatory constraints (ie capital and leverage ratio requirements).

6. *Linking Inside and Outside Money*

When the financial sector is well capitalized, the need for outside money is minimal (for example in terms of the liquidity service it provides, see *Goodfriend*, 2000) and hence has low value relative to inside money (resulting in a high MM). *Brunnermeier* et al. (2012) show that the effects of frictions on financial intermediation and the macro-economy can be amplified by shocks to risk preferences and liquidity. Such shocks are associated with a contraction of inside money. Monetary policy can mitigate such adverse effects by extending outside money supply to banks.

So the costs of frictions can be reduced by central bank balance sheet policies. Actually the literature has shown that balance sheet policies can affect the economy to the extent that there are frictions in private intermediation (*Gertler* and *Karadi*, 2013). Financial frictions show up in risk premia, which can be reduced by QE and/or extended refinancing operations, since by these instruments the central bank removes risks from the market (e.g. duration risk or credit risk) on to its balance sheet. For example, by asset purchases the central bank can reduce the term premium and credit risk premium in the bond market, which eases financial conditions for banks and non-financial firms that obtain funding in this market; see Deutsche Bundesbank (2016, 2017) for an overview. This implies that excess liquidity creation by central banks lowers the costs of frictions, as reflected in the negative derivative of n with respect to v^s in eq. (12).

Financial market conditions (τ_m) also influence n in eq. (12). Parameter τ_m summarizes various financial market channels that can affect banks' intermediation function, such as confidence effects, risk-taking appetite, market liquidity and asset price developments (see for instance *Beyer* et al., 2017). Worsening market conditions (i.e. lower τ_m) raise banks' cost of intermediation, for instance because financial market operations require higher provisions, while banks' wholesale funding costs increase if market distress increases (and vice versa). This makes n also a compensation for market risk and is reflected in the negative partial of τ_m in eq. (12).

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The link between bank lending (inside money creation) and central bank reserves is illustrated in Figure 3. In panel D an exogenous positive credit demand shock at $t = 1$ shifts the loan demand curve to the right (dotted downward sloping curve). This enables banks to raise the lending margin to m_1, by which credit supply increases to $i_{L,1}$ (following eq. (10)). The increased loan supply creates deposits (inside money M), as reflected in the shift along the inside money curve in panel A, leading to an autonomous extra demand for RR (shift of reserve demand curve to the right in panel C). The central bank provides additional reserves to banks to meet the demand for RR and to keep the money market rate at $i_{R,0}$. This increases the supply of reserves to R_1 (dotted vertical line in panel C).

The central bank reaction follows *Goodhart* (2009), who states that the demand for credit (L_d and thereby D and M) determines reserve balances and thereby H. The central bank changes reserves supply (through $\bar{V}^s$ in eq. (7)) in order to maintain its desired level of the interest rate. Following a positive credit demand shock at $t = 1$, and the subsequent central bank response to it, M (through L and D) and H (through reserves) stabilise at a higher level (M and H rise proportionally as in panel B).

As discussed above, banks' asset management determines the composition of L, F and ER on their individual balance sheets. In addition to regulatory parameters, governing both the length and loss absorption characteristics of bank balance sheets, determining factors are the risk and return (interest rates) of assets relative to the central bank deposit rate (i.e. interest rate i_{ER} on excess reserves), following *Tobin's* (1969) portfolio approach. For instance, if the yield on high quality liquid assets like government bonds would drop below i_{ER} then banks will substitute bonds (F) for central bank reserves (ER). This asset swap is then purely driven by banks' portfolio behavior.

So portfolio adjustments by banks and non-banks determine D.[12] It implies that over time t the level of D may differ from $D_{s,t=0}$ and so parameter β_t may differ from $\beta_{t=0}$ (in which case $\beta_t \neq 1$). Since β_t represents the slope of the inside money curve in Figure 3 panel A, its inverse ($1/\beta_t$) is the loan-to-deposit ratio. This ratio is another driver of the asset and liability management of banks.

7. *Impact of QE*

The impact of QE on money creation depends, firstly, on the identity of the seller of the assets purchased by the central bank. If the central bank purchases

[12] Loan origination creates deposits, but the composition of the asset side of the banks' balance sheet is the result of portfolio choices.

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assets F from (domestic) *non-bank* agents the MM will change.[13] This QE transaction is settled by banks, who credit the deposits (D) of the non-bank agents and pass the asset purchased by QE to the central bank in return for reserves, as depicted in Figure 5.A. So banks create inside money M via D and the central bank simultaneously creates outside money (shift of R_s to the right in panel C). This is the first round effect of QE. As a second round effect, the reserve expansion lengthens banks' balance sheet and raises banks' leverage. *Diamond* et al. (2021) show that this "reserve channel of QE" crowds out bank loans by a significant amount. *Horst* and *Neyer* (2019) come to a similar conclusion. This implies that the capacity to create inside money (D) by lending diminishes, also putting downward pressure on the future level of the MM.

If the assets are purchased from *banks*, inside money M does not change since QE only swaps F (e.g. bonds) for ER on the asset side of the balance sheet of banks and both do not count as inside money (see Figure 5.B). ER increases and thereby outside money H (shift of R_s to the right in panel C from $R_{s,0}$ to $R_{s,1}$). The swap of F for ER makes banks more liquid (raising κ_b) without lengthening their balance sheet, by which potential liquidity frictions in the bank lending channel diminish. Hence, costs n decrease and margin m increases. As a result, banks respond by extending more loans. which will be matched by higher demand since the lending rate i_L will likely decline (see the Annex). This raises M and so QE then has the intended effect.

Financial frictions related to higher risk of loans (higher σ_L) or deteriorating market conditions (lower τ_m) can constrain loan supply if banks' profitability (margin m) falls due to higher costs of frictions (Δn in Figure 4 panel D) that are not fully passed-through in a higher lending rate. This leads to a shift of the loan supply curve along the demand curve to $L_{s,1}$ and an increase of i_L. In the face of frictions, the central bank may try to unclog the bank lending channel by further expanding excess reserves (ie. increasing v^s which lowers n in eq. (12)

Central bank		Bank		Non-bank agent	
F ↑	ER ↑	ER ↑	D	D	
		F ↓		F	

Figure 5.B. Assets purchased in QE programme from banks

[13] The monetary aggregate remains unchanged when the ultimate seller is a non-domestic resident, unless the latter re-invests proceeds domestically. In the model, bank bonds are not part of assets F (F are claims of banks and not their liabilities). Furthermore, bank bonds of shorter maturity (up to two years) are part of the money supply in the euro area.

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and shifts the reserve supply curve to R_2 in Figure 4 panel C). This can mitigate frictions related to market liquidity risk (reflected in τ_m in eq. (12)), but cannot resolve all frictions, in particular frictions related to a lack of capital (κ_b) or poor loan quality (σ_L). In the latter case, banks may favour holding (on to) safe central bank reserves over supplying loans. The additional reserves then end up at bank's balance sheets without an increase in loan supply (illustrated by the lower dashed part of the inside money curve in Figure 4, panel A). Loan demand falls as well due to the increase of i_L. The excess reserve supply gets trapped at bank's balance sheets without solving underlying bottlenecks in financial intermediation. Actions by other agents, such as the government and supervisor, are needed to resolve such more structural frictions.

Banks may also prefer alternative safe assets such as government bonds, in particular if bond yields are higher than i_{ER}. In that situation an increase of *ER* stimulates the demand for bonds, exerting a downward effect on bond yields. This is particularly the case when the increase in *ER* is initiated through refinancing operations (as central bank lending is secured and thereby reduces the availability of bonds in the market). These dynamics reinforce a regime with a low market interest rate and a low MM (proceeds of bond issuances in the hands of governments are not part of inside money *M*), reflected in a shift along the upper dashed part of the curves in Figure 4, panels A and B. It indicates that bank behaviour and market conditions change in response to a low regime with excess liquidity.

Besides frictions, changes in relative returns of assets also affect the preference of banks for *ER*. For instance, portfolio rebalancing by non-bank agents from deposits to other assets such as bonds will lower market interest rates, including loan rates which tend to move in tandem with market interest rates, due to competitive pressure. This reduces the margin between the lending rate and the return on other assets versus the central bank deposit rate and thereby raises the preference of banks for excess reserves (which are remunerated at i_{ER}) relative to loans *L*[14]. This is a similar mechanism as the reversal rate of Brunnermeier and Koby (2018), being the lowest level of the policy interest rate at which further monetary easing is no longer supportive to lending due to a declining interest rate margin. So in the low regime, reserve demand of banks (ν^d) adjusts to the excess reserve supply induced by QE (ν^s). Banks' preferences can reinforce the tendency towards an excess liquidity trap, with an increasing amount of reserves sitting idle on banks' balance sheets.

[14] This is captured in eq. (10); if i_L falls relative to i_R (or i_{ER} in the low regime) less loans will be extended relative to reserve holdings.

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IV. Money Multiplier Dynamics

1. *Evolution across Time*

This section describes the evolution of both the MM and the marginal MM for the US and the euro area in the 1980–2021 sample period (monthly data 1980m1 – 2021m11). Figure 6 clearly points at two regimes: one "low regime" with a very low multiplier and very low interest rate and a "normal regime" with a higher MM and interest rates (panels A and C). While the graphs do not capture causality between interest rates and the multiplier, they show that a low interest rate is associated with excess reserves. This regime emerges from 2008 onward, when central banks reduced policy rates to very low levels and started to use their balance sheet as a policy tool, thereby offering excess reserves to banks at favourable conditions. The Fed cut the policy rate earlier and more rapidly than the ECB, and the Fed introduced QE already in 2008, several years before the ECB started to purchase assets. This explains why the low regime can more clearly be distinguished in the US than in the euro area. *Van den End* (2019) explains regime switches in the financial system related to excess liquidity by the behavior of interacting agents. The low regime indicates that the creation of excess reserves (outside money) did not go in tandem with a proportional rise of bank loans and thus creation of inside money. It suggests that the central bank policy of outside money (reserves) creation has been the dominant driver for the fall of the MM since the GFC.

As explained in section III.2, a cost shock (increase of n due to frictions, like loan default risk) reduces credit supply due to the decline of the margin m. Credit demand falls as well because i_L increases as a consequence of a rise in costs n. The data in Figure 7 empirically corroborate that the increased difference between i_L and i_R in the euro area and the US at the beginning of the GFC was related to higher costs of frictions being passed-through in a higher lending rate.[15] The resulting decline of credit demand (in line with eq. (9)) is confirmed by the decline of bank lending for several years in a row following the GFC. If the increased difference between i_L and i_R would have been driven by higher bank profitability (m), loan supply would be boosted in line with eq. (10). However, the downturn in lending during the GFC more likely indicates that the higher costs of frictions (n) reduced banks' margin m (in line with the Annex), so that lending was affected by both a negative credit supply and demand effect.

As another indicator for financial frictions we use the VIX index in Figure 8. The VIX is a measure of volatility implied by equity options and reflects market

[15] Until October 2008 the lending rate and (to a lesser extent) the money market rate had increased in the euro area (in the US until August 2008). This might have had a (lagged) negative effect on loan demand.

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sentiment, risk aversion and financial stability risk (*Bekaert* and *Hoerova*, 2014). Such financial market frictions are captured by parameter τ_m in eq. (12), with a rise in VIX proxying for a lower τ_m. Figure 8 shows that the low MM regime is more frequently associated with spikes in the VIX than the normal regime, particularly in the US. This is another indication that financial frictions are associated with a low level of the MM. One channel for this link is that high risk aversion stirs bank demand for safe assets, of which central bank reserves, at the expense of loans.

2. *Marginal Multiplier in the Pandemic*

The distinction between the normal and low MM regime is also visible in the marginal MM (eq. (5)), which captures the dynamics in the MM. Figure 6, panels B and D show that the marginal MM for the US and the euro area is distributed around 1. However, in the low regime the marginal MM is lower than 1, implying that changes in inside money are smaller than changes in outside money. This is another way of showing that the association of the fall of the MM with low market interest rate levels.

In the pandemic, the marginal MM in the US was higher than in 2008 – 2009 and rather dispersed in the euro area (Figure 6, panels B and D), despite the uptick in the VIX index in 2020 (Figure 8). It reflects a combined strong growth of both inside and outside money, which is a-typical in a crisis. Figure 9 shows that both components of the marginal MM increased strongly in 2020 – 2021, while in the GFC and in the euro debt crisis (in the euro area) inside money growth fell to even negative rates. The robust inside money growth in the pandemic owes to policy responses by central banks, supervisors and governments. Outside money increased rapidly as a result of the large-scale refinancing of banks and asset purchases by the ECB and the Fed in 2020 – 2021 (reflected in an increase of ER by monetary policy shock v^s, as in eq. (7)). This reduced the money market rate i_R, as well as the costs of financial market frictions (τ_m) in the early stages of the Covid crisis. Bank lending frictions were mitigated by public guarantees on bank loans and income support to households and firms, which kept non-performing loans low (i.e. a lower σ_L, implying lower lending costs n). Moreover, supervisors provided banks capital relief by allowing them to operate below certain capital thresholds (ECB, 2020), which reduced banks' capital costs (reflected in a higher κ_b).[16] It makes the pandemic a good example of the effectiveness of measures by other agents than the central bank to mitigate frictions for financial intermediation.

[16] A case in point is the exemption of excess reserves (which have swollen due to QE) from the leverage ratio calculation.

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According to eq. (9) – (13) and the Annex, lower costs n imply a higher margin m, as well as a lower lending rate i_L (in the model the decline of i_R also reduces i_L). Both support inside money creation. The data indeed show an accelerating growth of loans to firms and households in 2020 in the US and the euro area, which decelerated in 2021 (Figure 7). However, contrary to the model the lending rate did not really change following the decline of i_R (leading to some widening of the spread between i_R and i_L). This suggests that loan growth was primarily driven by credit supply, supported by the increase of margin m (in line with eq. (10)). Note that credit demand was supported by factors determined outside the model (captured by $\bar{L}_d$ in eq. (9)), such as the increased demand by non-financial corporations for working capital and liquidity buffers following the lockdowns.

The response of deposit holders also explains the a-typical MM dynamics in the pandemic. In 2020 – 2021 both precautionary and forced savings by house-

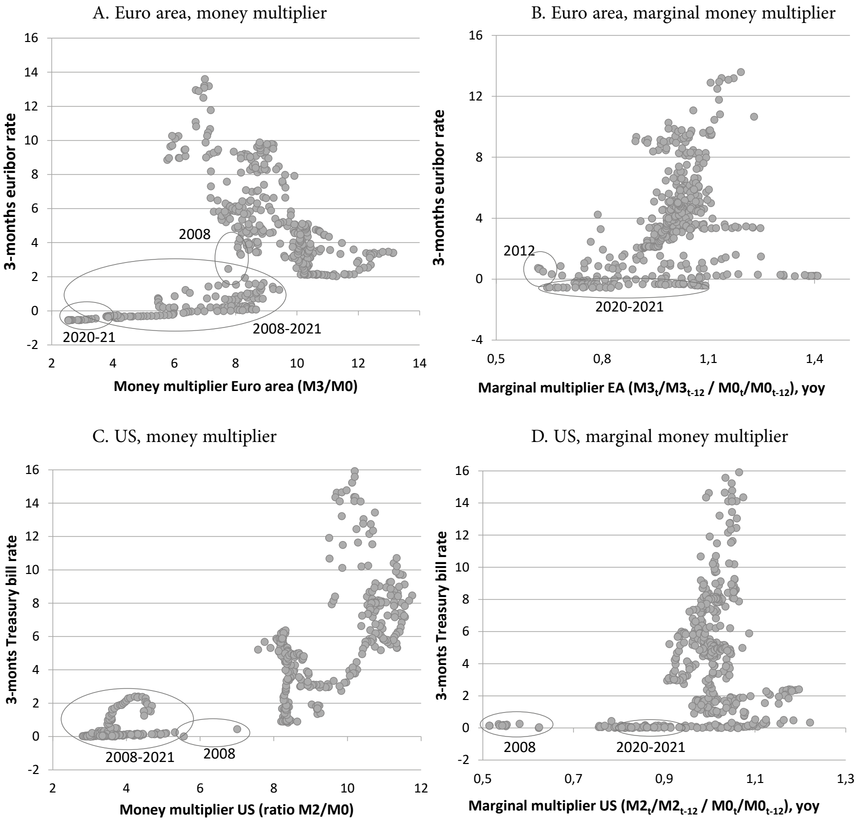

Figure 6. Money multiplier and interest rate, 1980m1 – 2021m11

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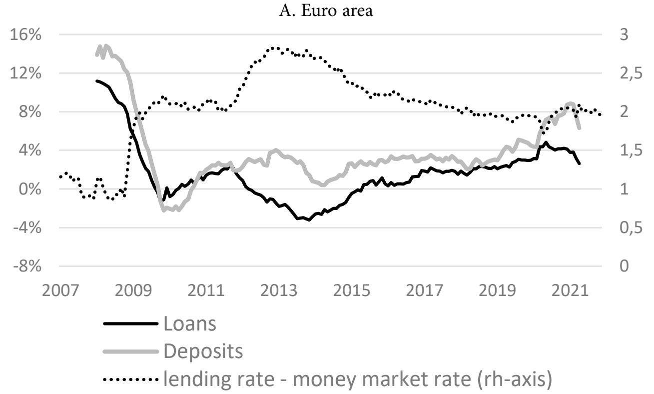

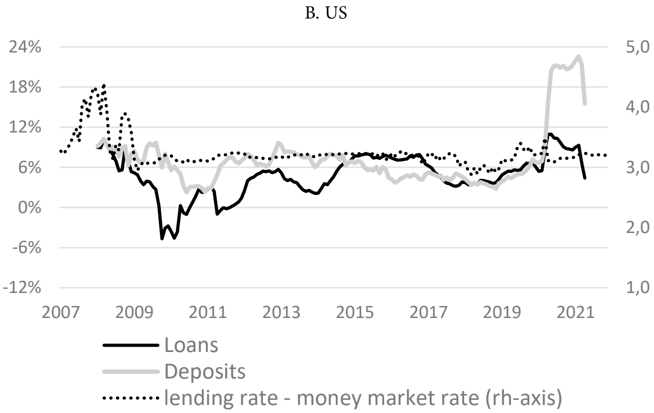

Sources: ECB, FRB StLouis

Figure 7. Bank lending and deposit taking to private non-financial sector (year-on-year growth rate; difference between bank loan rate and money market rate in percentage points)

holds increased rapidly, as reflected in the expansion of bank deposits in Figure 7. This partly reflects deposit creation by bank lending, but may also reflect a substitution of bank liabilities that do not count as money for deposits *D*. Unlike in the GFC, the stability of banks was not at stake in the pandemic and so the risk of deposits (σ_D) remained low. Since σ_D determines deposit holdings in eq. (16), banks' deposit base remained unaffected. This marks the crucial difference between the GFC – which was a banking crisis and thus did not provide incentives to increase deposits in the banking system – and the pandemic, which was a crisis outside the banking system and thus did incentivize private agents to increase their savings at banks.

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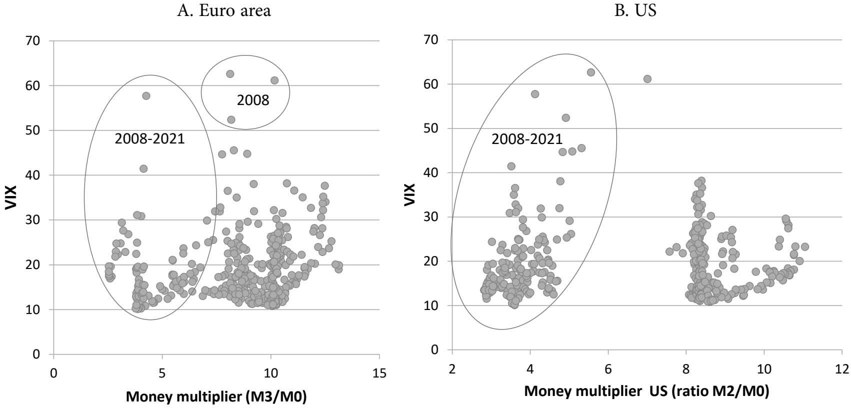

Figure 8. Money multiplier and VIX index, 1990m1 – 2021m11

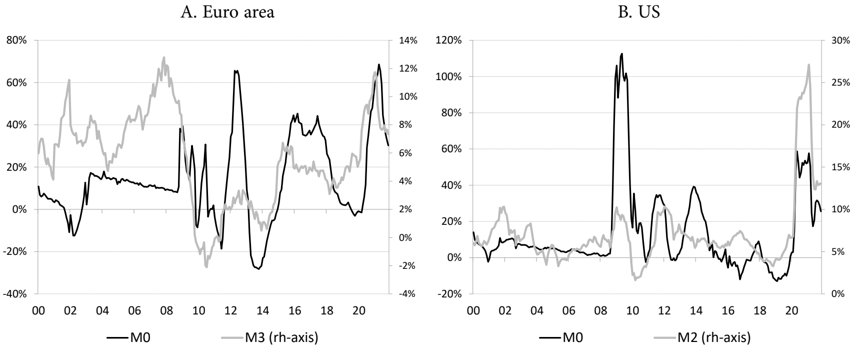

Figure 9. Inside and outside money growth (annual percentage change), 2000m1 – 2021m11

Another part of the increase of *D* is explained by the income support provided by governments to households and firms in the pandemic (*y* in eq. (16)). The central government is not part of the money holding sector and a transfer of funds from central governments to households and firms thus implies an increase of inside money in the form of bank deposits, driven by factors other than bank lending. Hence, the behaviour of deposit holders, interacting with government support measures, was another reason for inside money growth shoring up the (marginal) MM in the pandemic. It is a good example of a policy measure that boosts inside money without creating an excess liquidity trap, since the liquidity ends up in the hands of the money holding sectors.

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V. Discussion and Policy Implications

The low MM-regime can be interpreted as an unwanted by-product of central bank balance sheet policy aimed at lowering market rates in the face of the effective lower bound restriction on policy rates. This by-product comes in the form of an excess of outside money trapped on the balance sheet of the banking sector as the ultimate holder of central bank reserves. Our analysis presented in section III provides the behavioural underpinnings illustrating how this trap comes about: portfolio adjustments by both bank and non-bank agents not only contribute to the (intended) decline of market interest rates, but additionally (and unintentionally) create an environment characterised by risk-return profiles that increases the attractiveness of holding central bank reserves and other safe assets.[17]

Such an environment enables the absorption of the additional supply of reserves, but is not conducive to inside money creation. This perspective suggests that the monetary system has ended up in a new equilibrium situation associated with a low MM and low interest rate. The stylised facts in section 4 show that this regime or state is persistent. We argue that the low regime is a bad state from an economic perspective. The excess liquidity is not a free lunch, given that it presents a financial risk for the central bank and a cost for the banking sector. Particularly in the regime with a low MM and a low or even negative interest rate these risks and costs are mounting. The excess reserves expose the central bank to maturity risk and provisions are needed to insure against the financial risk implicit in an increasing interest rate. While these provisions indirectly post a cost to the tax payer, the excess reserves pose a cost to the banks given that – at an aggregate level – they hold these assets at a very low or negative return.

Moreover, the new state can be problematic if it goes in tandem with impaired financial intermediation. The new state is endogenous on central bank interventions, which market participants ingrain in their behaviour the longer the interventions persist. This comes with the risk that at some point (of excess liquidity) the financial sector may not be able to function on its own anymore. That would hamper an efficient allocation of funds in the economy that can have welfare costs. An inefficient allocation may also arise in the low interest rate regime if it stimulates portfolio rebalancing by non-bank agents that inflates asset prices and increases financial stability risk. The primary sources of such financial risk-taking are captured by the MM.

[17] This is akin to *Goodfriend's* (2002) description of central bank excess reserves in a floor system of monetary policy implementation as government debt with a floating market interest rate.

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The persistence of the low regime suggests that monetary policy by itself is impotent to escape from the liquidity trap. We argued that actions by other agents than the central bank are needed to escape from the trap. They can contribute to reduce frictions for inside money creation, as illustrated by the effectiveness of government and supervisory measures in supporting lending and deposit creation in the pandemic. It underlines that the transition to a low MM regime is not necessarily permanent. Having said this, the persistence of the MM regimes indicates that a return to the old state is hard to realize, taking into account that excess reserves have been there for many years and QE seems notoriously hard to end.

VI. Conclusion

The analysis in this paper illustrates that the MM summarizes information about the dynamics in monetary aggregates. We furthermore showed how a behavioural perspective on the MM helps to explain the dynamics of inside and outside money. The dynamics result from demand and supply decisions of different economic agents, who interact and respond to macro-financial conditions. In particular the creation of large outside money balances by central banks shaped a regime with a low MM and low market interest rates.

The persistence of the MM regimes indicates that the MM has been trapped in a new equilibrium situation since the GFC. This state reflects that the central bank and the private financial sector interact differently than before. Behavioural interactions have reinforced that excess liquidity supply remained trapped in the banking sector. While central banks created excess reserves for monetary policy reasons, the subsequent decline of market interest rates reduced the opportunity costs of reserve holdings and safe assets like government bonds. This has made reserve holdings (outside money) relatively more attractive compared to loans (inside money), reinforcing a regime with a low MM and low market interest rate. This has economic consequences, since the new regime is associated with different levels of market interest rates, reserve holdings and bank lending.

The low MM suggests that the financial intermediation process has not been working well since the GFC, as the large outside money creation has not been matched by inside money growth. This can be explained by the behaviour of agents and frictions, amongst other factors. This makes the MM a useful concept to understand the monetary implications of policy measures and shocks to which agents respond. The pandemic is an example where other agents than the central bank can – and might be needed to – help to escape from the excess liquidity trap by removing frictions for lending and deposit creation. Policy measures by such agents likely also run through other channels than the ones we modelled, such as liquidity transfers to the money holding sectors. Modelling

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such channels more in depth and using a general equilibrium perspective is left to future research.

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Annex

Partial derivatives of i_L and m with respect to i_R and n, based on eq. (9) – (13).

$$\frac{\partial i_L}{\partial i_R} = \frac{\varphi}{\gamma + \varphi} \qquad > 0$$

$$\frac{\partial m}{\partial i_R} = -\frac{\gamma}{\gamma + \varphi} \qquad < 0$$

$$\frac{\partial i_L}{\partial n} = \frac{\varphi}{\gamma + \varphi} \qquad > 0$$

$$\frac{\partial m}{\partial n} = -\frac{\gamma}{\gamma + \varphi} \qquad < 0$$

Given the parameter restrictions γ, φ, $\lambda > 0$.

Equation (12) reads as follows:

$$n = q\sigma_L + g\kappa_b + h\tau_m + jv^s$$

With q positive and g, h and j negative.

We now turn to a simultaneous equilibrium in both the money market and the bank loan market. Substituting eq. (8) in eq. (13) implies:

$$i_L = \frac{\left(\bar{L}_d - \bar{L}_s\right)\text{ö}+ \varphi\left(i_{ER} + \lambda^{-1}\left[v^d - v^s\right]\right) + \quad \left(q\sigma_L + g\kappa_b + h\tau_m + jv^s\right)}{\varphi + \gamma}$$

and

$$L = \frac{\left(\varphi\bar{L}_d + \gamma\bar{L}_s\right)\text{ö}- \varphi\left(i_{ER} + \lambda^{-1}\left[v^d - v^s\right]\right) - \quad \left(q\sigma_L + g\kappa_b + h\tau_m + jv^s\right)}{\varphi + \gamma}$$

Key parameters are the sensitivity of banks to the profitability of providing loans and to the (opportunity) cost of holding reserves, as well as the loan demand sensitivity of bank clients to the price of bank credit, i. e. φ, λ and γ. Stability of the equilibrium in the loan market requires $\gamma + \varphi > 0$, a condition that is fulfilled given our parameter restrictions.

Conventional monetary policy is implemented using i_{ER} and unconventional via v^s. The effects of these policies on the equilibrium bank lending rate are represented by:

$$\frac{\partial i_L}{\partial v^s} = \frac{\varphi}{\gamma + \varphi}\left(j - \lambda^{-1}\right)$$

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$$\frac{\partial i_L}{\partial i_{ER}} = \frac{\varphi}{\gamma + \varphi}$$

Using our parameter restrictions this implies $\partial i_L / \partial v^s < 0$ and $0 < \partial i_L / \partial i_{ER} < 1$. It clearly shows how unconventional monetary policy affects the banking sector both via the conditions in the reserve market and via financial frictions.

Equilibrium effects of (un)conventional monetary policies on the amount of loans read as follows:

$$\frac{\partial L}{\partial v^s} = -\gamma \frac{\partial i_L}{\partial v^s} \qquad > 0$$

$$\frac{\partial L}{\partial i_{ER}} = -\gamma \frac{\partial i_L}{\partial i_{ER}} \qquad -1 < \partial L / \partial i_{ER} < 0$$

That is, a change in monetary policy, conventional or unconventional, has the expected effects on the equilibrium values of both the price and quantity of credit. For the reserve market, the effects are:

$$\frac{\partial R}{\partial v^s} = 1$$

$$\frac{\partial R}{\partial i_{ER}} = 0$$

Illustrating the central bank role as monopolist supplier of reserves.

Given the linear nature of our model, the equilibria in both markets will be unique, as will be the simultaneous equilibrium.

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