The Money-Creation Model: Graphic Illustration

Abstract

This paper proposes a pedagogical apparatus embodying a solid micro-foundation with emphasis on the public’s choice between currency and demand deposits being an optimal decision. Based on the proposed pedagogical apparatus, this paper explains how money supply is related to the combined behaviors of the central bank, commercial banks, and the public.

1. Introduction

Macroeconomics as well as money and banking textbooks usually adopt the T-account pedagogy to illustrate the money-creation process and the money multiplier. This paper proposes a pedagogical exposition to illustrate how money supply is related to the combined behaviors of the central bank, commercial banks, and the public. Our graphical analysis emphasizes that the public's choice between currency and demand deposits is an optimal decision. This salient feature contributes to at least two advantages. Firstly, it provides a solid micro-foundation for money-creation theory that traditional macroeconomics as well as money and banking textbooks lack (or neglect). Though an appropriate micro-foundation for money-creation theory is often ignored by economists, such an analysis can indeed give students a more complete picture concerning the roles played by the three protagonists (the central bank, commercial banks, and the public) in money creation.

Secondly, most macroeconomics textbooks (for example, Burda and Wylosz (1997, p. 223), Barro (1997, pp. 669-670), and Jansen et al. (1994, p. 475)) point out that the currency-deposit ratio varies over time and/or across countries. They also indicate that a change in the composition of the public’s money holding often plays a crucial role in affecting money supply. However, perhaps due to the ease of explanation, these textbooks take the ratio of the public’s currency to demand deposits as given. To reflect these practical observations, it is more plausible that the public's currency-deposit ratio should be an endogenous variable and result from a rational decision on the part of the public. From this perspective, our analysis is more realistic when compared with the traditional approach in macroeconomics textbooks.

2. The Depositor’s Optimal Decision

Let \( C \) and \( D \) denote currency held by the public and demand deposits, respectively. The money supply \( M \) can thus be expressed as:

\[
M = C + D
\]
Branson (1989, p. 353) documents that commercial banks obtain reserves from two sources. First, the Federal Reserve (Fed) purchases bonds from commercial banks through open market operations, leading commercial banks to obtain non-borrowed reserves $RU$. Second, the Fed makes discount loans to commercial banks, causing these commercial banks to have borrowed reserves $RB$. On the other hand, commercial banks allocate their total reserves in three ways. First, since the Fed requires that a certain fraction of deposits be kept as reserves, commercial banks should hold required reserves $RR$. Second, in addition to required reserves, commercial banks may choose to hold excess reserves $RE$. Third, the depositors may convert some of their deposits into currency $C$, and thus these reserves are used as currency in the hands of the public. This gives us the following relation:

$$RU + RB = RR + RE + C \text{ or } C = RU + RB - RE + rD.$$  \hfill (2)

In (2), by defining $r$ as the required reserve ratio, we have $RR = rD$.

Assuming that depositors are concerned about their holdings of currency and demand deposits, their utility function can thus be expressed by the following form:

$$U = U(C, D) ; \quad UC > 0, UD > 0, UCC < 0, UDD < 0.$$  \hfill (3)

The depositors’ optimal decision is to choose the best combination of currency and demand deposits that maximizes their satisfaction level, subject to the constraint reported in (2). As shown in Figure 1, the constraint line $CL$ describes the feasible combinations faced by the depositors. As indicated in (2), the vertical intercept of the $CL$ line is $RU + RB - RE$ and the slope of the $CL$ locus is $-r$. In addition, the set of indifference curves, namely $IC$, that reflect the ranking of the depositors’ preferences. Thus, the depositors choose a combination of currency and demand deposits so as to attain the highest level of satisfaction given the constraint line $CL$.

Assume initially that non-borrowed reserves, borrowed reserves, excess reserves, and the required reserve ratio are $RU_0$, $RB_0$, $RE_0$, and $r_0$, respectively. Accordingly, as indicated in Figure 1, the initial constraint line is $CL_0$, the vertical intercept of the $CL_0$ locus is $RU_0 + RB_0 - RE_0$, and the slope of $CL_0$ is $-r_0$. Point $Q_0$, at which both $IC_0$ and $CL_0$ are tangential to each other, represents the highest utility that can be reached by the depositors given the constraint. The best combination of currency and demand deposits is $C_0$ and $D_0$. We then draw a 45-degree line $MM_0$, that passes through point $Q_0$, to serve as an auxiliary line. Given the definition of the money supply $M = C + D$, it is clear that the vertical intercept of the 45-degree line $MM_0$ is the initial money supply $M_0$ (i.e.,

![Fig. 1 Depositors’ Optimal Choice and Money Supply Determination](image)
3. The Underlying Factors of the Money Supply

We now are ready to deal with the issue of how the Fed, commercial banks, and the public govern the actual money supply.

In general, the Fed employs three major tools to affect the money supply: open market operations, the required reserve ratio, and the discount rate. Commercial banks affect the money supply by means of changing their excess reserves. Depositors alter the money stock by adjusting their desired currency-deposit ratio. We then address the linkage between money supply and the behavior of the Fed, commercial banks, and the public.

The Fed’s Instruments

Open Market Operations

Open market operations are purchases and sales of government bonds by the Fed, and it is the policy instrument that the Fed utilizes most often. When the Fed engages in open market operations to purchase government bonds from commercial banks, commercial banks will increase their holdings of non-borrowed reserves from $RU_0$ to $RU_1$. As indicated in Figure 2, this will shift the constraint line rightward from $CL_0$ to $CL_1$, and, as a result, the vertical intercept of the $CL_1$ line ($RU_1 + RB_0 - RE_0$) is greater than that of the $CL_0$ line ($RU_0 + RB_0 - RE_0$). With this change in the constraint line, to maximize their utility the depositors will choose point $Q_1$, where the new constraint line $CL_1$ is tangential to the indifference curve $IC_1$. The corresponding optimal currency and demand deposits associated with point $Q_1$ are now $C_1$ and $D_1$, respectively. This implies that if the Fed purchases government bonds from commercial banks, depositors will raise their holdings of currency from $C_0$ to $C_1$ and demand deposits from $D_0$ to $D_1$.¹

We draw a 45-degree line $MM_1$ that passes through point $Q_1$ to serve as the auxiliary line. It is clear that the vertical intercept of the $MM_1$ line ($M_1$) is the new level of money supply after the Fed engages in open market operations. By comparing the $MM_1$ line with $MM_0$, we can easily find that the vertical intercept of $MM_1$ is smaller than that of $MM_0$. This reveals that the money supply rises when the Fed engages in open market operations to purchase government bonds from commercial banks.

¹To be more consistent with reality, we assume that both currency and demand deposits are normal goods.
A Change in the Required Reserve Ratio

We next consider what would happen if the Fed were to change the required reserve ratio, which is illustrated in Figure 3. When the Fed raises the required reserve ratio from $r_1$ to $r_2$, the constraint line will rotate downward from $CL_0$ to $CL_1$, since the vertical intercept of the constraint line remains intact and the slope of the constraint line (in terms of absolute value) increases. Faced with the new constraint line $CL_1$, utility-maximizing depositors will move to point $Q_1$, where the new constraint line $CL_1$ is tangential to the indifference curve $IC_1$. As shown in Figure 3, a rise in the required reserve ratio induces depositors to lower both currency (from $C_0$ to $C_1$) and deposits (from $D_0$ to $D_1$). By drawing a 45-degree line $MM_1$ that passes through point $Q_1$, the vertical intercept of the $MM_1$ line reflects the new level of money supply. Since the vertical intercept of $MM_1$ is greater than that of $MM_0$, a rise in the required reserve ratio lends to lower the money supply.

A Change in the Discount Rate

If the spread between the market interest rate and the discount rate increases, commercial banks are inclined to borrow more discount loans from the Fed. Accordingly, when the Fed raises the discount rate, commercial banks incur a higher cost for any reserves that they borrow from the Fed. In the face of a higher cost of loans, commercial banks have an incentive to lower their discount borrowing from the Fed. With this understanding, commercial banks will lower their borrowed reserves from $RB_0$ to $RB_1$ in response to a rise in the discount rate. As a consequence, Figure 4 indicates that the constraint line $CL_0$ will shift leftward to $CL_1$, and the vertical intercept of $CL_1$ is $RU + RB_1 - RE_0$.

Faced with the new constraint line, the depositors, in order to maximize utility, will choose point $Q_1$, where the new constraint line $CL_1$ is tangential to the indifference curve $IC_1$. By comparing point $Q_1$ with point $Q_0$, it is clear that a reduction in borrowed reserves will induce depositors to lower their holdings of currency from $C_0$ to $C_1$ and deposits from $D_0$ to $D_1$. It follows from Figure 4 that since the vertical intercept of $MM_1$ is greater than that of $MM_0$, we can conclude that the money supply will decrease when the Fed raises the discount rate.
Commercial Banks’ Behavior

Figure 5 addresses the link between commercial banks’ activities and the money stock. When commercial banks raise their holdings of excess reserves from \( RE_0 \) to \( RE_1 \), the constraint line will shift leftward from \( CL_0 \) to \( CL_1 \). The vertical intercept of the \( CL \) locus is then \( RU + RB_0 \). Faced with the new constraint line, depositors will choose point \( Q_1 \), where the new constraint line \( CL_1 \) is tangential to the indifference curve \( IC_1 \), as their new optimum position. This implies that a rise in excess reserves will induce depositors to lower their holding of currency from \( C_0 \) to \( C_1 \) and demand deposits from \( D_0 \) to \( D_1 \). Moreover, by referring to Figure 5, given that the vertical intercept of \( MM_0 \) is greater than that of \( MM_1 \), the money supply will decrease when commercial banks raise their holdings of excess reserves.

Depositors’ Behavior

Depositors can affect the level of money stock through changing their preference to hold currency relative to demand deposits. A change in depositors’ preference may occur in some situations. First, when the economy experiences either bank runs or bank panics, depositors may risk incurring substantial losses on deposits. They thus have an incentive to have a greater preference for currency and less preference for deposits. Second, when depositors subjectively anticipate a surge in inflation, the relative attractiveness of currency to deposits will rise since depositors will increase their consumption of goods.

We utilize Figure 6 to address what would happen when depositors exhibit a stronger preference for currency and less preference for demand deposits. In such a case, the indifference map will become flatter. Hence, at the initial equilibrium point \( Q_0 \), the new indifference curve \( IC' \) is flatter than the constraint line \( CL_0 \), and the new equilibrium should occur at point \( Q_1 \), which is to the left of \( Q_0 \) on the \( CL_0 \) line. At point \( Q_1 \), the combination of currency and demand deposits is equal to \( C_1 \) and \( D_1 \). Accordingly, when depositors exhibit a greater preference for holding currency relative to demand deposits, they will raise...
their holding of currency from $C_0$ to $C_1$ and reduce their demand deposits from $D_0$ to $D_1$. Analogously, by drawing a 45-degree line $MM_1$ that passes through point $Q_1$, the vertical intercept of the $MM_1$ line (labeled $M_1$ in Figure 6) reflects the new level of money supply. By comparing the vertical intercepts of both lines $MM_1$ and $MM_0$, it is quite clear that the vertical intercept of $MM_1$ is greater than that of $MM_0$. Consequently, the money supply will shrink when depositors exhibit a greater preference for holding currency relative to demand deposits.

Before ending this section, we would like to emphasize that our graphical apparatus could be used to analyze bank panics in both historical and contemporary experience. Faced with a crisis situation, the public is inclined to convert deposits into currency, leading to a rise in the currency-deposit ratio. Therefore, in order to meet the substantial surge in deposit outflows, the commercial banks will respond by raising their holdings of excess reserves. This implies that not only will the indifference curve become flatter, but the $CL$ line will also shift to the left. Therefore, the money supply will fall dramatically.

4. Concluding Remarks

This paper provides a graphical pedagogy as a supplement to the T-account pedagogy, with the salient feature of our pedagogical apparatus being that it embodies a solid micro-foundation. In particular, we highlight that the Fed cannot completely control the money supply, and that commercial banks and the public also play a crucial role in determining the level of money supply. Our graphical illustration will enhance and deepen a student’s understanding of the money-creation process.

**Ching-Chong Lai**, **Juin-Jen Chang**, **Ming-Ruey Kao**

1Institute of Economics, Academia Sinica
2Research Center for Humanities and Social Sciences, Academia Sinica


References