Monetary Economics

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1. Simple Model of Money

We have known in previous education stages that functions of money are, medium of exchange, unit of account, and store of value. However, the demand for money is distinct from the demand for the goods studied elsewhere in economics. People want goods for the utility received from their consumption. In contrast, people do not want money in order to consume it; they want money because money helps them get the things they want to consume. In this way, money is a medium of exchange – something acquired to make it easier to trade for the goods whose consumption is desired.

The problem facing future generations of this economy is very simple. They want to acquire goods they do not have. Each has access to the nonstorable consumption good only when young but wants to consume in both periods of life. They must therefore find a way to acquire consumption in the second period of life and then decide how much they will consume in each period of life.

We examine, in turn, two solutions to this economic problem. The first, a centralized solution, proposes that an all-knowing, benevolent planner will allocate the economy's resources between consumption by the young and by the old. In the second, decentralized solution, we allow people to use money to trade for what they want. We then compare the two solutions and ask which is more likely to offer people the highest utility. The answer helps provide a first illustration of the economic usefulness of money.

1.1. Overlapping Generations Model

1.1.1. Assumptions

- Each individual lives only two periods. She is *young* in the first period, and is *old* in the second period.
- The economy only has one kind of commodity, and the commodity is unstorable.
- *Young* people are endowed with endownment y, while the *old* have no such endowments.
- The economy keeps iterating for infinitely-many periods.
  - If the economy only works for finitely-many periods, everyone will care for herself more.

1.1.2. Centralized Solution

From the government's perspective, the feasible set for the society is

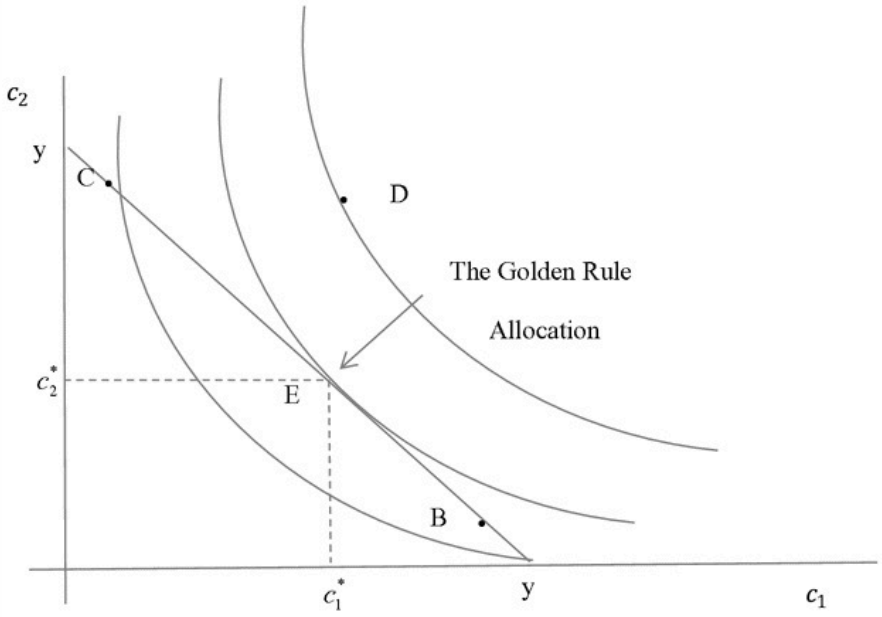
$$N_t c_{1,t} + N_{t-1} c_{2,t} \leq N_t y$$

which means the total consumption for the young and the old at present should not be no more than the total endownment of the young at present.

Under stationarity, $N_t = N, \forall t$ (constant population), the stationary equilibrium is determined by

$$c_1 + c_2 \leq y$$

Note that for initial old, their "selfish" motivation would persuade them to consume as much resource as possible. However, if they care about future generations, the problem won't be that confusing.



Benevolent government will find the tangent (c_1^*, c_2^*) point to maximize the utility level, which is called the **Golden Rule Allocation**.

1.1.3. Decentralized Solution

In the decentralized case, we assume perfectly competitive market and perfect record-keeping system.

Budget constraints (BC) for the yound and old are:

$$\begin{aligned} \text{Young: } c_{1,t} + \varphi_t &\leq y \\ \text{Old: } c_{2,t+1} &\leq \varphi_{t+1}^R \end{aligned}$$

where φ_t is a choice variable, and can be set flexibly by the young; φ_{t+1}^R is the transfer from the young to the old, determined by the young, and is beyond the decision of the old.

Define conversion rate x_{t+1} as

$$x_{t+1} = \frac{\varphi_{t+1}^R}{\varphi_t}$$

Then, the budget constraint for the young and the old and be combined to be

$$c_{1,t} + \frac{c_{2,t+1}}{x_{t+1}} \leq c_{1,t} + \varphi_t \leq y$$

Consider the market of money. In equilibrium, the market should clear, and demand equates supply.

$$\begin{aligned} \text{Demand} &= N_{t-1} \cdot c_{2,t} = N_{t-1} \cdot (\varphi_{t-1} x_t) \\ \text{Supply} &= N_t \cdot (y - c_{1,t}) \end{aligned}$$

When demand equals to supply, we can get

$$x_t = \frac{N_t(y - c_{1,t})}{N_{t-1}\varphi_{t-1}} = \frac{N_t(y - c_{1,t})}{N_{t-1}(y - c_{1,t-1})}$$

Under stationary equilibrium, $c_{1,t} = c_1, \forall t$; $N_{t-1} = N_t = N$. Therefore, $x_t = 1$, and the combined BC is equivalent to

$$c_1 + c_2 \leq y$$

which coincides with the feasible set for the society. Since the combined BC is identical to the feasible set, the decentralized and the centralized solution are the same.

However, if the model economy has no perfect records, in the centralized case, the optimized outcome would be the same; while in the decentralized case, lack of records would lead to **autasky**, meaning that there would be no trade between generations.

1.2. Money is Memory

Instead of consumption goods transfers across periods, consider the role of fiat money in an economy. Fiat Money is

- Provided by government without cost
- Storable without cost
- Fully divisible

Suppose a fixed stock of M of fiat money has been issued by the government, and each indivual holds m_t of money. At period t, the value of each unit is v_t, and the dollar price of the consumption good is p_t, with $v_t = \frac{1}{p_t}$.

The budget constraints for a representative in economy in two periods are as follows.

$$\begin{aligned} \text{When young:} \quad & c_{1,t} + v_t m_t \leq y \\ \text{When old:} \quad & c_{2,t+1} \leq v_{t+1} m_t \\ \implies & c_{1,t} + \frac{v_t}{v_{t+1}} c_{2,t+1} \leq y \end{aligned}$$

where $\frac{v_t}{v_{t+1}}$ is the (real) gross return of money, and $\frac{v_t}{v_{t+1}} - 1$ is the (real) net return of money.

When the market of money clears, demand equates supply.

$$\begin{aligned} \text{Demand} &= N_t(y - c_{1,t}) \\ \text{Supply} &= v_t M_t \\ \implies v_t &= \frac{N_t(y - c_{1,t})}{M_t} \end{aligned}$$

where the stock of fiat money should be expressed in its real value.

Consider two adjacent periods,

$$\frac{v_{t+1}}{v_t} = \frac{N_{t+1}(y - c_{1,t+1})}{N_t(y - c_{1,t})} \cdot \frac{M_t}{M_{t+1}}$$

Under stationarity, it must be that the gross return of money equals to 1, i.e., $\frac{v_{t+1}}{v_t} = 1$.

The lifelong budget constraint is then

$$c_1 + c_2 \leq y$$

which again coincides with the centralized case.

Compared with the economy without record which then goes to autasky, money plays a role of allocating resources between generations in the economy. Specifically, money is viewed as stock of value. In short, money is memory!

Back to consider the price level under market-clearing condition for money,

$$p_t = \frac{1}{v_t} = \frac{M_t}{N_t(y - c_{1,t})}$$

The equation shows that the growth of money supply will have an effect on the price level, while the decision on consumption will not be affected. Thus, comprehensively speaking, money is neutral.

Note that the **neutrality** of money is not equivalent to the uselessness of money.

1.3. Population Growth

Consider population growth,

$$N_t = nN_{t-1}, n > 1$$

Feasible set for the society, (under stationarity, $c_{1,t} = c_1, c_{2,t} = c_2, \forall t$)

$$N_t c_1 + N_{t-1} c_2 \leq N_t y$$
$$\Leftrightarrow c_1 + \frac{1}{n} c_2 \leq y$$

The market of money clears when demand equates supply, under the same logic, we can get

$$\frac{v_{t+1}}{v_t} = n$$

Recall that the lifelong budget constraint is

$$c_1 + \frac{v_{t+1}}{v_t} c_2 \leq y$$
$$\Leftrightarrow c_1 + \frac{1}{n} c_2 \leq y$$

Again, the lifelong budget constraint coincides with the feasible set, and the decentralized and the centralized scenarios will reach the same optimized outcome.

2. Barter

In the discussions above, we have only covered economy with fiat money and with single consumption good. However, there can be alternatives to fiat money as a way for exchange, and barter is one vivid example.

Assume the same settings in OLG model, but with J different types of goods. When an individual is young, she is endowed with y units of 1 type of good; and when she becomes old, she has no other endowment, but hopes to consume another type of good. We suppose the goods can be costlessly stored, and each search (or match) is costly with α. Also, the economy has a total stock of fiat money of M, which can be costlessly stored.

If all members in the economy use direct barter, all combinations of J types of goods have $J^2 - J$ possibilities. Thus, the barter will entail an average search cost of $\alpha(J^2 - J)$ in total, simply from the definition of α.

If money is used instead, if successfully matched, the young would give his goods to the old, and in return hold the money from the old; and the old would give the yound his money and in return get the consumption good. In a single try, a young person's probability of finding an old person who wants what she is selling is $\frac{1}{J}$. The young person wants fiat money and does not care about which type of old person is encountered, because all old people carry what the yound people wants, fiat money. In other words, the double coincidence requires that the old person wants what the young person has, since money is the generally accepted means of exchange. Note that the probability of a successful match in monetary exchange is greater than that under direct barter. And because each person undertakes two such searches, one when yound and one when old, lifetime search costs will averge $2\alpha J$ when people use money.

The search costs when using direct barter are greater than those when using money if

$$\alpha(J^2 - J) > 2\alpha J \Leftrightarrow J > 3$$

And the search cost advantage of money grows with the complexity of the economy.

Moreover, the usefulness of a commodity or fiat money as a medium of exchange depends on its exchange costs. Monetary exchange involves two trades - goods for money, then money for goods - whereas barter requires only one trade. If a money is costly to exchange, its advantage in reducing search costs may be offset by the costs of the second trade. Specifically, let λ denote the exchange cost of goods per person, and let λ_m denote the exchange cost associated with using money. An exchange cost is incurred whenever goods or money are accepted. The lifetime exchange cost of barter are equal to λ because each person accepts delivery of goods once in a lifetime. Remember that in the barter economy people only trade when old since any consumption by young people is from their own endowment. In contrast, the exchange costs of monetary exhange equal $\lambda_m + \lambda$, because each person accepts money when yound and goods when old.

	Expected Search Cost	Exchange Cost	Total Cost
Barter	$\alpha(J^2 - J)$	λ	$\alpha(J^2 - J) + \lambda$
Money	$2\alpha J$	$\lambda + \lambda_M$	$2\alpha J + \lambda + \lambda_M$

3. Commodity Money

Different from fiat money, commodity money has its intrinsic value. They share it in common as a medium of exchange. Due to its inate intrinsic value, commodity money can either be consumed, or be used as medium for trade.

Suppose gold is the kind of commodity money of interest, and has intrinsic value of $\tilde{v}$ per unit. From the beginning, the initial old in the economy hold the stock of gold, M^g in total, m^g for each individual.

The two-period budget constraint for a representative in the economy is:

$$\begin{aligned} \text{When young:} \quad & c_{1,t} + v_t^g m_t^g \leq y \\ \text{When old:} \quad & c_{2,t+1} \leq v_{t+1}^g m_t^g \\ \implies & c_{1,t} + \frac{v_{t+1}^g}{v_t^g} c_{2,t+1} \leq y \end{aligned}$$

The market of money clears when demand equates supply, and under stationarity, $c_{1,t} = c_1, v_t^g = v_g, m_t^g = m^g, \forall t$:

$$\begin{aligned} N(y - c_1) &= v^g (N \cdot m^g) \\ \implies v^g &= \frac{N(y-c_1)}{M^g} \end{aligned}$$

Since the gold, the commodity money, has its own intrinsic value, the gold is used to trade if and only if its value in trade is no less than its intrinsic value. Otherwise, the commodity money would exit circulation and be reduced to a consumption good.

$$v^g = \frac{N(y-c_1)}{M^g} > \tilde{v}$$

However, if $v^g < \tilde{v}$, the initial old will choose to consume gold rather than trade it. But they will not consumer all the gold. As the gold is consumed, the total stock of gold in the economy begins to fall, and the price of gold will begin to rise then. As long as the price of gold v^g is less than intrinsic value $\tilde{v}$, the process will continue and the price of gold will increase. Eventually, the price of gold must rise to its intrinsic value. At this point, the consumption of gold will stop and then be used as a medium of exchange from the point forward in time.

Moreover, because commodity money may be consumed, the **quantity theory of money** may not hold in quite the same way for commodity money that it did for fiat money. Quantity theory of money predicts that if two economies are identical except that the fiat money stock in one is twice as large as in the other, the price level will be twice as high (the value of money will be half as high) in the economy with the larger money stock. Prices adjust to the stock of money. Now consider two economies that are identical except that the gold stock in one is twice as large as in the other. If gold is never consumed but serves solely as a commodity money, prices simply will be twice as high in the economy with the larger stock of gold, just as they were in the case of fiat money. But if gold is consumed at the margin in both countries, with a trading value just equal to its intrinsic value, then the economy with a larger gold stock will consume gold until gold's trading value equals gold's intrinsic value. After the consumption of gold, the amount of gold used as money will be the same in the two economies. The intrinsic value of gold sets a **minimum** value for the trading value of gold, preventing higher nominal prices. If we consider the initial stock of gold in the two economies, the quantity theory does not hold because the price level in the economy with the larger initial stock of gold is not twice as high as the price level in the economy with the smaller gold stock. However, if we consider the stocks of gold actually used as money in the two economies, then the quantity theory does hold. In this case, the

quantity theory holds because the stock of gold used as money adjusts to the price level and not because the price level adjusts to the stock of gold.

We see, then, that the price of gold will equal or exceed its intrinsic value if it is used as a medium of exchange. Because of this property, what serves as a medium of exchange in an economy has implications for the **distribution of wealth**. For example, if a commodity money system with $v_t^g > \tilde{v}$ were replaced with a fiat money system, the price of gold would fall to its intrinsic value of $\tilde{v}$. For this reason, owners of gold or other possible commodity monies are very interested in the medium of exchange used in their economy.

However, the commodity money system has its **inefficiency**. Starting from the same microeconomic foundation, all consumption possibilities in the commodity money economy and those in the fiat money ecoonomy are *equally attainable*. With regard to future generations, the commodity money regime provides no advantages (or disadvantages) relative to the fiat money regime. Even with this, it is the *initial old* who are better off if our commodity money economy is switched to the use of fiat money as a medium of exchange. The amount of the consumption good the initial old could purchase with fiat money would be identical to the amount that could be purchased in the commodity money regime. In addition, they could consume all their holdings of gold, which gives them even more utility. Clearly, then, the consumption and utility of the initial old are higher in the fiat money regime than in the commodity money regime. And keep in mind that this is accomplished wihout diminishing the welfare of future generations. The intuition is that, with a commodity money system, resources that have intrinsic value are tiled up to a medium of exchange. In constrast, the fiat money system utilitzes intrinsically worthless resources to provide the same services. **A fiat money system allows for the same trading patterns while freeing up a commodity that is useful for nonmenatary purposes.**

4. Inflation

An increasing fiat money stock acts as an implicit proportional tax on money holdings, causing individuals to economize on their holdings of fiat money. By economizing on their money holdings, individuals do *not* fully take advantage of the benefits that fiat money provides. This results in a lower level of utility than could be attained without monetary expansion.

4.1. Basic Model

With other settings the same as in OLG, let the money supply growth be such that

$$M_t = zM_{t-1}, z > 1$$

where z is the gross growth rate. $M_t = zM_{t-1} \Leftrightarrow M_t - M_{t-1} = (1 - \frac{1}{z})M_t$.

Suppose the new money is evenly distributed to the old as a lump-sum transfer, worth a_t units of the consumption good.

$$a_t = \frac{v_t(M_t - M_{t-1})}{N_{t-1}} = \frac{v_t(1 - \frac{1}{z})M_t}{N_{t-1}}$$

which means newly issued money is pumped into the economy though lump-sum transfer to the old.

If with lump-sum transfer to the old, the two-period budget constraint for a representative is

$$\begin{aligned} \text{When young:} \quad & c_{1,t} + v_t m_t \leq y \\ \text{When old:} \quad & c_{2,t+1} \leq v_{t+1} m_t + a_{t+1} \\ \implies & c_{1,t} + \frac{v_t}{v_{t+1}} c_{2,t+1} \leq y + \frac{v_t}{v_{t+1}} a_{t+1} \end{aligned}$$

When the market of money clears, in the same logic, demand equates supply.

$$\begin{aligned} N_t(y_1 - c_{1,t}) &= v_t M_t \\ \implies v_t &= \frac{N_t(y - c_{1,t})}{M_t} \\ \frac{v_{t+1}}{v_t} &= \frac{N_{t+1}/N_t}{M_{t+1}/M_t} = \frac{n}{z} \end{aligned}$$

We then assume constant population, i.e., $n = 1$; and grwoing money supply, $z > 1$, then

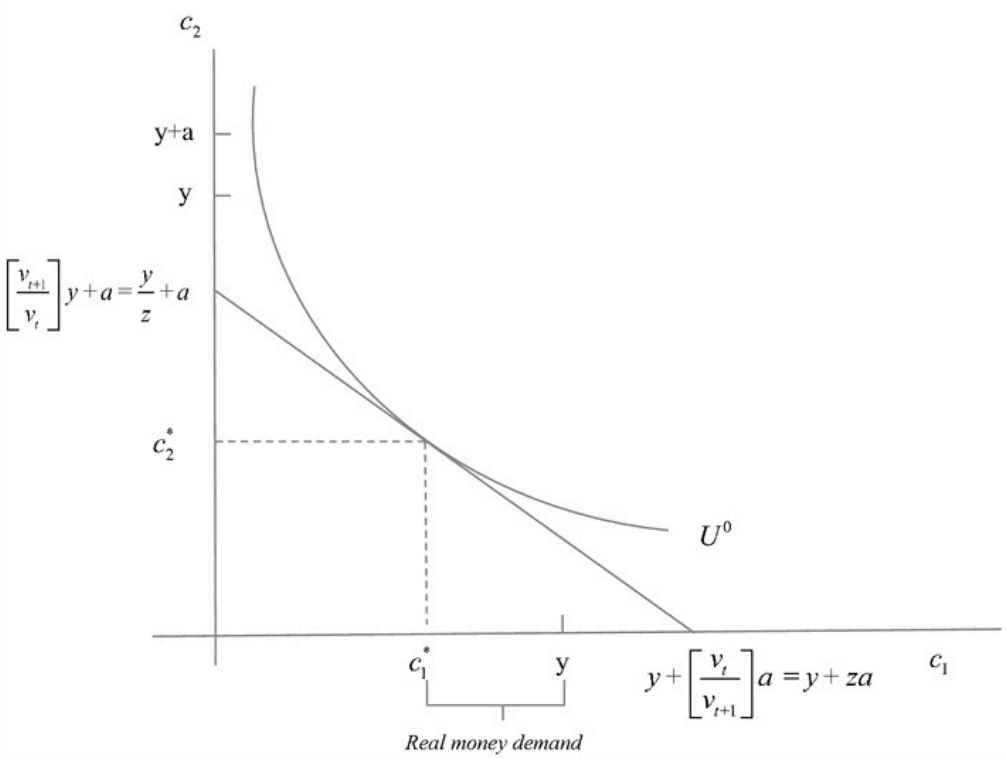
$$\frac{v_{t+1}}{v_t} = \frac{1}{z} \Leftrightarrow \frac{v_{t+1}}{v_t} - 1 = \frac{1}{z} - 1 < 0$$

which means when money supply increases, the real return of money would decrease. Expansion of the money supply creates inflation as more dollars bid for the same number of goods. The price level would go up, with value of money going down over time.

Based on the real return of money, together with stationarity, the lifelong budget constraint comes down to

$$c_1 + zc_2 \leq y + za$$

On graph, inflation has altered the budget set in two ways. First, the budget line is *flatter*. This means to get a unit of good when old, a person must give up more units when young than when there was no inflation. This reflects the lower rate of return offered by money when new money is being created. Second, the budget set intercepts the horizontal axis at $y + za$ instead of y, because a person's income now includes both the endowment and the subsidy.



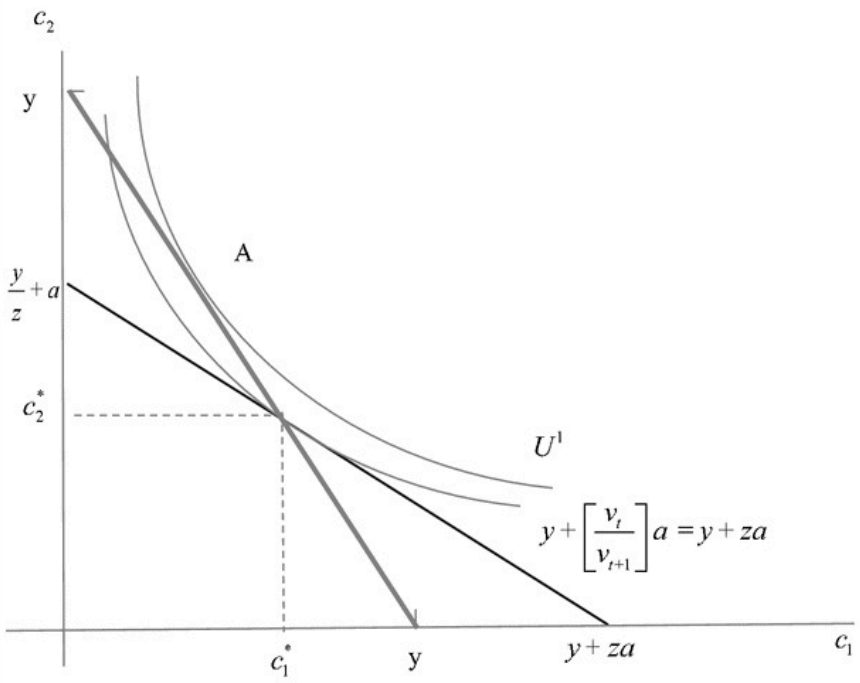
The intuition of lower rate of return is that, although the government can create the fiat money out of thin air, the real value of government subsidy must come from *somewhere*. The feasible set is not magically expanded when the government decides to print additional intrinsically useless pieces of paper. Because th total number of goods in the economy is fixed at the total endownment $N_t y$, the gifts to old people can come only from losses sustained by them or by others.

However, the original feasible set for the society is

$$N_t c_{1,t} + N_{t-1} c_{2,t} \leq N_t y$$
$$\Leftrightarrow c_1 + c_2 \leq y$$

if under stationarity and constant population.

The feasible set line starts at y on the vertical axis and **intersects the budget line at** (c_1^*, c_2^*). If (c_1^*, c_2^*) lay in the interior of the feasible set, it would imply that someone was throwing goods away, an action not consistent with utility maximization. If it lay outside the feasible set, people would be consuming more goods than exist, which is impossible. Therefore, the equilibrium consumption bundle (c_1^*, c_2^*) must lie on the edge of the feasible set; that is, the feasible set line passes through (c_1^*, c_2^*). (Mathematical prove comes later.)



On the graph, point A is preferred by the future generations over (c_1^*, c_2^*) because it lies on a higher indifference curve. Furthermore, because second-period consumption is higher at point A than at (c_1^*, c_2^*), the initial old also prefer point A over (c_1^*, c_2^*).

The tax on money balances induces future generations to *reduce* their demand for money $(y - c_1)$ to a level below the quantity each person would hold in the efficient equilibrium. Moreover, the drop in the demand for fiat money reduces the value of the initial money balances owned by the initial old, thus also reducing their utility. Inflation tax is a *proportional* tax, with equal tax rate for everyone holding the money. Thus, the incentives to hold real balances are affected, and so are the incentives to supply labor. Inflation may effect **aggregate output** in addition to the **timing of consumption**.

The loss from such inflation for each individual holding money in period $t-1$ to period t is

$$\frac{M_{t-1}(v_{t-1} - v_t)}{N} = \frac{M_{t-1}v_t(z-1)}{N}$$

The gain from the inflation, in essence is the receipt of the lump-sum transfer, is

$$a_t = \frac{M_{t-1}v_t(z-1)}{N}$$

Then, the gain just compensates the loss.

4.1.1. The Limits to Seigniorage

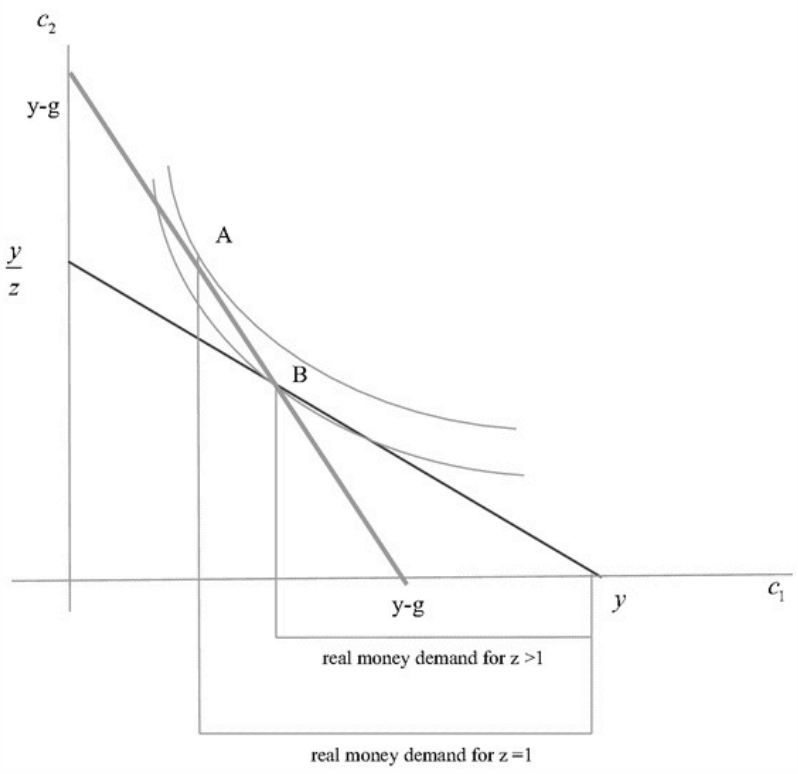
Although the government is able to print any number of dollars, the value of those dollars shrinks as the government prints more fiat money. Therefore, government revenue in terms of real goods is limited by the real value of the fiat money stock. Seigniorage does not represent an unlimited source of government revenue.

Real government revenue from seigniorage at t is

$$(M_t - M_{t-1})v_t = \left(1 - \frac{1}{z}\right)v_t M_t$$

where $v_t M_t$ represents the real value of the fiat money stock, so-called "tax base". The term $\left(1 - \frac{1}{z}\right)$ represents the fraction of the value of the real fiat money stock that winds up as government revenue as seigniorage "tax rate".

However, when z rises, each individual will choose to reduce the real balances of money held in an attempt to reduce the amount of goods lost to the government through inflation. Thus, the reduction of the demand for fiat money reduces the real value of fiat money balances and then the real value of the fiat money the government is printing. The implication is that, the seigniorage tax base shrinks as the money growth rate increases.



4.1.2. Equilibrium Consumption & Feasible Set

We wish to prove algebraically that all goods are consumed in equilibrium – that is, that the monetary equilibrium consumption bundle (c_1^*, c_2^*) is on the line defining the feasible set. From the work done previously, we know that the following equations – the lifetime budget constraint, the definition of the subsidy a, and the market clearing condition – describe the stationary monetary equilibrium:

$$c_1^* + \frac{z}{n}c_2^* = y + \frac{z}{n}a$$
$$a = \frac{\left(1 - \frac{1}{z}\right)v_t M_t}{N_{t-1}}$$
$$v_t M_t = N_t(y - c_1^*)$$
$$\implies a = \frac{\left(1 - \frac{1}{z}\right)v_t M_t}{N_{t-1}} = \frac{\left(1 - \frac{1}{z}\right)v_t M_t \cdot n}{N_t} = \left(1 - \frac{1}{z}\right)v_t m_t \cdot n = \left(1 - \frac{1}{z}\right)n(y - c_1^*)$$

The lifetime budget constraint is then

$$c_1^* + \frac{z}{n}c_2^* = y + \frac{z}{n} \cdot \left(1 - \frac{1}{z}\right)n(y - c_1^*)$$
$$\Leftrightarrow c_1^* + \frac{1}{n}c_2^* = y$$

which by nature proves that (c_1^*, c_2^*) is on the line defining the feasible set.

4.2. Growing Population

If we allow for a growing population, $N_t = nN_{t-1}, n > 1$,

$$v_t = \frac{N_t(y - c_1)}{M_t} \implies \frac{v_{t+1}}{v_t} = \frac{n}{z}$$

where $a_{t+1} = a, c_{1,t} = c_1, \forall t$ is assumed under a stationary equiilibrium. To keep the value of the money (and thus the price level) constant, the rate of expansion of the fiat money stock z must be set equal to the rate of growth of money demand, which is the rate of growth of the population n.

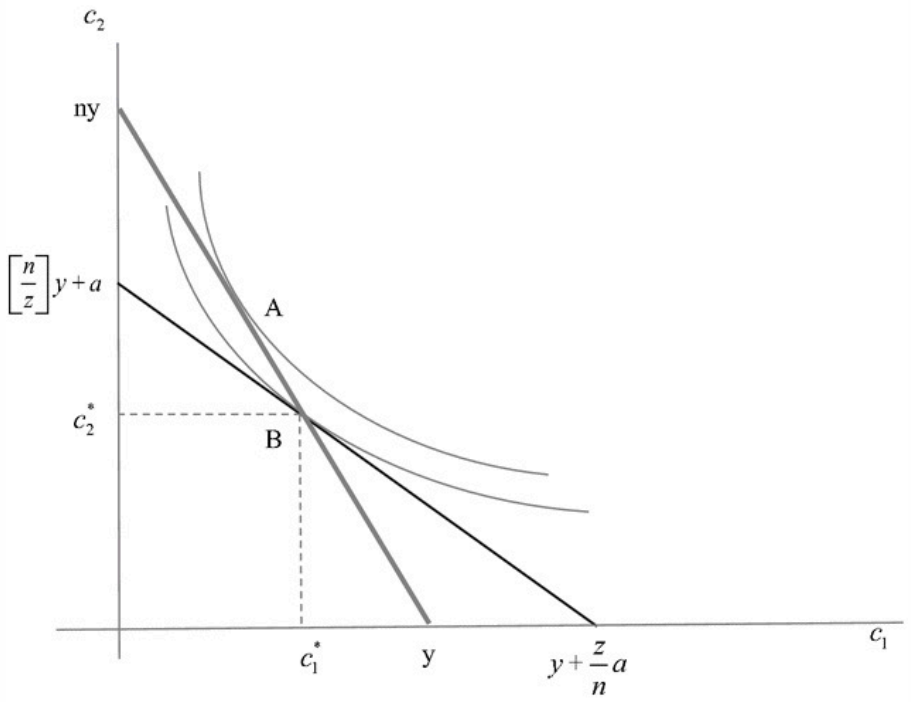
The budget line in this growing economy is the same. Plug in $\frac{v_{t+1}}{v_t}$ and stationarity to get

$$c_1 + \frac{z}{n}c_2 \leq y + \frac{z}{n}a$$

Compare the set with the feasible set. The printing of money and the growing of population not alter what is feasible,

$$c_1 + \frac{1}{n}c_2 \leq y$$

Again, note that neither z or a can change what is feasible, and they will not appear in the inequality above.



Note that even with the monetary policy of **setting z equal to n,** the budget line still cannot coincide with the feasible set. The budget set tells the person that goods are equally available in every period. However, this is not the true state of the economy. The economy is growing. Therefore, if in each generation young people consume one less good when young, there will be n extra goods available for old people in each generation. The message that the economy can offer n goods to the old for each good not consumed by the young is not conveyed through the budget set if prices are constant over time. Consequently, people value future consumption *less* than they should have, and will thus consume more when young and less when old.

4.3. Government Expenditure

Government's Budget Constraint can be expressed in dollar unit.

$$\begin{aligned} \text{Expenditure:} \quad & p_t G_t + (1+i) D_{t-1} \\ \text{Revenue:} \quad & T_t + D_t + (M_t - M_{t-1}) \end{aligned}$$

where G_t is in its real-good meaning. D_t, T_t, M_t are in their dollar unit. $(1+i)D_{t-1}$ is the payment of principal and interest for matured debt. $(M_t - M_{t-1})$ is the seigniorage implicitly levied through increasing money supply.

When the ends meet, expressed in real-good meaning, $v_t = \frac{1}{p_t}$,

$$G_t + (1+i) D_{t-1} v_t = v_t (T_t + D_t) + v_t (M_t - M_{t-1})$$

For simplicity, we assume that the revenue of the government uniquely comes from seigniorage, i.e., the rate of money creation can finance the government's acquisition of

$$G_t = v_t (M_t - M_{t-1}) = v_t M_t (1 - \frac{1}{z})$$

And denote (constant) government purchases per **old** person as

$$g = \frac{G_t}{N_{t-1}}$$

We assume that the goods the government acquires from its seigniorage revenue are used in such a way as *not* to affect an individual's *consumption bundle* choice, and also no direct effect on the *relative desirability* of c_1 of c_2. For simplicity, we could even think of the government as merely dumping the acquired goods into the ocean. *No subsidy* for the old this time. This allows us to study the effects of acquiring revenue for the government in isolation from the benefits of the government purchases.

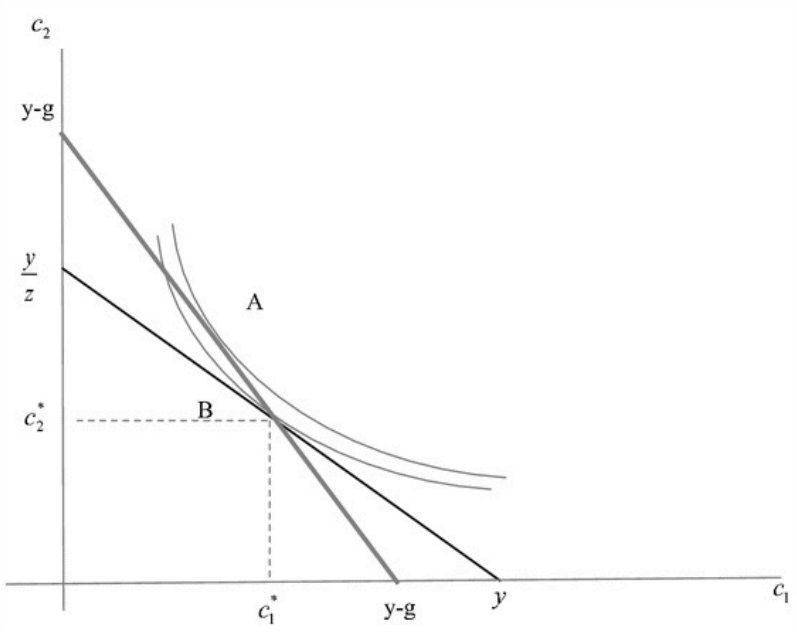
Therefore, the feasible set for stationary allocations is now given by

$$\begin{aligned} \text{Feasible Set: } & N_t c_1 + N_{t-1} c_2 + G_t \leq N_t y \\ \text{Per-Capita Form: } & c_1 + \frac{c_2}{n} + g \leq y \\ \text{Constant Population: } & c_1 + c_2 + g \leq y \end{aligned}$$

Assume for now that the population is constant, then $\frac{v_{t+1}}{v_t} = \frac{1}{z}$. The lifelong budget constraint under stationarity is

$$c_1 + z c_2 \leq y$$

As before, the slope of the budget line has been made flatter, which implies that an individual must give up more of c_1 to get a unit of c_2 in the presence of inflation because money has a lower rate of return. In addition, we now find that the budget set has shrunk; it lies inside the budget set without inflation. This occurs because the goods acquired by the expansion of the money stock are now being used up by the government instead of being returned to individuals as a subsidy.



where the inflation tax still creates a distortion.

4.4. Non-Distorting Tax

We try to get a budget set of a monetary equilibrium to reflect the feasible set, in the hope of getting a nondistorting outcome. Consider a fixed tax τ of goods collected from each old person. We refer to such a tax as a lump-sum tax because the amount paid to the government is not affected by any actions the indiidual may undertake.

$$\begin{aligned}\text{Young: } c_{1,t} + v_t m_t &\leq y \\ \text{Old: } c_{2,t+1} &\leq v_{t+1} m_t - \tau \\ \text{Lifelong Budget: } c_{1,t} + \frac{v_t}{v_{t+1}} c_{2,t+1} &\leq y - \frac{v_t}{v_{t+1}} \tau\end{aligned}$$

Suppose both population (i.e., money demand) and the stock of money are fixed over time. The fixed tax is set such that $\tau = g$ to fully finance the government's budget. Then the budget set is

$$c_1 + c_2 \leq y - g$$

which is **identical** to the per-capita feasible set! By using lump-sum taxes, the government raised revenue with *no distortion of the budget set* - that is, without inducing people to reduce their money balances in an effort to avoid inflation's implicit tax on those money balances. Again, we see that any tax on an economic (positive) activity is inferior to a lump-sum tax because it reduces the incentive to undertake that activity.

5. International Monetary Systems

When each country issues its own fiat money, the organizing principle is that there is a price at which each currency trades for another country's currency. In other words, the exchange rate is the rate at which one country's currency is traded for another country's currency.

5.1. International Exchange

To address these international issues, we assume that there exist two countries, a and b, each with its own fiat money. As in OLG, people live two-period lives in overlapping generations. They are endowed with goods when young but not when old, yet they want to consume in both periods of life. The endowments in each country consist of the same goods (a good in country a is indistinguishable from a good in country b). People are indifferent to the origin of the goods they purchase. We use superscripts a and b to identify the parameters and variables of each country. Assume that all changes in the fiat money stock are used to purchase goods for the government. Also assume there is free international trade in goods.

The monies of the two countries can be traded at the "exchange rate" e_t, which is defined as the units of country b money that can be purchased with one unit of country a money. For convenience, suppose country a is the US and country b is Japen. Then the exchange rate is

$$e_t = \frac{\text{Japanese yen}}{\text{US dollar}}$$

the number of Japanese yen per U.S. dollar or, alternatively, the number of yen that can be bought with a dollar.

Bydefinition, the owner of a unit of country a money at time t can buy v_t^a goods, and the owner of a unit of country b money at time t can buy v_t^b goods. If people are free to trade at the exchange rate e_t, then the owner of a unit of country a money has the option of purchasing v_t^a goods with country a money, or alternatively trading a unit of country a money for e_t units of country b money, which will buy $e_t v_t^b$ goods. The process can be reversed for an individual trading country b money for country a money. Owners of both countries' monies be different between their two options if and only if

$$v_t^a = e_t v_t^b \quad \Leftrightarrow \quad e_t = \frac{v_t^a}{v_t^b} \left(= \frac{p_t^b}{p_t^a} \right)$$

This is the so-called **Law of One Price**.

We wish to determine the behavior of this exchange rate under alternative international monetary arrangements. In particular, we will examine two arrangements: one in which young people are constrained to hold the money of their home country and one in which young people are permitted to hold any country's currency.

5.2. Foreign Currency Controls

Under foreign currency controls, the **citizens** of each country are permitted to hold over time **only** the fiat money of their own country. Foreign currency controls do not rule out the possibility of trade between the two countries. Young people do not migrate, while an old citizen who wishes to buy goods from another country may travel to the foreign currency to exchange his money and then make the purchase. There is a single consumption good in the world. The imposition of foreign currency controls implies that each country has its own money supply and demand that independently determine the value of its fiat money.

$$v_t^a M_t^a = N_t^a(y^a - c_{1,t}^a)$$
$$v_t^b M_t^b = N_t^b(y^b - c_{1,t}^b)$$

In the absence of market frictions, competition results in the price of the good being the same across countries. The exchange rate e_t is therefore

$$e_t = \frac{v_t^a}{v_t^b} = \frac{\frac{N_t^a(y^a - c_{1,t}^a)}{M_t^a}}{\frac{N_t^b(y^b - c_{1,t}^b)}{M_t^b}} = \frac{N_t^a(y^a - c_{1,t}^a)}{N_t^b(y^b - c_{1,t}^b)} \cdot \frac{M_t^b}{M_t^a}$$

The exchange rate, the value of country a in terms of country b money, depends simply on the *relative* values of the demand for money and the supply of money in the two countries.

The rate of change of the exchange rate is generally

$$\frac{e_{t+1}}{e_t} = \frac{\frac{v_{t+1}^a}{v_t^a}}{\frac{v_{t+1}^b}{v_t^b}} = \frac{n^a}{n^b} \cdot \frac{z^b}{z^a}$$

5.3. Indeterminacy of Exchange Rate

Because foreign currency controls force people to exchange money to buy the goods of another country, they impose extra costs on international trade in a world of costly money exchange. Therefore, let us consider our two-country model economy with young people free to hold and use the money of any country.

Since people are now allowed to hold the money of either country, we can no longer determine the money supply and demand of each country separately but must examine the world's supply of and demand for money. The world supply of fiat money, measured in goods, is $v_t^a M_t^a + v_t^b M_t^b$, and the world demand for fiat money is $N_t^a(y^a - c_{1,t}^a) + N_t^b(y^b - c_{1,t}^b)$. The market of money should clear, when supply equals to demand,

$$v_t^a M_t^a + v_t^b M_t^b = N_t^a(y^a - c_{1,t}^a) + N_t^b(y^b - c_{1,t}^b)$$

A serious problem now appears in our effort to find the exchange rate. We have the single equation above with which to determine two variables, v_t^a and v_t^b. Such an equation has an **infinite** number of solutions. Because $e_t = \frac{v_t^a}{v_t^b}$, we can find an equilibrium in which world money supply equals world money demand for any positive exchange rate e_t. This **indeterminacy** of the exchange rate did not appear when foreign currency controls limited citizens to their own country's money. In that case, the equality of money supply and money demand determined the value of fiat money in each country; the two market-clearing equations, which in turn determined the exchange rate.

Note that, because people are free to hold either country's money, the size of one nation's money demand affects the real value of the world money supply. However, it no longer determines the rate of exchange, because a nation is no longer restricted to using only its own money. Similarly, the supply of money printed by any one country does not determine the exchange rate, because this money can be used in any country.

In the absence of the government determination of the exchange rate, the exchange rate in a unified world economy can be whatever people **believe** it to be. It follows that, if these beliefs fluctuate, the exchange rate will also fluctuate because there is nothing to pin it down. These fluctuations need not be tied to changes in real economic conditions.

5.4. International Currency Traders

With exchange-rate indeterminacy, the multiplicity of exchange rates that satisfy the conditions for a stationary equilibrium suggests that exchange rates may fluctuate dramatically as multinationals change the composition of their money balances. These fluctuations make each currency a risky asset. Those who have access to only a single currency, however, will see the real value of their money balances, and thus their consumption, rise or fall with the exchange rate. Multinationals can free themselves from this risk if they hold a balanced portfolio of both monies so that if the exchange rate changes, the decreased value of one currency is offset by the increased value of the other.

Consider a model economy in which there are three types of people:

1. citizens of country a, forced by law to hold only country a's money;
2. citizens of country b, forced by law to hold only country b's money;
3. multinational people, free to hold either currency.

Let N_t^a, N_t^b, N_t^c, repectively, represent the number of people of each type in a generation *born* in period t.

Each country's money is held by its own citizens and perhaps by multinational people as well. Let λ_t represent the fraction of the multinational people's money balances that is held in the form of country a's money. We can now write the two equations that represent the markets for the currencies of countries a and b, respectively:

$$v_t^a M_t^a = N_t^a(y^a - c_{1,t}^a) + \lambda_t N_t^c(y^c - c_{1,t}^c)$$
$$v_t^b M_t^b = N_t^a(y^b - c_{1,t}^b) + (1 - \lambda_t) N_t^c(y^c - c_{1,t}^c)$$

The more the multinational people (type c) want to hold country a's money (i.e., the greater the value of λ_t), the greater the value of country a's money will be and the lower the value of country b's money will be. This, in turn, implies that the greater the value of λ_t, the greater the exchange rate e_t will be. However, because the multinational people are free to hold any fraction of their money balances in each country's money, there are many possible equilibrium exchange rates.

Note that in the real world, although this equalizing of currency balances may free multinationals from risk, it may be bothersome or otherwise costly to hold perfectly diversified stocks of both countries' currency.

5.5. Fixed Exchange Rate

A fixed exchange rate is defined as an equilibrium in which the exchange is **constant** over time. Formally, a fixed exchange rate is defined as

$$\begin{aligned} & e_{t+1} = e_t \\ \implies \quad & z^a = \frac{n^a}{n^b} z^b \end{aligned}$$

To fix the exchange rate, therefore, one or both of the countries must choose rates of fiat money creation that satisfy the equation above. Of course, a monetary authority committed to a fixed exchange rate can no longer freely set the rate of money creation in order to raise a chosen level of seigniorage revenue. A country can choose the rate of money creation to **fix the exchange rate** or to acquire its preferred level of **seigniorage revenue**, but it *cannot* meet both objectives.

5.5.1. Cooperative Stabilization

Cooperative stabilization refers to exchange rate policies conducted by two governments that stand ready to exchange currencies at some given rate. The exchange rate would also be fixed over time. In the absence of foreign currency controls, fiat currencies are held voluntarily. However, no currency will be held voluntarily if its value will fall over time relative to the value of other currencies. Such a currency offers a lower rate of return than the others, inducing everyone to switch to other currencies.

5.5.2. Unilateral Defense

It is difficult to get all the countries to agree on what the exchange rate should be for every currency. Sovereign nations generally do not practice unlimited commitment. In order for the fixed exchange rate to be supported without the full cooperation of foreign central banks, one way would require the government to tax its citizens, using the revenue to purchase the foreign currency demanded.

To illustrate how a unilateral defense would work, consider our two-country model economy with no foreign currency controls and no cooperation between central banks. Now suppose that the entire world arbitrarily decides to exchange a part of its holdings of country a money for country b money. In contrast to cooperative stabilization in which the holders of country a money exchange the currency for country b money, unilateral defense requires taxes to be collected. In effect, country b says they will not trade one type of money for another. However, country b's central bank will exchange money for goods. The government of country a pledges to tax the old in order to defend a fixed exchange rate. (The tax is levied on the old because they are the citizens who will lose if the nation's money loses value.) Because of the absence of foreign currency controls we will assume that some of each country's currency is held by the old of each country. Recall that the world market for currency is given by

$$\begin{aligned} & v_t^a M_t^a + v_t^b M_t^b = N_t^a (y^a - c_{1,t}^a) + N_t^b (y^b - c_{1,t}^b) \\ \Leftrightarrow \quad & \bar{e} v_t^b M_t^a + v_t^b M_t^b = N_t^a (y^a - c_{1,t}^a) + N_t^b (y^b - c_{1,t}^b) \end{aligned}$$

where $\bar{e}$ denotes the fixed exchange rate.

Specifically, suppose countries a and b are identical. In each country, the population of every generation is 100 , and each young person wants real money balances worth 10 goods. This implies that aggregate really money balances in each country are

$$N_t^a(y^a - c_{1,t}^a) = N_t^b(y^b - c_{1,t}^b) = (100)(10) = 1000$$

Also assume that the total fiat money stock of country a is \$800 and that of country b is £600. We assume that there are no foreign currency controls in effect and that each money is held in both countries. In particular, we assume that the fiat money stocks are equally dispersed among the initial old of both countries. Because there are 100 people born in each generation, there are 200 initial old people across the two countries. This implies that each member of the initial old holds \$4 and £3, regardless of citizenship. Finally, assume that the exchange rate is fixed at $\bar{e} = \frac{1}{2}$; that is, \$1 trades for £0.5.

From the world money market-clearing condition, we can find the value of each country's fiat money in a stationary equilibrium.

$$\implies \frac{1}{2} \cdot v_t^b \cdot 800 + v_t^b \cdot 600 = 1000 + 1000 \implies v_t^b = 2$$
$$\implies v_t^a = \bar{e} v_t^b = 1$$

The consumption by each old person in both countries is equal to the real value of that person's total money holdings.

$$c_t^a = c_t^b = v_t^a \cdot 4 + v_t^b \cdot 3 = 10 \text{ goods}$$

Now suppose that every member of the initial old of both countries decides to cut their real balances of country a money in half. Each member of the initial old therefore turns in \$2 to the monetary authority of country a in order to acquire country b money. Assume that the monetary authority of country b has agreed to cooperate by printing as much of its currency as demanded, sending it to the monetary authority of country a. This is an example of cooperative stabilization. Because the exchange rate is fixed at $\frac{1}{2}$, country b must print £0.5 for every dollar turned in by the old. At the end of the currency exchange, the stock of dollars has shrunk by \$400 and the stock of pounds has grown by £200. In this situation, the total fiat money stock of each country has become \$400 and £800, respectively. Then as was done earlier, use the world money market-clearing condition to solve for the value of country b money.

$$M_t^a = 400, M_t^b = 800$$
$$\implies \frac{1}{2} \cdot v_t^b \cdot 400 + v_t^b \cdot 800 = 1000 + 1000 \implies v_t^b = 2$$
$$\implies v_t^a = \bar{e} v_t^b = 1$$
$$\implies c_t^a = c_t^b = v_t^a \cdot 4 + v_t^b \cdot 3 = 10 \text{ goods}$$

Thus, there is no change to the consumption by each old person under a policy of cooperative stabilization. Demand for real money balances is unchanged and the supply of world money is unchanged in a cooperative stabilization as people hold fewer dollars and more pounds.

Now let us see how the results differ when country a attempts a unilateral defense of the exchange rate. Suppose country b refuses to print fiat money to accommodate the desires of the old to trade in their dollars for pounds. Assume that the government of country a decides to honor its pledge to exchange currency through an equal tax on every one of its old citizens. To do this, the government of country a must raise tax revenue sufficient to honor its pledge to provide all of the country b money demanded. The monetary authority in country a gives goods collected from taxes to those giving up country a money. The people can then go to the monetary authority in country b to acquire the desired money.

We begin by describing the steps in the unilateral defense. There are 200 old people across the two countries and each is turning in \$2. With $\bar{e} = \frac{1}{2}$, the process ends when the number of dollars is exchanged for pounds. Thus, country a's monetary authority must acquire £200. Next, thec entral bank must give goods to the old equal in value to the currency. Remember that country b's monetary authority is not printing any new currency. So, country a's monetary authority must give up the value of country b's money times the total quantity of money acquired, which is represented by $v_b^t(£200)$ goods. Because country a can tax *only its own citizens*, each old person of country a will be required to pay a tax

$$\frac{200v_t^b}{100} = 2v_t^b$$

To determine the quantity of the tax, v_t^b has to be figured out. The total fiat money stock of country a falls to 400, with country b money stock constant as $M_t^b = 600$.

$$M_t^a = 400, M_t^b = 600$$
$$\implies \frac{1}{2} \cdot v_t^b \cdot 400 + v_t^b \cdot 600 = 1000 + 1000 \implies v_t^b = 2.5$$
$$\implies v_t^a = \bar{e} v_t^b = 1.25$$

By decreasing the total world money supply and leaving the demand for money unchanged, we see that the value of all currency will increase under a unilateral defense of the exchange rate. This stands in marked contrast to the cooperative stabilization solution in which we found that the value of each currency remained unchanged.

Thus, each old person living in country a must be taxed

$$2v_t^b = 5$$

Now that the tax has been collected, country a is capable of acquiring new money from country b's monetary authority. Remember, there are 500 goods divided by **200** old people (all the old people to return country a money for b), so that country a purchases 2.5 goods worth of newly printed pounds. At 2.5 goods per pound, each old person will acquire one additional pound. So now after turning in \$400, leaving \$2 per old person, each old person started with £3 and ends up with £4.

For the old of country b, who do not pay any taxes, old-age consumption is

$$c_t^b = v_t^a \cdot 2 + v_t^b \cdot 4 = 12.5 \text{ goods}$$

For the old of country b, who must pay a tax to defend their currency, old-age consumption is

$$c_t^a = v_t^a \cdot 2 + v_t^b \cdot 4 - (\text{tax}) = 7.5 \text{ goods}$$

The old of country b benefit from the unilateral defense policy because the real value of their currency holdings increases and they are not subject to a tax. The old of country a are made worse off by this policy of unilateral defense than they were under the cooperative stabilization policy. In effect, only the citizens of country a pay the tax that increases the value of all money holders, transferring wealth from the taxpayers of the country defending the exchange rate to the money holders of the other country.

6. Central Bank & Independence

6.1. Central Bank

The Federal Reserve System includes

- The Federal Reserve Banks: 12家联邦储备银行
- The Board of Governors of the Federal Reserve System (联邦储备委员会)
- The Federal Open Market Committee (FOMC，联邦公开市场委员会)
- The Federal Advisory Council (联邦咨询委员会）
- Around 2,900 member commercial banks

6.1.1. Federal Reserve Banks

Federal Reserve Banks are quasi-public institution owned by private commercial banks in the district that are members of the Fed system.

- Member banks elect **six** directors for each district; three more are appointed by the Board of Governors
  - Three A directors are professional bankers
  - Three B directors are prominent leaders from industry, labor, agriculture, or consumer sector
  - Three C directors appointed by the Board of Governors are not allowed to be officers, employees, or stockholders of banks
    - Designed to reflect all constituencies of the public
- Nine directors appoint the president of the bank; subject to approval by Board of Governors

6.1.1.1. Functions

- Clear checks
- Issue new currency
- Withdraw damaged currency from circulation
- Administer and make discount loans to banks in their districts
- Evaluate proposed mergers and applications for banks to expand their activities
- Act as liaisons between the business community and the Federal Reserve System
- Examine bank holding companies and state-chartered member banks
- Collect data on local business conditions
- Use staffs of professional economists to research topics related to the conduct of monetary policy

6.1.1.2. Special Role of the Federal Reserve Bank of New York

The Federal Reserve Bank of New York plays a special role in the Federal Reserve System for several reasons.

- First, its district contains many of the largest commercial banks in the United States, the safety and soundness of which are paramount to the health of the U.S. financial system.
- The second reason for the New York Fed's special role is its active involvement in the bond and foreign exchange markets.
- The third reason for the Federal Reserve Bank of New York's prominence is that it is the only Federal Reserve Bank to be a member of the Bank for International Settlements (BIS).
- Finally, the president of the Federal Reserve Bank of New York is the only permanent voting member of the FOMC among the Federal Reserve Bank presidents, serving as the vice-chair of the committee. Thus, he or she and the chair and vice-chair of the Board of Governors are the three most important officials in the Federal Reserve System.

6.1.1.3. Federal Reserve Banks & Monetary Policy

- Directors "establish" the discount rate
- Decide which banks can obtain discount loans
- Directors select one commercial banker from each district to serve on the Federal Advisory Council which consults with the Board of Governors and provides information to help conduct monetary policy

- Five of the 12 bank presidents have a vote in the Federal Open Market Committee (FOMC)

6.1.1.4. Member Banks

- All national banks are required to be members of the Federal Reserve System.
- Commercial banks chartered by states are not required but may choose to be members.
- Depository Institutions Deregulation and Monetary Control Act of 1980 subjected all banks to the same reserve requirements as member banks and gave all banks access to Federal Reserve facilities.

6.1.2. Board of Governors

- Seven members headquartered in Washington, D.C.
- Appointed by the president and confirmed by the Senate
- 14-year non renewable term
- Required to come from different districts
- Chairman is chosen from the governors and serves four-year term

6.1.2.1. Duties of the Board of Governors

- Votes on conduct of open market operations
- Sets reserve requirements
- Controls the discount rate through "review and determination" process
- Sets margin requirements (保证金要求)
- Sets salaries of president and officers of each Federal Reserve Bank and reviews each bank's budget

- Approves bank mergers and applications for new activities.
- Specifies the permissible activities of bank holding companies.
- Supervises the activities of foreign banks operating in the United States.

6.1.2.2. Chairman of the Board of Governors

- Advises the president on economic policy
- Testifies in Congress
- Speaks for the Federal Reserve System to the media
- May represent the United States in negotiations with foreign governments on economic matters

6.1.3. Research Staff

- The Federal Reserve System is the largest employer of economists not just in the United States, but in the world
- The most important task of the Fed's economists:
- to follow the incoming economic data from government agencies and private sector organizations
- and to provide guidance to the policy-makers, on the direction in which the economy might be headed and the potential impact of monetary policy actions on the economy

6.1.4. Federal Open Market Committee (FOMC)

- Meets **eight** times a year
- Consists of seven members of the Board of Governors, the president of the Federal Reserve Bank of New York, and the presidents of four other Reserve banks
- Chairman of the Board of Governors is also chair of FOMC
- Issues directives to the trading desk at the Federal Reserve Bank of New York

6.2. Independence of Central Banks

6.2.1. Estimate the Independence

- Instrument v.s. goal independence
- Independent revenue
- Fed's structure is written by Congress, and is subject to change at any time
- Presidential influence
  - Influence on Congress
  - Appoints members

- Appoints chairman although terms are not concurrent

6.2.2. Pro v.s. Aaginst Independence

- Reasons for independence
  * Political pressure would impart an inflationary bias to monetary policy
  * Political business cycle
  * Could be used to facilitate Treasury financing of large budget deficits: accommodation
  * Too important to leave to politicians—the principal-agent problem is worse for politicians
- Reasons against independence
  * Undemocratic
  * Unaccountable
  * Difficult to coordinate fiscal and monetary policy
  * Has not always used its independence successfully

6.2.3. ECB

Characteristics

- National Central Banks control their own budgets and the budget of the ECB
- Monetary operations are not centralized
- Does not supervise and regulate financial institutions

Governing Council

- Monthly meetings at ECB in Frankfurt, Germany
- Nineteen National Central Bank heads and six Executive Board members
- Operates by consensus
- ECB announces the target rate and takes questions from the media
- To stay at a manageable size as new countries join, the Governing Council will be on a system of rotation.

Independence

- Most independent in the world
- Members of the Executive Board have long terms
- Determines own budget
- Less goal independent
- Price stability
- Charter cannot by changed by legislation; only by revision of the Maastricht Treaty

7. Money Supply Process

Three players in the money supply process

1. Central bank: Federal Reserve System (the Fed)
2. Banks: depository institutions; financial intermediaries
3. Depositors: individuals and institutions

Factors affecting money supply

- Open Market Operation
- Loans to Financial Markets

Other Factors

- Float (浮款)
- Treasury deposits at the Fed (联储在财政部存款)
- Interventions in the foreign exchange market (干预外汇市场)
  - open market operation under extensive definition

7.1. The Fed's Balance Sheet

Assets	Liabilities
Securities	Currency in circulation
Loans to Financial Institutions	Reserves

- **Liabilities**
  - Currency in circulation: in the hands of the public
  - Reserves: bank deposits at the Fed and vault cash
- **Assets**
  - Government securities: holdings by the Fed that affect money supply and earn interest
  - Discount loans: provide reserves to banks and earn the discount rate

Note: Balance Sheets of PBoC & the Fed

- Major asset items
  - PBoC
    - Foreign exchange
    - Claims on other depository corporations
  - the Fed

    - U.S. Treasury securities
    - Agency MBS
- Major liability items
    - PBoC
        - Reserve money
    - the Fed
        - Deposits held by depository institutions other than term deposits

7.2. Open Market Purchase

7.2.1. Open Market Purchase from a Bank

For simplicity, we assume 100% required reserve ratio.

Federal Reserve System:

Assets		**Liabilities**	
Securities	+$100m	Reserves	-$100m

Banking System:

Assets		**Liabilities**
Securities	−$100m	
Reserves	+$100m	

Results are

- Net result is that reserves have increased by $100m. Monetary base has risen by $100m.
- **No** change in currency.

7.2.2. Open Market Purchase from the Nonbank Public

7.2.2.1. Person selling the bonds deposits the Fed's check in the bank

Non-Bank Public

Assets		Liabilities	
Securities	−$100m		
Checkable Deposits	+$100m		

Banking System:

Assets		Liabilities	
Reserves	+$100m	Checkable Deposits	+$100m

Federal Reserve System:

Assets		Liabilities	
Securities	+$100m	Reserves	+$100m

- Identical result as the purchase from a bank

7.2.2.2. Person selling the bonds cashes the Fed's check

Non-Bank Public

Assets		Liabilities	
Securities	−$100m		
Currency	+$100m		

Federal Reserve System

Assets		Liabilities	
Securities	+$100m	Currency in circulation	+$100m

Results are

- Reserves are unchanged.
- Currency in circulation increases by the amount of the open market purchase.
- Monetary base increases by the amount of the open market purchase.

7.2.3. Open Market Purchase: Summary

- The effect of an open market purchase on reserves depends on whether the seller of the bonds keeps the proceeds from the sale in currency or in deposits.
- The effect of an open market purchase on the monetary base always increases the monetary base by the amount of the purchase.

7.3. Loans to Financial Institutions

Banking System

Assets		**Liabilities**	
Reserves	+$100m	Loans (Borrowing From Fed)	+$100m

Federal Reserve System

Assets		**Liabilities**	
Loans (Borrowing From Fed)	+$100m	Reserves	+$100m

Results are

- Monetary liabilities of the Fed have increased by $100
- Monetary base also increases by this amount

7.4. Multiple Deposit Creation

Overview of the Fed's Ability to Control the Monetary Base

- Open market operations are controlled by the Fed.
- The Fed cannot determine the amount of borrowing by banks from the Fed.
  - China's frequent use of structural monetary policy is influenced by government policy guidance.
- Split the monetary base into two components, $MB_n = MB - BR$
  - The money supply is positively related to both the non-borrowed monetary base MB_n andt o the level of borrowed reserves, BR, from the Fed.

7.4.1. Simple Model

Assuming that banks do not hold excess reserves, then

$$\text{Required Reserves } (RR) = \text{Total Reserves } (R)$$

The requirement of reserves, by nature, equals to required reserve ratio R times the total amount of checkable deposits D.

$$\begin{aligned} r \times D &= R \\ \implies D &= \frac{1}{r} \times R \\ \implies \Delta D &= \frac{1}{r} \times \Delta R \end{aligned}$$

Critique of the Simple Model

- Holding cash stops the process
  - Currency has no multiple deposit expansion.
- Banks may not use all of their excess reserves to buy securities or make loans.
- Depositors' decisions on how much currency to hold, and bank's decisions on amount of excess reserves to hold, also cause the money supply to change.

7.4.2. Advanced Model

Factors Determining Money Supply

Player	Variable	Change in Variable	Money Supply Response	Reason
Federal Reserve System	Nonborrowed monetary base, MB_n	↑	↑	More *MB* for deposit creation
	Required reserve ratio, rr	↑	↓	Less multiple deposit expansion
Banks	Borrowed reserves, BR	↑	↑	More *MB* for deposit creation
	Excess reserves	↑	↓	Less loans and deposit creation
Depositors	Currency holdings	↑	↓	Less multiple deposit expansion

Money is defined as currency plus checkable deposits: M_1. Link the money supply (M) to the monetary base (MB) and let m be the money multiplier,

$$M = m \times MB$$

Under the ideal environment in the simple model, $m = \frac{1}{r}$.

Assume that the desired holdings of currency C and excess reserves ER grow proportionally with checkable deposits D. Naturally, define currency ratio as $c \equiv \frac{C}{D}$, and excess reserves ratio as $e = \frac{ER}{D}$. The total amount of reserves (R) equals the sum of required reserves (RR) and excess reserves (ER). And the former equals the required reserve ratio r times the amount of checkable deposits D.

$$\begin{aligned} R &= RR + ER \\ &= r \cdot D + e \cdot D \\ &= (r + e) \cdot D \end{aligned}$$

The monetary base MB equals currency C plus reserves R.

$$\begin{aligned} MB &= C + R \\ &= (c + r + e) \cdot D \end{aligned}$$

This equation reveals the amount of monetary base needed to support the existing amounts of checkable deposits, currency, and excess reserves.

The total amount of money M equals the currency C plus the checkable deposits D.

$$\begin{aligned} M &= C + D \\ &= (1 + c) \cdot D \\ &= (1 + c) \cdot \frac{MB}{c + r + e} \\ &= \frac{1 + c}{c + r + e} \cdot MB \end{aligned}$$

Therefore, the multiplier after considering more real circumstances is

$$m = \frac{1 + c}{c + r + e}$$

Back in the ideal case, $c = e = 0$, and $m = \frac{1}{r}$.

8. Tools of Monetary Policy

- Conventional Policy Tools
  - OMOs
  - Discount lending
  - Reserve requirements
- Unconventional Policy Tools
  - Liquidity facilities
  - QE
  - IOR (interest rate on reserves)
    - interest payment to all reserves
  - Forward guidance
    - central bank's communication with the public to build reasonable expectations.
  - NIR (negative interest rates)

中国人民银行的货币政策工具

- 法定存款准备金率(required reserve ratio)
- 再贴现政策(discount policy)
- 公开市场操作
- 结构性货币政策工具
  - 支农、支小再贷款、再贴现等工具
  - 直达工具：普惠小微企业贷款延期支持工具 & 普惠小微企业信用贷款支持计划
  - 碳减排支持工具和支持煤炭清洁高效利用专项再贷款