Chapter 14
Money and Monetary Policy in the Intertemporal Framework

We have for the most part ignored the role of money and thus monetary policy in our study so far. This is because the main issues we have been considering – in particular, the idea of optimal decision-making by representative agents, which lead to the benchmark consumption-leisure and consumption-savings optimality conditions – turn out to not require explicit consideration of money.

Our lack of meaningful inclusion of "money" is also in part due to the fact that it has proven somewhat difficult to construct a simple framework for the three distinct roles that "money" plays in modern society. For centuries (or perhaps millienia), those three distinct roles have been thought to be:

1) A medium of exchange (which circumvents the problems of barter exchange, which is nearly impossible in developed economies)

2) A unit of account (as an example, if you spend U.S. dollars at a U.S. store, the price tags will be denoted in numbers of U.S. dollars, rather than in, say, numbers of ballpoint pens)

3) A store of value (if a piece of fruit were used to make payments, one piece of fruit would obviously decay very quick, within days or weeks at best – which implies that its value erodes quickly; instead, one piece of fibrous and secure paper that displays George Washington's portrait is likely to last for decades)

Despite the theoretical difficulty of incorporating the "hows" and "whys" of particular societies or countries or eras settling on a commonly understood definition of "money," it is virtually **entirely** about money around which the divide between the RBC school of thought and the New Keynesian school of thought emerges. To illustrate the fundamental difference between the two theories and hence the fundamental split in modern macroeconomic theory, we need to develop a concept of **money market equilibrium**, which in turn requires both money demand and money supply. We will take a shortcut, but widely-used, approach, which is the **money-in-the-utility (MIU) function** framework to generate demand for money.

Simply put, the MIU approach simply inserts (real) money – that is, the purchasing power of monetary units – as an argument to the representative consumer's utility function. Before getting to the economics of and short-run and long-run policy recommendations that emerge from the MIU framework, though, we refresh ourselves on the linkages between monetary markets and bond markets.

Government Bond Market

You should already be familiar with the concepts briefly presented in this section. But because the connection between monetary markets and bond markets is crucial for understanding how monetary policy operates, a brief recap seems appropriate.

We assume that the bonds are all government bonds.[103] In "conventional" times, the Federal Reserve implements its policy decisions via open market purchases or sales of U.S. government bonds. Moreover, we assume all bonds are nominal bonds, meaning that each unit of a bond pays back a fixed amount of currency.

We will speak of a single government bond market within a country, even though there are many different types of bonds issued by governments, distinguished primarily by their maturity length and face value. A bond's **maturity length** is the time from issuance until the full value of the bond is repaid to the bond-holder, while a bond's **face value** is the full value that is repaid upon maturity. For example, the U.S. government issues one-month Treasury bills, three-month Treasury bills, six-month Treasury bills, two-year Treasury notes, three-year Treasury notes, five-year Treasury notes, and ten-year Treasury notes of various face values.[104]

Bonds are simply loans, a point that is often misunderstood. Regardless of a bond's maturity length and face value, a government bond is simply a loan that a bond-holder provides to the government to be repaid at a later date with interest. The amount to be repaid at the pre-specified date is the bond's face value.

Because the face value is not repaid until some future time period, the amount that a bond-holder would be willing to pay **in the current period** for a bond of face value FV dollars is something less than FV dollars. The reason for this is simply the time-discounting of future values. For example, $100 one year from now is likely worth less than $100 to you right now – in other words, you are likely to be willing to accept something less than $100 at this instant in lieu of receiving nothing now and $100 one year from today.

Because of time-discounting, the period-t price (denoted P_t^b) of a one-period maturity bond is related to its face value FV_{t+1} and the nominal interest rate i_t, which represents

[103] There exist also corporate bonds (bonds issued by companies) and hence markets for corporate bonds, which are important markets. However, for standard, or "conventional," monetary policy purposes, it is fairly irrelevant which types of bonds exist, so we will ignore corporate bond markets.

[104] There are also many other maturity lengths of U.S. government bonds.

the interest component between period t and period t+1. The relationship between these three objects is

$$P_t^b = \frac{FV_{t+1}}{1+i_t}.$$

The way this expression is written makes it seem that it defines the price of a bond. But a common interpretation of this expression is that it instead defines the nominal interest rate i_t, because at any point in time a bond's face value and the amount bond demanders are willing to pay are known. Thus, knowledge of P_t^b and FV_{t+1} can be thought of as defining i_t.

Algebraically, we can emphasize this relationship by simply re-arranging the expression above to isolate for the nominal interest rate, which is

$$i_t = \frac{FV_{t+1}}{P_t^b} - 1.$$

These two equations are obviously equivalent to each other.

We also include three other simplifying points for the sake of ease of the ensuing analysis.

1. The face value is always equal to $FV = 1$, hence we can drop the time subscript and the tedious-to-write FV.

2. In practice, there are two main types of bonds – coupon bonds and zero-coupon bonds. A coupon bond is one that makes interest payments (called coupon payments) to the bond-holder at specified times before a final payment of the face value at the maturity date, while a zero-coupon bond offers no intermediate payments before the payment of the face value at the maturity date. For convenience, we will suppose that all bonds are zero-coupon bonds because it does not matter for either the short-run or long-run analysis.

3. Nominal bond repayments are always fully repaid on time.

The last point says the government never defaults on its nominal bond obligations, which, if we zoom in on the U.S. government, is true.

Money-in-the-Utility (MIU) Function and Money Demand

Now we begin with the infinite-horizon framework. The particular financial asset application when we first considered the infinite-horizon framework was stock-market pricing. But a broader theme that emerges from the previous analysis is about **asset pricing** in general, regardless of the particular type of financial asset under consideration. In the expanded infinite-period framework here, there will be three distinct types of assets: stocks, money, and bonds. Figure 79 portrays this richer class of financial assets and the timing of events.

Mathematically, we augment the representative consumer's period-t utility function to now include **money demand** as an argument – in particular, the **demanded** quantity of money, which is the essence of the MIU model. Suppose the representative consumer's period-t utility function is

$$u\left(c_t, \frac{M_t^D}{P_t}\right),$$

in which M_t^D / P_t is the consumer's demand for **real** money balances – that is, for the **purchasing power** that a **given nominal demand** M_t^D holdings provides. Overall, the real money demand argument is a stand-in for the various roles that money plays in different time periods, as described earlier.

Because of the subjective discount factor $\beta \in (0,1)$ (which indeed carries over from our earlier analysis of the infinite-period framework), the **lifetime discounted utility from the perspective of the very beginning of period t** can be stated as

$$u\left(c_t, \frac{M_t^D}{P_t}\right) + \beta u\left(c_{t+1}, \frac{M_{t+1}^D}{P_{t+1}}\right) + \beta^2 u\left(c_{t+2}, \frac{M_{t+2}^D}{P_{t+2}}\right) + \beta^3 u\left(c_{t+2}, \frac{M_{t+3}^D}{P_{t+3}}\right) + \ldots$$
$$= \sum_{s=0}^{\infty} \beta^s u\left(c_{t+s}, \frac{M_{t+s}^D}{P_{t+s}}\right);$$

the second line writes the present-value lifetime utility function compactly using the summation operator $\sum$.

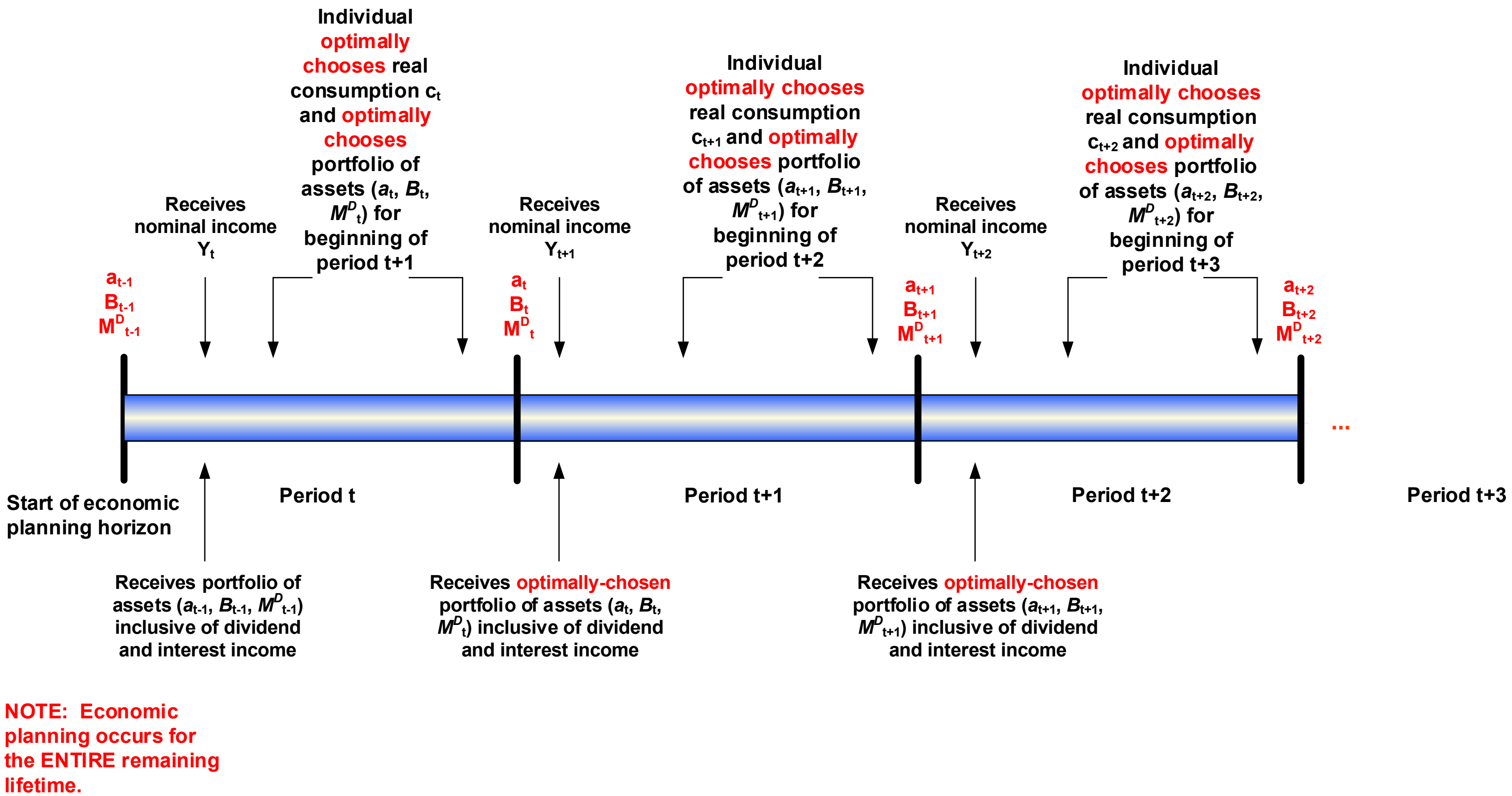

Figure 79. Timeline of events in infinite-period monetary framework.

During every time period, an optimal "rebalancing" amongst the three assets in the portfolio occurs. This is described in the period-t budget constraint of the consumer,

$$P_t c_t + P_t^b B_t + M_t^D + S_t a_t = Y_t + M_{t-1}^D + B_{t-1} + (S_t + D_t) a_{t-1},$$

in which, as in the basic asset-pricing framing, P_t is the nominal price of consumption, S_t is the nominal price of a one unit of stock in period t, and D_t is the nominal dividend per share in period t. Notice the timing of the budget constraint: in period t, the consumer chooses nominal money holdings to carry into period t+1.[105] (And see also Figure 79.)

In turn is implied that the period t+1 flow budget constraint is

$$P_{t+1} c_{t+1} + P_{t+1}^b B_{t+1} + M_{t+1}^D + S_{t+1} a_{t+1} = Y_{t+1} + M_t^D + B_t + (S_{t+1} + D_{t+1}) a_t,$$

the period t+2 flow budget constraint is

$$P_{t+2} c_{t+2} + P_{t+2}^b B_{t+2} + M_{t+2}^D + S_{t+2} a_{t+2} = Y_{t+2} + M_{t+1}^D + B_{t+1} + (S_{t+2} + D_{t+2}) a_{t+1},$$

and so on for periods t+3, t+4, t+5, ...

Optimal Choice

The sequential Lagrange problem stated in nominal terms is

$$\begin{aligned}
&u\left(c_t, \frac{M_t^D}{P_t}\right) + \beta u\left(c_{t+1}, \frac{M_{t+1}^D}{P_{t+1}}\right) + \beta^2 u\left(c_{t+2}, \frac{M_{t+2}^D}{P_{t+2}}\right) + \beta^3 u\left(c_{t+2}, \frac{M_{t+3}^D}{P_{t+3}}\right) + \dots \\
&+\lambda_t \cdot \left[Y_t + M_{t-1}^D + B_{t-1} + (S_t + D_t) a_{t-1} - P_t c_t - P_t^b B_t - M_t^D - S_t a_t \right] \\
&+\beta \lambda_{t+1} \cdot \left[Y_{t+1} + M_t^D + B_t + (S_{t+1} + D_{t+1}) a_t - P_{t+1} c_{t+1} - P_{t+1}^b B_{t+1} - M_{t+1}^D - S_{t+1} a_{t+1} \right] \\
&+\beta^2 \lambda_{t+2} \cdot \left[Y_{t+2} + M_{t+1}^D + B_{t+1} + (S_{t+2} + D_{t+2}) a_{t+1} - P_{t+2} c_{t+2} - P_{t+2}^b B_{t+2} - M_{t+2}^D - S_{t+2} a_{t+2} \right] \\
&+\dots
\end{aligned}$$

[105] Mechanically, we know this because it is M_t^D, rather than M_{t-1}^D, that appears on the left-hand-side of the budget constraint, and the left-hand-side represents "outlays" in period *t*.

which should look familiar to you – it is simply an extension of the sequential Lagrange function in our earlier study of stock-market pricing.

The first-order conditions with respect to c_t , a_t, B_t, and M_t^D are, respectively,

$$u_1\left(c_t, \frac{M_t^D}{P_t}\right) - \lambda_t P_t = 0,$$

$$-\lambda_t S_t + \beta\lambda_{t+1}\left(S_{t+1} + D_{t+1}\right) = 0,$$

$$-\lambda_t P_t^b + \beta\lambda_{t+1} = 0,$$

and

$$u_2\left(c_t, \frac{M_t^D}{P_t}\right) \cdot \frac{1}{P_t} - \lambda_t + \beta\lambda_{t+1} = 0.$$

The first condition states the usual result that the marginal utility of consumption equals the Lagrange multiplier (scaled by the price level P_t). The second first-order condition is our familiar stock-pricing equation. The third first-order condition is that on bond holdings. In the fourth first-order condition, the $1/P_t$ term arises because each individual can **choose** his/her **nominal** money holdings, but takes the aggregate price level P_t as given. Because **real, not nominal,** money demand is the second argument of the utility function, the chain rule is required, which generates the $1/P_t$ term.

These four first-order conditions taken together generate **many** rich insights about linkages between bonds markets and stock markets, between bond markets and monetary markets, and are the foundation of possible ideological divides between whether or not changes in monetary policy affect either short-run macroeconomic conditions or long-run macroeconomic conditions or both. The following sections describe these insights in turn. As you will see, we will go back and forth between "macroeconomic theory" and "finance theory" – given the richness of the framework, the "intersection" between the two apparently different strands of thought turns out to be a very clear intersection.

Pricing Kernel and Asset Prices

Delve back into a bit of finance theory, we can rearrange the first-order condition on bond holdings to get

$$P_t^b = \frac{\beta\lambda_{t+1}}{\lambda_t}.$$

This already sheds a lot of light on the intersection of macro and finance! Recall from our study of stock-pricing that $\beta\lambda_{t+1}/\lambda_t$ was defined as the "pricing kernel" of the economy.

Here it is!

The price of a nominal bond equals the pricing kernel times one.[106]

Or, stated from the opposite perspective, the pricing kernel of an economy equals the price of a short-term riskless nominal bond.[107]

Note that the above P_t^b expression is of the same general form as the stock-pricing equation we encountered earlier – the price of an asset (P_t^b) depends on a pricing kernel and a future payoff (which is simply $FV = 1$). Bonds are thus priced using the general type of asset-pricing equation we used to price stocks.

Continuing, the first-order condition on a_t gives us

$$S_t = \frac{\beta\lambda_{t+1}}{\lambda_t}(S_{t+1} + D_{t+1}),$$

which is our usual stock price condition. From what we now know, we can alternatively express the stock-price as

$$S_t = P_t^b(S_{t+1} + D_{t+1}),$$

which explicitly demonstrates a crucial linkage between bond prices and stock prices. Stock prices can thus be said to be keyed (partially) off of bonds prices.

[106] The "one" here is simply the payoff of the nominal bond in our model – that is, we assumed that the face value, hence the payoff, of the bond is $FV = 1$.
[107] The "riskless" component was mentioned above, so we can think of these nominal bonds as U.S. government nominal bonds.

The big-picture, finance-theoretic, lesson to take away here is that asset-pricing equations invariably have the same general form, regardless of what specific type of asset is being considered. That general form is

price of asset in current period = (pricing kernel) x (asset-appropriate future returns)

Fisher Equation

We can obtain the exact Fisher equation as an implication of optimal choices in this model, rather than as a relationship which we so far have seemingly "assumed" to be true.

To see this, begin with the last expression, $S_t = P_t^b(S_{t+1} + D_{t+1})$. Divide this expression through by the nominal price level P_t (which is distinct from the nominal price of a bond P_t^b), to get

$$\frac{S_t}{P_t} = P_t^b \frac{(S_{t+1} + D_{t+1})}{P_t}.$$

Next, on the right-hand-side, multiply and divide by P_{t+1} / P_{t+1} (which is of course just multiplying by one, which is always a valid operation to conduct…) to arrive at

$$\frac{S_t}{P_t} = P_t^b \frac{(S_{t+1} + D_{t+1})}{P_{t+1}} \cdot \frac{P_{t+1}}{P_t}.$$

The **real** price of stock purchased in period t is S_t / P_t (because it is divided by the current price level), while the **real** payoff in period t+1 of the stock purchased in period t+1 is $(S_{t+1} + D_{t+1}) / P_{t+1}$ (because it is divided by the future price level). The period-(t+1) real payoff divided by the period-t real price is **defined as the real return** on the asset – that is, it is the object we have heretofore been calling the real interest rate.[108]

Letting r_t denote the real interest rate between period t and period t+1, we therefore have that

[108] Stocks are considered to be "real" assets because their payoff is generally not fixed in currency terms, whereas bonds are considered to be "nominal" assets because their payoff is generally fixed in currency terms (non-indexed bonds, at least).

$$1+r_t = \frac{(S_{t+1}+D_{t+1})/P_{t+1}}{S_t/P_t}.$$

With this, we can write the previous expression as

$$\frac{1}{P_t^b} = (1+r_t)\cdot\frac{P_{t+1}}{P_t}.$$

Only one more step remains in obtaining the exact Fisher relation from first principles. To finish the algebra, note that, by construction and based on our definitions, $1/P_t^b = 1+i_t$, and $P_{t+1}/P_t = 1+\pi_{t+1}$.

The previous expression can thus be re-written as

$$1+i_t = (1+r_t)(1+\pi_{t+1}),$$

which **is** the exact Fisher relation.

The economic intuition behind the Fisher equation is that it links the returns available on nominal assets (nominal bonds) and the returns available on real assets (stocks). The linkage is through inflation; once the nominal returns of bonds are adjusted by inflation, **their returns on nominal bonds are exactly equal to the returns on stocks,** provided financial markets are "operating well."

This type of idea – that, once returns are converted into comparable units, they are equalized when markets are behaving rationally – goes by the terminology of **no-arbitrage** in finance theory. No-arbitrage relationships are key building blocks of more advanced finance theory; we defer richer consideration of issues stemming from such relationships to a more advanced course on finance theory.

The exact Fisher equation emerges naturally in any model featuring **both** nominal assets and **any** type of real asset, not just stocks. This brings us back full circle to our initial study of the two-period consumption-savings model, in which we asserted the exact Fisher equation.

Nominal Interest Rates and Money Demand

Next, let's consider how the nominal interest rate i_t affects macroeconomic conditions. So far, we have not exploited the information contained in the first-order conditions with respect to consumption or money holdings, but now we finally will.

Rewrite the first-order condition on nominal money holdings from above as

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{P_t} - \lambda_t = -\beta\lambda_{t+1}.$$

We know from the first-order condition on bond holdings that $\beta\lambda_{t+1} = \lambda_t P_t^b$; inserting this in the previous expression gives

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{P_t} - \lambda_t = -\lambda_t P_t^b.$$

Dividing through by λ_t,

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{\lambda_t P_t} - 1 = -P_t^b.$$

Next, we can use the first-order condition on consumption to replace the $\lambda_t P_t$ term on the left-hand-side, giving us

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{u_1\left(c_t, \frac{M_t^D}{P_t}\right)} = 1 - P_t^b.$$

The term on the left-hand-side now is just the MRS between real money demand and consumption – i.e., it is the ratio of the marginal utility of (real) money to the marginal utility of consumption.

As for the right-hand-side of this expression, because $P_t^b = 1/(1+i_t)$, it can be stated as

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{u_1\left(c_t, \frac{M_t^D}{P_t}\right)} = 1 - \frac{1}{1+i_t}.$$

One final algebraic simplification gives us the **consumption-money optimality condition**

$$\frac{u_2\left(c_t, \frac{M_t^D}{P_t}\right)}{u_1\left(c_t, \frac{M_t^D}{P_t}\right)} = \frac{i_t}{1+i_t},$$

which states that the MRS between period-t real money and period-t consumption equals a function of the nominal interest rate at the representative agent's optimal choice. This optimality condition is completely analogous to the consumption-leisure optimality condition and the consumption-savings optimality condition with which we have become familiar. The consumption-money optimality condition states that when consumers are making their optimal choices, they choose consumption and **real** money holdings in such a way as to equate their MRS between consumption and money demand to a function of the **nominal** interest rate.

Except for interpretation, the indifference-curve/budget constraint diagram in Figure 80 ought to look familiar by now.

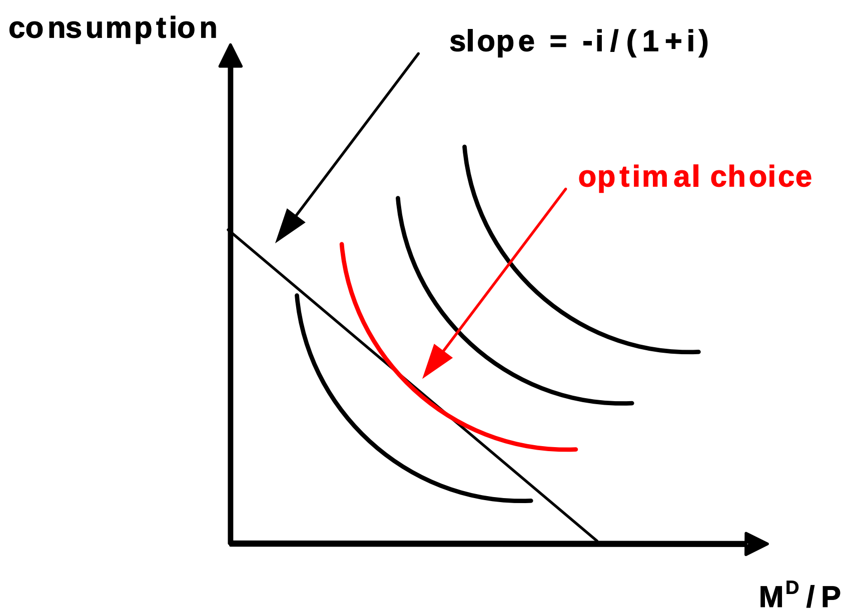

Figure 80. Consumption-money demand optimality condition.

Also, as in, say, the consumption-leisure analysis, we can translate the optimal choices for any particular nominal interest rate *i* in the indifference curve/budget constraint diagram in Figure 80 to a market diagram. Figure 81 traces the quantity of money demanded as a function of its price *i*. To get from Figure 80 to Figure 81, conduct the following thought experiment: successively lower the nominal interest rate i in Figure 80. Along the money demand axis, it seems to be the case that M^D successively increases. If this is true, this generates the clear downward-sloping portion of the money demand function in the money-market space of Figure 81.

Continuing the thought experiment, suppose i is extremely small – for example, i = 0.0125. It is apparent from the consumption-money optimality condition that the budget line is extremely flat. **If *i* were to hit exactly zero or turn strictly negative, the optimality condition would make no sense at all.** Because of the strict equality sign in the consumption-money optimality condition, it would imply that the MRS between consumption and real money demand was negative, which violates (at least 99.9999% of the time…) basic microeconomic principles. Casual inspection of Figure 80, which has the "usually shaped indifference curves" that are strictly convex to the origin, also visually confirms this.

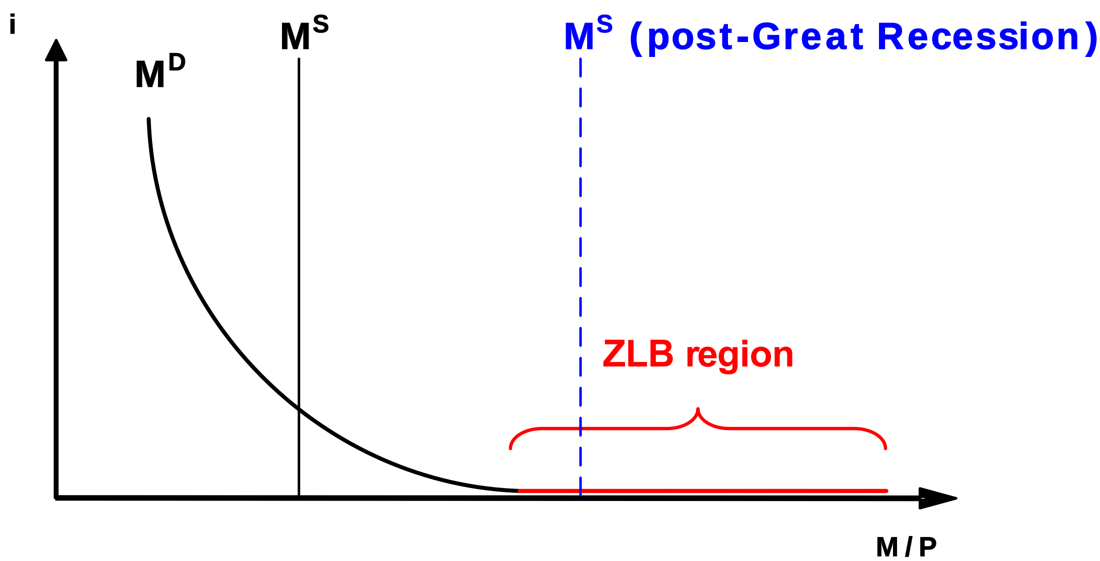

Figure 81. The money market. Money demand (M^D) increases as nominal interest rate i decreases. Nominal interest rates can never fall below zero.

Hence emerges the **"zero lower bound" (ZLB) restriction on nominal interest rates,** which states exactly what we concluded: **nominal interest rates can never fall below zero.** The ZLB restriction is clear in money market space in Figure 81.

Functional Form for Preferences

To facilitate both the short-run and long-run monetary policy analyze, as well as to formalize what was "casually" concluded immediately above, let's specialize our utility function to

$$u\left(c_t, \frac{M_t^D}{P_t}\right) = \ln c_t + \ln \frac{M_t^D}{P_t}.$$

This functional form displays strictly convex to the origin indifference curves in the indifference curve space of Figure 80. And none of the policy conclusions we reach below depend on this particular functional form, but it allows for ease of algebraic manipulations to come.

The marginal utility functions associated with this utility form are obviously $u_1\left(c_t, \frac{M_t^D}{P_t}\right) = \frac{1}{c_t}$ and $u_2\left(c_t, \frac{M_t^D}{P_t}\right) = \frac{1}{M_t^D / P_t}$. [109] This means that the period-t consumption-money optimality condition can be written as

$$\frac{c_t}{M_t^D / P_t} = \frac{i_t}{1+i_t},$$

which is diagrammable in Figure 80. Or, recasting it in money-market space,

$$\frac{M_t^D}{P_t} = \left(\frac{1+i_t}{i_t}\right) c_t,$$

which is diagrammable in Figure 81.

With all of this now in place, we are ready to examine two long-standing questions in monetary analysis, one a short-run issue, the other a long-run issue. Both the long-run and short-run issues center around **the question of whether or not monetary policy is neutral.**

Monetary policy is said to be **neutral** with respect to the economy if **changes** in monetary policy **do not affect real aggregate outcomes in the economy.** Symmetrically, monetary policy is said to be **non-neutral** with respect to the economy if **changes** in monetary policy **do affect real aggregate outcomes in the economy.**

[109] Verify this for yourself. Also note well that there is no use of the chain rule here – the chain rule was **already** used to obtain the consumption-money optimality condition, irrespective of the precise utility functional form.

Monetary Policy I: The Short-Run

To consider neutrality vs. non-neutrality in the short run, we first have to define more rigorously what the "short run" is, and then look at the ordering of events within that "short run."

A natural interpretaion of "short run" in our multi-period model is **one period of time,** which we label "period t."

What about the "ordering of events" within that one period of time? Figure 82 zooms in on period t and diagrams one example. The two main aspects around which the short-run neutrality debate revolves are whether or not an "unexpected change" in Federal Reserve monetary has occurred and the fact that money markets almost universally clear quickly.[110] Figure 82 contains both of these aspects.

Suppose that a monetary policy "shock" has occurred. For the sake of concreteness, suppose the money supply in period *t*, M_t^S, unexpectedly turns out to be larger than markets had earlier (earlier within the short-run period *t*, to be more precise, and as Figure 82 shows) anticipated. The motivation is likely meant to "boost aggregate demand."

Regardless of policy motivation, by definition of money market equilibrium,

$$\frac{M_t}{P_t} = \frac{M_t^D}{P_t} = \frac{M_t^S}{P_t}$$

must be true, regardless of whether a policy shock has occurred.[111] In turn, the (equilibrium) money demand function (based on the particular functional form described above) requires that

$$\frac{M_t}{P_t} = \left(\frac{1+i_t}{i_t}\right)c_t \, .$$

For this expression to hold with equality, a nominal money supply shock requires that P_t adjusts or c_t adjusts or i_t adjusts, or any combination thereof. **Notice that whatever it is**

[110] The vastly liquid and continuously operating money market funds (which directly corresponds to the money market in our analysis) had failed to clear only three times in their 37-year history up until the 2008 financial crisis.

[111] Note that in equilibrium, we drop the "S" and "D" superscripts because the very definition of **equilibrium** is that supply = demand.

that adjusts to maintain money-market equilibrium, it all occurs in the short run. That is, all of these prices and quantities are dated period *t*.

To simplify the analysis, and because it has been empirically true in the U.S. from late 2008 until at least 2014, suppose the short-term nominal rate is $i_t = 0$. In terms of Figure 81, the economy has hit the zero lower bound.

The unanticipated monetary stimulus then has to effect either nominal prices P_t in the short run or consumption quantity demand c_t in the short run, or both.

Let's paint the two polar extreme cases, first the strict Keynesian sticky price view, and then the strict RBC flexible price view.

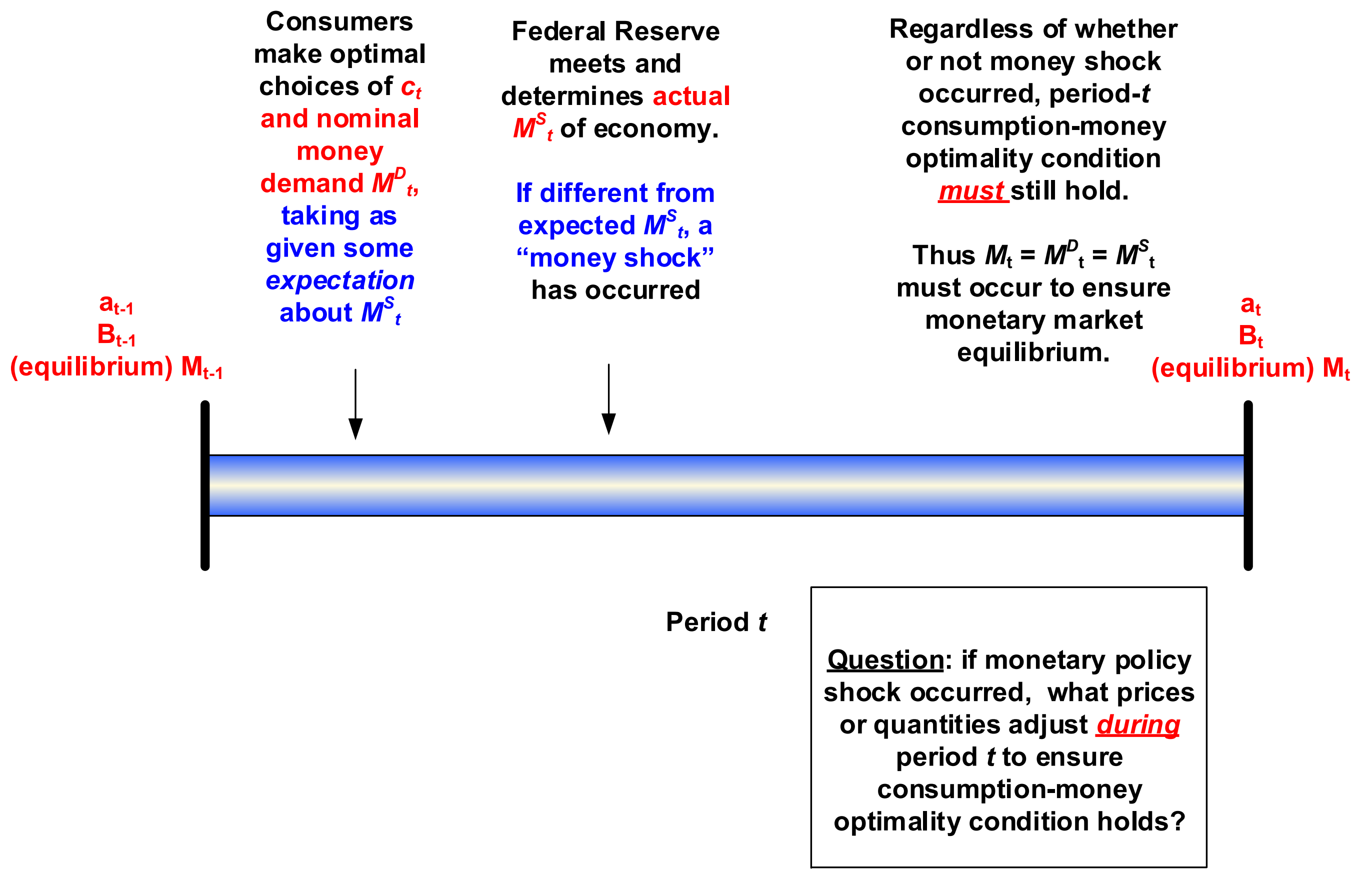

Figure 82. Timing of events within a given period. Second half of timeline emphasizes that money-market equilibrium is achieved in every period time of time.

In the strict Keynesian case, nominal prices do not adjust in the short run. Thus, feeling flush with unexpectedly large quantities of cash, consumers will raise their demand for goods in the short run. "Monetary stimulus" has succeeded in that real quantity demanded has increased, at least in the short run. **Monetary policy is thus non-neutral in the Keynesian school of thought.**

In the strict flexible-price RBC case, nominal prices adjust very quickly. Provided that "very quickly" is shorter than the length of period *t*, the unexpected increase in consumption demand is quickly **neutralized** -- the terminology is not coincidental – by a rapid increase in P_t. In this case, all "monetary stimulus" has created is a burst of inflation. **Monetary policy is thus neutral in the RBC school of thought.**

Figure 83 illustrates these two extreme cases from the perspective of the period-t goods market. The aggregate goods demand function necessarily shifts outwards due to an unexpected increase in the nominal supply – the (equilibrium) money demand expression $\frac{M_t}{P_t} = \left(\frac{1+i_t}{i_t}\right) c_t$ shows this.

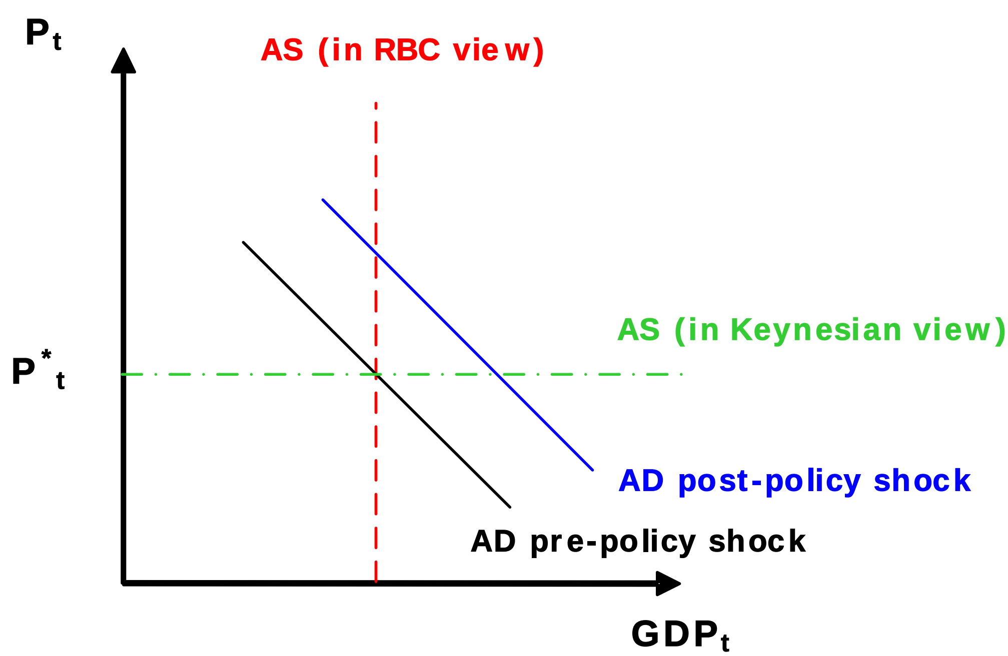

Figure 83. Following a positive shock to monetary policy, aggregate demand shifts outwards.

Whether or not this leads to a temporary increase in equilibrium GDP depends entirely on the shape of the "short-run aggregate supply function."

For macro-relevant lengths of "period t" (which is typically quarterly because GDP accounts are compiled and referenced for the January – March quarter, April – June quarter, the July – September quarter, and the October – December quarter), data suggests that an empirically-relevant slope of aggregate supply is strictly positive – so, somewhere between the extremely flat Keynesian AS function and the extremely vertical RBC-style AS function.

For modern macroeconomists, this then begs the question: what are the microeconomic reasons for "partial" nominal price stickiness?

We sidestep this issue for now, and return to it later in the more advanced "New Keynesian Theory" section of the book. For the remainder of the analysis here, we consider the effects of monetary policy in the long run.

Monetary Policy II: The Long-Run

We have been considering an infinite-period framework. As we were able to do in our earlier, simpler, infinite-period model absent money, it is useful to consider steady-states. In our explicitly monetary model here, considering the steady-state will starkly reveal a relationship important to all of monetary theory, a relationship between inflation and the rate of growth of the nominal money supply of the economy. This way of thinking about inflation commonly goes under the name of "monetarism" or the "quantity theory of money."[112]

Let's continue to use the utility function

$$u\left(c_t, \frac{M_t^D}{P_t}\right) = \ln c_t + \ln \frac{M_t^D}{P_t},$$

but, just like in the consideration of short-run effects above, none of the conclusions we reach depend on this particular functional form.

For the sake of not having to turn back many pages, recall that the money demand expression is

[112] One of the most-often quoted sayings by the late Milton Friedman, the 1976 Nobel laureate in economics, is that "inflation is everywhere and always a monetary phenomenon," which has commonly been interpreted to mean that it is the actions of the central bank of an economy (in particular, how the central bank manages the money supply of an economy) that **alone** determine the rate of inflation in the economy. As we are about to see, precisely speaking, only in the steady state (i.e., in the "long run" or "on average") is inflation a purely monetary phenomenon.

$$\frac{M_t^D}{P_t} = \left(\frac{1+i_t}{i_t}\right)c_t.$$

A completely analogous condition holds in period t-1 (or period t-2, or period t+1, etc.):

$$\frac{M_{t-1}^D}{P_{t-1}} = \left(\frac{1+i_{t-1}}{i_{t-1}}\right)c_{t-1}.$$

Let's combine these time-t and time-(t-1) versions of the consumption-money optimality condition by dividing the former by the latter; doing so gives us

$$\frac{M_t^D / P_t}{M_{t-1}^D / P_{t-1}} = \frac{c_t}{c_{t-1}}\left(\frac{1+i_t}{i_t}\right)\left(\frac{i_{t-1}}{1+i_{t-1}}\right).$$

Reorganizing terms a bit, we have

$$\frac{M_t}{M_{t-1}}\frac{P_{t-1}}{P_t} = \frac{c_t}{c_{t-1}}\left(\frac{1+i_t}{i_t}\right)\left(\frac{i_{t-1}}{1+i_{t-1}}\right).$$

From our usual definition of inflation, we have that $\frac{P_{t-1}}{P_t} = \frac{1}{1+\pi_t}$. Now define the **growth rate of nominal money** in an analogous way. Specifically, **define** $\mu_t = \frac{M_t}{M_{t-1}} - 1$ **as the growth rate of the nominal money stock of the economy between period t-1 and period t.** As an example, if the nominal money supply does not change between period t-1 and period t, the nominal money growth rate is $\mu_t = 0$.

Using our definitions of the inflation rate and the money growth rate above, we can rewrite it as

$$\frac{1+\mu_t}{1+\pi_t} = \frac{c_t}{c_{t-1}}\left(\frac{1+i_t}{i_t}\right)\left(\frac{i_{t-1}}{1+i_{t-1}}\right).$$

Now let's consider the steady-state. Recall our definition of a steady-state as a state of the economy in which all real variables settle down to constant values over time, but nominal variables need not do so. Let's make the latter part of this concept a bit more precise than we did earlier: it is only nominal *level* variables that need not settle down to constant values in the long run. For example, the nominal price *level* of the economy need not settle down to a constant value in the long run. The same is true of the *level* of the nominal money supply of the economy.

On the other hand, nominal *growth rate* variables *do* settle down to constant values in the long run. That is, **the growth rate of a nominal variable is considered to be a real variable.** Moreover, interest rates, regardless of real or nominal, also settle down to constant values in the steady-state.

Applying this more precise concept of a steady-state to the previous expression above, we see that *all* of the variables contained in it settle down to constant values in the long-run: that is, $c_{t-1} = c_t = \bar{c}$, $i_{t-1} = i_t = \bar{i}$, $\mu_{t-1} = \mu_t = \bar{\mu}$, and $\pi_{t-1} = \pi_t = \bar{\pi}$. Imposing these steady-state values and canceling terms, we obtain

$$\frac{1+\bar{\mu}}{1+\bar{\pi}} = 1,$$

or, more simply,

$$\bar{\pi} = \bar{\mu}. \tag{1.12}$$

Expression (1.12) captures the essence of the **monetarist school of thought** within macroeconomics, stating that (in the long run – i.e., in the steady state) the inflation rate of the economy is governed by the rate of growth of the money supply.

The rate of growth of the money supply is controlled by an economy's central bank because it is ultimately the economy's sole (legal) supplier of money. The higher is the growth rate of money in an economy, the higher is (in the long-run) the economy's inflation rate.

Hence, monetary policy is non-neutral in the long-run. This long-run monetarist perspective is universally accepted by modern-day RBC-oriented macroeconomists and modern-day New-Keynesian-oriented macroeconomists – both camps acknowledge that in the long run, nominal prices do adjust.[113] The neutrality debate is entirely about the short-run.

We will next examine even further the causes and consequences of monetary policy in both the short run and the long run, with a special focus on the interactions between monetary policy and fiscal policy. This monetarist linkage will be in the background of many of the causes and effects we discuss there.

[113] This view apparently would not have been shared by Keynes himself, to whom the famous phrase "In the long run, we're all dead!" is attributed.