Notes on real effects of monetary policy, risk, swaps, liquidity, and intermediation

1. How does monetary policy affect investment?

The question we're interested in is the impact of monetary policy on investment and hence the real economy. Intuitively, an increase in the rate of growth in the money supply leads to inflation. An increase in inflation reduces the return to holding money. A decrease in the return on money will cause savers to shift from holding money to other assets. As the supply of funds for these other assets increases, their return will fall. As this return falls there is downward pressure on loan rates charged by banks and hence the cost of borrowing falls. We should observe greater borrowing for investment, which eventually leads to greater investment.

So what will this result depend on? How does it work? What are the channels of influence? Which variable affects another? We need a model that can help illuminate this intuition.

It would seem that the model requires a saver allocating savings among several assets including fiat money and deposits at banks. We would also need to include a banking sector and competition in the credit market among banks. Finally, there must be someone borrowing and investing in the model. Once we have these elements, and understand how they work, we can provide a theoretical explanation for what we observe going on in credit markets.

We will study a two period OGE. There are N identical savers, N identical banks, and N borrowers who borrow to invest. Banks intermediate between the savers and borrowers. We assume that the three groups are of equal size although this is easily extended to the case where they are not. There will be two assets, money and deposits at banks. Borrowers will borrow to invest.

Savers

First, consider the saver. Preferences are given by $U(c_1, c_2)$ and there are two assets a saver can hold, fiat money, m/p, and deposits at a bank, d. A saver's endowment is $(w, 0)$. Her constraints are $c_1 = w - s$ and $c_2 = (1+r)s$. Substitute in to the utility function, $U(w - s, (1+r)s)$. The saver chooses savings to max U. The first order condition is $-U_1 + (1+r)U_2 = 0$. When we solve this, savings depends on w and 1+r, $S(w, 1+r)$. This is the total that is saved. Then the saver allocates this total among the different assets. With money and deposits, savings is equal to $m/p + d$,

$$S(w, 1+r) = m/p + d. \tag{1}$$

If we observe the saver holding both assets, it must be that the rates of return are the same. If the return to money is $1+r_m$ and the return to deposits is $1+r$, then

$$1+r_m = 1+r. \tag{2}$$

We need to figure out the saver's expectation about $1+r_m = p_t/p_{t+1} = 1/(1+\pi)$, the inverse of the inflation rate. By equality of rates of return in equation (1), $1+r = 1/(1+\pi)$. We will make a case for this later when we introduce the government's policy.

Exercise: Suppose utility is $U = Ln(c_1) + \beta Ln(c_2)$. Show that the savings function is $S(w, 1+r) = \beta w/(1+\beta)$. Note that with this utility function savings does not depend on the interest rate. This is a special case. So the saver's allocation in this example is given by $\beta w/(1+\beta) = m/p + d$. If there is only one asset deposits, then $d = \beta w/(1+\beta)$.

Banks

Next, consider the representative bank. Let D be total deposits and L be total loans. The bank's balance sheet is

Bank	
Assets	Liabilities
L	D
L = D	

Loans generate income for the bank, while deposits requiring interest generate cost. Suppose the bank pays 1+r on deposits and receives interest of 1+g on loans. The cash flow profit of the bank is equal to repayment of old loans plus interest, minus new loans, plus new deposits, minus old deposits plus interest,

Profit = (1+g)L(old) – L(new) + D(new) – (1+r)D(old).

In equilibrium, L(old) = L(new) and D(old) = D(new) so

Profit = gL – rD.

But the bank's books have to balance so L = D. Therefore, if there is competition in banking that drives profit to zero, rates must equalize,

$$g = r. \qquad (3)$$

The gap g – r is the rate spread. In this example it is zero. This is not generally true and we will see examples later where it is positive.

Exercise: Suppose there is a fixed cost F of providing banking services so profit is given by, Profit = (1+g)L(old) – L(new) + D(new) – (1+r)D(old) - F. What happens to the rates in equilibrium where competition drives profit to zero? What is the rate spread?

If there are N identical depositors, D = Nd, where d is the individual depositor's deposit, and if there are N identical borrowers, L = Nl, where the individual loan is l. Since L = D, or, Nl = Nd, it follows that l = d in our economy.

Borrowers

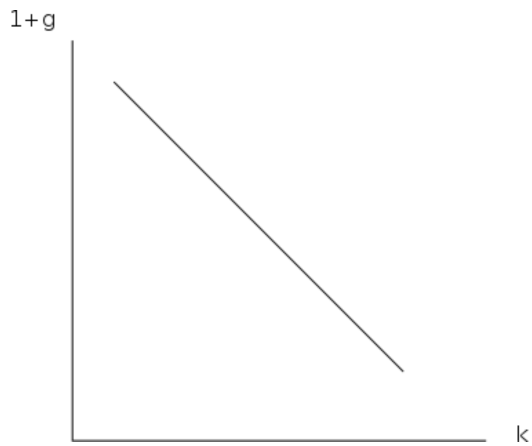
Assume each borrower is endowed according to (0, y), where y = f(k). In a sense the borrower produces their own second period endowment with actions taken in the first period. The idea is that the borrower borrows b in order to make an investment of k in technology that produces a return of y = f(k). So b = k. Assume f(k) is subject to diminishing returns. Thus, $f'(k) = df/dk > 0$ and $f''(k) < 0$. There is 100% depreciation so the capital is used up in production. The investor's profit is

Profit = f(k) – (1+g)b = f(k) – (1+g)k.

Profit maximization implies

$$f' = 1 + g \,. \tag{4}$$

The demand for capital investment is downward sloping, as in the graph below.[1] A lower cost of borrowing allows firms to borrow more in order to invest more. So if government policy reduces borrowing costs, firms will invest more.



Finally, we need to say where the inflation comes from. Suppose the government increases the money supply by 1+z each period,

$$M_t = (1+z)M_{t-1}. \tag{5}$$

We could assume the government prints new money each period and uses it to buy some of the goods produced by the private sector, seigniorage, and then throws them into the ocean, i.e., builds an aircraft carrier. So one assumption is the following,

$$G = (M_t - M_{t-1})/p_t.$$

Under this scenario, what will an agent expect of the price level in the future? One reasonable expectation is that prices will increase by 1+z. Hence $1+\pi = p_{t+1}/p_t = 1+z$ is the inflation rate. So $1+r_m = p_t/p_{t+1} = 1/(1+z)$.

How does monetary policy affect this economy? Since the return to holding money is $1+r_m = 1/(1+\pi) = 1/(1+z)$, under our assumption on expectations, it follows that $1+r = 1/(1+z)$ by equation (2) in equilibrium. So if we differentiate this we get,

$$\frac{dr}{dz} = -\frac{1}{(1+z)^2} < 0 \,.$$

An increase in the rate of growth of the money supply reduces the return to holding money by increasing inflation. However, if savers hold both money and deposits, the rate

[1] This follows from equation (4), $f''dk = dg$. An increase in the loan rate by the bank reduces borrowing and hence capital investment.

of return to deposits must also fall so savings must shift from money to deposits, i.e., the supply of savings into deposits must increase.

We know that under competition in the banking sector, 1+r = 1+g from equation (3) so 1+g = 1/(1+z). It follows from this that

$$\frac{dg}{dz} = -\frac{1}{(1+z)^2} < 0 .$$

So the interest charged on loans must fall as more deposits flow into banks.

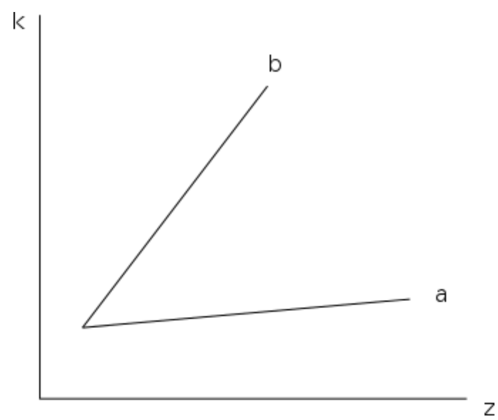
And from equation (4) we know that

$$f' = 1/(1+z) . \tag{6}$$

Differentiate this to obtain,

$$\frac{dk}{dz} = -\frac{1}{(1+z)^2 f''} > 0 .$$

This is captured in the curves below. Compare two economies a and b. Now imagine an equal increase in the rate of growth of the money supply in both economies. There will be more of an increase in investment in economy b than economy a. (Can you demonstrate this in the graph?)



So an increase in the rate of growth of the money supply increases inflation and this causes a shift in portfolios from money to other assets including deposits at banks. An increase in the supply of deposits induces a decrease in the loan rate 1+g causing more borrowing to occur. This in turn causes an increase in investment. This mechanism is due to Tobin and this is one model that can capture this channel of monetary policy, i.e., **Tobin's effect**.

Exercise: As a result of the financial meltdown in Europe, Cyprus is taxing bank deposits. Impose tax t on deposits so to deposit d at a bank you have to give d + td = (1+t)d to the bank as the deposit but only get back (1+r)d as a return next period, where t is the tax rate on deposits. The bank hands over the tax = td to the government. Show that under an equality of rates of return,

$$\frac{1+r}{1+t} = 1 + r_m = \frac{1}{1+z}$$

in equilibrium. Argue that an increase in the tax reduces deposits and investment. Describe the mechanism as to why this happens.

2. Fisher's equation

In the real world of finance and credit markets, nominal interest rates are easily observed. These are the rates you see quoted on the evening news and on financial web sites. However, economists are typically interested in real interest rates because this tells us something about the productivity of the economy and investments. Is there a connection between nominal rates and real rates? As it turns out, there is.

Fisher's equation captures the relationship between nominal interest rates and real interest rates. Real rates reflect the productivity of investment for example in capital. Nominal rates also reflect this. In addition to this, however, nominal rates also reflect inflation.

Consider the model of the saver above in section 1 and consider the budget constraints,

$$c_1 = w - d - m/p$$

$$c_2 = (1+r)d + m/p'$$

where S = m/p + d. Multiply through by price,

$$pc_1 = pw - pd - m$$

$$p'c_2 = p'(1+r)d + m$$

These equations are all in nominal magnitudes, e.g., dollars. So pc_1 is dollars spent on first period consumption and c_1 is literally units of the good. Next, divide the second equation through by the original price p,

$$p'c_2 / p = p'(1+r)d/p + m/p\,,$$

or, using the definition of inflation,

$$(1+\pi)c_2 = (1+\pi)(1+r)d + m/p\,.$$

We can define the nominal interest rate, following Fisher, as

$$1+i = (1+\pi)(1+r)\,.$$

The nominal interest rate is the real interest rate 1+r adjusted for inflation $1+\pi$. Notice $1+i = 1+\pi+r+r\pi$, by multiplying out the right hand side of the last equation. If r = 2% and inflation is 3%, then $1+i = 1+.03+.02+(.02)(.03) = 1.05+.0006$. Notice that the term $r\pi = .0006$ is really small in magnitude so it is typically ignored. In that case 1+i = 1.05.

So Fisher's famous equation is

$$i = \pi + r\,. \qquad (7)$$

Take the real interest rate and add the inflation rate to it to get the nominal interest rate. So if r = 2% and π= 3%, i = 5%. If inflation jumps to π =5%, then in the short run i = 7%. However, according to the Tobin effect of section 1, an increase in inflation will eventually cause agents to shift from money to other assets like bank deposits paying more interest and this will cause a drop in lending rates. This will in turn induce greater business investment reducing r. So in a long run sense, if r = 2% and π= 3%, so that i =

5%, an increase in inflation to 5% in the long run may cause a change in r to r = 1% so i = 6% instead. But this economy may also have greater capital investment as well.

3. Risky business

A. First model: saver bears risk.

Unfortunately, there is much uncertainty and risk in investing. On occasion, returns can be very high. Unfortunately, this is not always the case. In this section we want to ask about the impact of uncertainty and what may happen if there is a perceived in crease in risk.

Consider the model of section 1 but assume the investment is risky. Suppose the saver deposits d in the bank and this is the only asset. However, the return is not a sure thing. There are two states of the world, a good state where the deposit pays (1+r)d with probability q, and a bad state where it pays only $\varepsilon > 0$. The constraints for the saver are

$c_1 = w - d$,
$c_{21} = (1+r)d$,
$c_{22} = \varepsilon$,

where c_{21} is consumption in the second period in the good state and c_{22} is consumption in the second period in the bad state, and $(1+r)d > \varepsilon$. Expected utility[2] is

$$EU = Ln(c_1) + \beta[qLn(c_{21}) + (1-q)Ln(c_{22})], \quad (8)$$

Where 0 < b < 1 is the discount factor from before. Substitute the constraints into the utility function,

$Ln(w - d) + \beta qLn((1+r)d) + \beta(1-q)Ln(\varepsilon)$,

and maximize,

$-1/(w - d) + \beta q/d = 0$,

and simplify.[3]

$$d = \frac{\beta q}{1+\beta q} w. \quad (9)$$

This is the supply of deposits to the banks. It generalizes the case where there is no uncertainty. If q = 1, and the only asset is deposits, then $d = \beta w/(1+\beta)$. The deposit in equation (9) is increasing in income w, increasing in b, the discount factor, and increasing in q, the probability of the good state occurring.

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[2] One reasonable way of analyzing asset holding under uncertainty is to use the expected utility model. Calculate the probabilities of the good and bad state and multiply each by the utility in that state, $qLn((1+r)d)$ and $(1-q)Ln(\varepsilon)$, and add them.

[3] Here's the algebra:

$\beta q/d = 1/(w - d)$,
$\beta q(w - d) = d$,
$\beta qw - \beta qd = d$,
$\beta qw = d + \beta qd$,
$\beta qw = (1 + \beta q)d$, and divide to get d.

This should make intuitive sense. Savers are more willing to put funds into risky deposits if they feel there is a greater probability of success. On the downside, if they also perceive a decrease in that probability, they will deposit less in a risky endeavor. This is important because savers do tend to pull back on investments when a recession hits. This is one of the reasons central banks issue statements trying to calm the markets when the economy begins going into a recession.

Exercise: Show that the deposit is increasing in the probability of the good state. Hint: differentiate equation (9).

Next, assume the banks are just "pass throughs" so they pay 1+r in the good state and ε in the bad state on deposits and charge the interest 1+r on loans. However, if the loan cannot be repaid, the bank forecloses on the investment and only receives ε.

Now consider the borrower/investor. They will invest in a risky technology that pays f(k) in the good state and ε in the bad state. Their expected profit is

$$\begin{aligned}\pi &= \text{good state} + \text{bad state},\\ &= q[f(k) - (1+r)b] + (1-q)[\varepsilon - \varepsilon]\\ &= q[f(k) - (1+r)k],\end{aligned}$$

where k = b. Maximize profit to obtain,

$$q[f'(k) - (1+r)] = 0,$$

so $f'(k) = 1+r$ and the probability of success or failure doesn't directly affect the investment in this model. It does affect deposits, as we saw earlier in equation (9).

For example, suppose $y = Ak - k^2/2$ for A > 0. Then profit maximization implies df/dk = A – k = 1+r, which is easy to solve for k, k = A – (1+r).

As in section 1, the interest rate affects investment in the following way,

$$f''(k)dk = dr,$$

or,

$$\frac{dk}{dr} = 1/f''(k) < 0.$$

This tells us that our model predicts there is a negative correlation between investment and the cost of investing, which fits well with the real world. This should make sense. If the cost of borrowing increases firms will borrow less and invest less. This is one reason central banks keep interest rates low in a recession.

In equilibrium, s = d = l = b = k, i.e., savings equal deposits equal loans equal borrowing equal investment, or k = d for short. So using equation (9) for d,

$$k = \frac{\beta q}{1+\beta q} w.$$

Notice that investment is increasing in the probability of the good state occurring, q.[4]

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[4] $$\frac{dk}{dq} = \frac{bw}{1+bq} - \frac{bqw}{(1+bq)^2}b = \frac{[bw(1+bq) - bqwb]}{(1+bq)^2} = \frac{bw}{(1+bq)^2} > 0.$$

An increase in the probability of the good state increases deposits into the banking system making more funds available for investment. On the downside, a decrease in the probability of the good state reduces deposits and this in turn reduces investment.

Example: Suppose $y = Ak – k^2/2$ so when profit is maximized, $A – k = 1+r$. We can solve this to get capital investment,

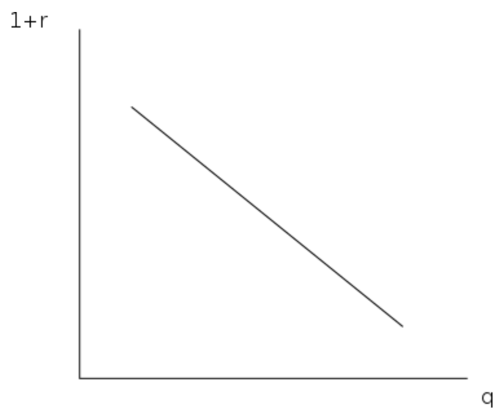
$k = A – (1+r)$.

Since in equilibrium, $k = d$, substitute d from (9) for k,

$$A – (1+r) = \beta qw/(1+\beta q).$$

This sets up a negative relationship between the interest rate and the probability of the good state occurring depicted in the graph,

Greater uncertainty about the good state of nature occurring as denoted by a decrease in q leads to deposits falling as people pull their deposits out of banks and this raises the interest rate in our model economy.



How can we interpret a recession? One interpretation is that investments become riskier. We can model this as a decrease in q. A decrease in q reduces deposits in this economy and this in turn raises interest rate and lowers business investment. Credit dries up!

Another application has to do with tax policy. In many countries the government subsidizes risk taking by subsidizing borrowing. This is an attempt in some cases to overcome a decrease in the probability of the good state occurring. So the government might run a deficit in order to subsidize borrowing for investment purposes.

Exercise: Consider imposing a **tax on deposits**. Replace w with $w – T$ in equation (9), where T is the tax. How does the tax affect deposits? Next suppose the government uses tax revenue to subsidize borrowing, so $1 + r - \theta$, where θ is the subsidy rate so $T = \theta k$. What is profit for the investor? What is the condition for maximizing profit? Can you figure out how the subsidy rate θ affects investment, i.e., what is $dk/d\theta$?

B. Second model: banks bear the risk.

Suppose the bank bears the risk of uncertainty in investment outcomes. In that case the saver receives 1+r on their deposits at the bank in both states of nature so deposits are given by $d = \beta w/(1+\beta)$, q = 1 for the saver since someone else bears the risk, and the bank bears the risk of loans going bad.[5]

Suppose $\varepsilon = 0$ for simplicity. In the good state the bank receives q(1+g)L in repayment and receives nothing in the bad state. Its profit is

$$\text{Profit} = q(1+g)L(\text{old, good state}) - L(\text{new}) + D(\text{new}) - (1+r)D(\text{old})$$
$$= q(1+g)L - L + D - (1+r)D,$$

in equilibrium. Its liabilities are its deposits, D. Its assets are its ***good*** loans. For a large bank the probability of the good state can be gauged by past defaults and q will represent the actual fraction of business loans that are good and do not default so qL is the good loans, sometimes referred to as "performing" loans. Recall the empirical exercise at the beginning of the semester on bankruptcies. So D = qL and profit becomes[6]

$$\text{Profit} = [q(g - r) - (1 - q)]L.$$

Competition in banking leads to zero profit so

$$g - r = (1 - q)/q > 0.$$

This is the rate spread between lending and deposit rates. The spread adjusts for the possibility of defaults, i.e., the bad state occurring. If q increases, the spread falls, i.e., an increase in the probability of the good state occurring causes banks to reduce the risk spread g - r.

The borrower borrows b to invest in k, b = k, with payoff f(k) in the good state and nothing in the bad state. Their profit is

$$\text{profit} = q[f(k) - (1+g)k].$$

Maximize profit to get,

$$f'(k) = 1 + g.$$

So an increase in the loan rate leads to a decrease in investment. In addition, an increase in q, which lowers the loan rate g, leads to an increase in investment. This should make sense. If the probability of the good state occurring goes up, banks will

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5 If the saver receives the same return in both states of nature, expected utility becomes

$$EU = Ln(w-d) + \beta q Ln((1+r)d) + (1-q)\beta Ln((1+r)d)$$
$$= Ln(w-d) + \beta Ln((1+r)d),$$

the same as when there is no uncertainty.

6
$$\text{profit} = q(1+g)L - L - rD$$
$$= q(1+g)L - L - rqL$$
$$= (q(1+g) - 1 - rq)L$$
$$= (q(1+g) - 1 - (1+r)q + q)L$$
$$= (q(g - r) - 1 + q)L$$
$$= (q(g - r) - (1 - q))L.$$

reduce the risk premium charged on loans. A reduction in the rate charged on loans will induce greater investment in this model. It also works in reverse on the downside; a decrease in q, or increase in 1 – q of the bad state, leads to an increase in the risk spread in the loan rate and this in turn leads to a drop in investment.

4. Credit default swaps (CDS)

One issue that is somewhat controversial has to do with credit default swaps or CDSs. A swap is a contract that literally exchanges one stream of payments for another. It could involve any asset that delivers a payoff stream over time, e.g., student loans, mortgage payments, interest on bonds, credit card receivables. A CDS is a lot like car insurance. You pay regular premiums and receive coverage. If the good state occurs, and there is no accident, then the insurance is not activated. If you're in an accident, then the bad state occurs and the insurance is activated. It will then pay off on your claim. Insurance companies impose restrictions like deductibles that are designed so the buyer of the insurance bears some risk. This is to mitigate any moral hazard problems, i.e, the availability of the insurance may cause some to drive less safely raising the probability of an accident and a deductible makes this risky for the driver. In addition, you cannot buy an accident policy on someone else's car; you have to own the vehicle in question before an insurance company will sell you a policy.

We can apply this to financial markets. A buyer purchases a CDS on an asset like a bond because they are worried the bond may default and not pay interest. The buyer pays regular premiums to the seller of the CDS. If the good state occurs the swap is not activated. If the bad state occurs, the swap is activated and it replaces one stream of payments with another as stated specifically in the CDS contract.

Imagine it is a GM bond that will pay a stream of interest: R, R, R, ….. for ten years, the maturity of the bond. If there is a complete default after period 5, then the stream is: R, R, R, R, 0, 0,…... The swap would kick in after period 4 and the buyer of the swap would receive a payment of P from the seller of the swap so the stream would look like: R, R, R, R, P, P, ……, until maturity. Under complete coverage $P = R$. The bank may impose $P < R$ to make sure the buyer of the swap bears some of the risk.

Consider our model of the saver. The saver, who we might think of as a large pension plan with millions in assets, invests in a bond, B, issued by someone else, say GM, who wants to borrow. In the good state the bond pays $(1+r)B$ and in the bad state it pays ε. Expected utility is given by equation (8), as in the last section, and $c_1 = w – B$, $c_{21} = (1+r)B$, and $c_{22} = \varepsilon$. Maximize and solve to get the following,[7]

$$B = q\beta w/(1+q\beta). \qquad (10)$$

The demand for the bond, or supply of loanable funds to the bond market, is increasing in the probability of the good state, the discount factor, and the saver's income.

What actually happens? The saver buys the bond hoping to get a stream of interest (1+r). In a multi-period model the saver would hope to get a stream

1+r, 1+r, ….., 1+r

[7] Differentiate: $Ln(w – B) + \beta qLn((1+r)B) + b(1 – q)Ln(e)$
So, $- 1/(w – B) + qb/B = 0$.

for thirty years on a long term bond. But what if GM defaults? Then the bondholder gets nothing under a complete default, and pennies on the dollar under a partial default.

Now consider a swap. It costs a fixed value, say F. It pays off (0, 1+r) = (good state, bad state), i.e., it pays off nothing in the good state and 1+r in the bad state. Now the saver's constraints become

$c_1 = w – F – B,$

$c_{21} = (1+r)B$

$c_{22} = (1+r)B,$

and expected utility becomes

$EU = Ln(w – F – B) + \beta qLn((1+r)B) + \beta(1 – q)Ln((1+r)B),$

But the last two terms combine,

$EU = Ln(w – F – B) + \beta Ln((1+r)B).$

Notice that the swap has eliminated uncertainty about the payoff of the bond to the individual saver. Now maximize,

$-1/(w – F – B) + \beta/B = 0$

and solve

$$B = \beta(w – F)/(1 + \beta). \qquad (11)$$

How does the swap affect bond volume? We need to compare equation (10) with equation (11). If **$(w – F)/(1+\beta)$** > **$qw/(1+q\beta)$**, then loan volume is greater under the swap.

Exercise: Can you show the following:

If $w(1 – q) > (1+q\beta)F$, then $B]_{swap} > B]_{no\ swap}$.

In the exercise, if q = .9, b = 1, then the condition is 0.1w > 1.9F. Now the "saver" in this example might be a large pension fund like the state employees of California, or CalPERS. In that case, w represents the fund available for investing purposes and could be quite large.

A natural question to ask is where the swap comes from. Consider the investment bank or insurance company that offers a swap, like AIG. It receives F and pays out (1+r)B in the bad state so its profit is

$Profit = F – (1-q)(1+r)B.$

Competition among companies like AIG and investment banks like Goldman offering swaps should drive economic profit to zero, so

$F = (1-q)(1+r)B.$

Solve for B,

$B = F/(1-q)(1+r)$

and substitute this into equation (11),

$$F/(1-q)(1+r) = b(w – F)/(1 + b). \qquad (12)$$

This is messy since F is on both sides of the equation, but it tells us exactly how the premium F will be determined and what it responds to. The solution for F is given by[8]

[8] Cross multiply equation (12): $(1+\beta)F = \beta(w – F)(1-q)(1+r)$ and break the right hand side apart,

$(1+\beta)F = \beta(w – F)(1-q)(1+r) = \beta(1-q)(1+r) – \beta F(1-q)(1+r),$

$$F = \frac{\beta(1-q)(1+r)}{1+\beta+\beta(1-q)(1+r)}. \quad (13)$$

The premium is decreasing in q. So when q increases, F decreases, i.e., when the probability of the good state increases, the probability of the bad state falls and so too does the premium for the default swap. So corr(F, q) < 0.

Recall that it is competitive firms that are offering the swaps. These firms should respond to a perceived increase in the riskiness of the bond market by increasing the premiums they charge for swaps. In fact, we can use changes in F to track perceived risk. When the financial crisis deepened, the swap premiums increased dramatically for a number of firms like Washington Mutual (WAMU) and other troubled financial institutions, many of which failed. They reached incredible levels so that the insurance was too expensive to afford.

Several economists like Oliver Hart have suggested using changes in these premiums to impose rules on firms issuing the bonds in order to regulate them. The regulations would kick in only when the risk premiums for a bank or other finance company increased above a certain level. For example, Washington Mutual issued a variety of derivative bonds in heavy volume. Investors started buying CDSs on this paper. At first the premiums were very low. However, as the crisis deepened and Washington Mutual came under close scrutiny, the premiums on these swaps increased dramatically almost overnight. This signaled the market that WAMU was in trouble because of its large portfolio of derivative assets.

The following table is taken from Hart and Zingales (2010). An entry in the Table indicates the cost of insuring \$10,000 from default for one year. For example, the first entry \$11 means that it cost \$11 to insure \$10,000 of BOA's debt against default for one year. Clearly, by March of 2008 there were several banks in serious trouble. Hart and Zingales would use a market trigger based on the CD rate to force a bank in trouble to undertake a "stress" test and subsequently take drastic action like increasing its capital, or finding a partner to merge with.

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collect F on the left side,

$(1+\beta)F + bF(1-q)(1+r) = \beta(1-q)(1+r)$,

and factor the F out on the left,

$[1+\beta+\beta(1-q)(1+r)]F = \beta(1-q)(1+r)$,

and solve for F to get the result in the notes, equation (13).

Table 1 One year CD rates during the crisis

Financial Inst	8/15/07	3/14/08	9/29/08
BOA	11	93	124
JP Morgan	19	141	103
Wells Fargo	23	113	113
WAMU	44	1181	3305
Lehman Bors	38	572	1128
Bear Stearns	113	1264	118
AIG	31	289	821

Swaps can be used to short a company. If one believes, for example, that a bank, or large company like GM, is in trouble, one can buy a swap on the bank's or GM's debt and derivatives held as an asset. If the company goes under or defaults on its debt, then whoever sold you the CDS has to pay you. The tradeoff is between the premiums you have to pay the seller of the CDS and the time it takes for Lehman or GM to go under. The longer the company holds out and continues paying on its bonds the more expensive it is to use a swap to short its debt. And there is also the possibility that the company might survive. For example, while Lehman went under, GM was bailed out. So anyone holding swaps trying to short GM would have lost their bet. Many believe that one useful reform of the system would be to eliminate swaps on assets one does not own.

If the buyer owns the bond that is being insured by the swap, it is called a simple CDS or CDS for short. However, the buyer doesn't have to own the bond. In the case when the buyer doesn't own the bond, or underlying asset, it is called a naked CDS. And a collateralized debt object or CDO is a collection of CDSs. A synthetic CDO is one where the buyer owns ***doesn't own*** the underlying assets or CDSs. Buying a naked CDS is like buying fire insurance on your neighbor's house. You get paid by the insurance if your neighbor's house burns down! AIG was actually selling CDSs after the housing market crashed. Buying such a policy is like buying fire insurance on your neighbor's house ***AFTER*** it has already started burning down and is one of the reasons AIG went bankrupt and needed to be bailed out.

Some believe that CDSs without any risk to the buyer lead to too much risk being undertaken. This is socially inefficient and raises a lot of questions about regulating financial services. If the buyer of the swap bears no risk, they may undertake too much risk. And if non-owners of the asset being insured can buy this sort of insurance, it may lead to behavior that brings the bad state of nature about. Some believe that swaps should only be allowed for someone who actually owns the asset being insured.

In fact, complete insurance may also cause moral hazard to occur, which is why auto insurance companies impose deductibles. For example, if a large pension fund buys bonds from a large corporation like GM, the pension managers have a stake in the behavior of the company issuing the bond. They want to make sure the company will pay off on the bond. So they want to make sure the company is not undertaking risky behavior, e.g., making constant design changes in their products, producing shoddy quality, allowing poor overseas labor practices, and so on. However, if the pension managers bear no risk, say because they bought a risk free swap on GM's bond, they may not exercise oversight.

Another problem when non-owners of an asset can buy a swap on the asset is that it may become impossible to pay off all the buyers of swaps on the asset if a default occurs. Paying off on a swap may be affordable for the seller if it only has to pay owners of the asset who bought swaps, e.g., pension fund that owns GM's bonds. However, it is especially problematic if non-owners of the asset are allowed to buy insurance on the asset. The seller of the swap like Lehman Bros. could find itself paying out on thousands of claims on a single default and could easily default on its swap contracts itself. This is one of the reasons AIG went bankrupt and had to be bailed out by the US government.

5. Reserve requirements

Reserve requirements can be viewed as a tax on deposits at the bank, which is probably why banks do not like them and try to subvert them. However, they may serve a useful purpose in case of an old fashioned run on a bank or a more modern version consisting of a run on a bank's assets, like its portfolio of derivative assets.[9]

Let θ be the reserve requirement. It is the fraction of deposits which must be held on reserve at the central bank. Consider the bank's balance sheet:

Bank	
Assets	Liabilities
Reserves = θD	Deposits = D
Loans = L	

$$L + \theta D = D.$$

Or, $L = (1 - \theta)D$. The bank's profit is given by

$$\text{Profit} = (1+g)L(\text{old}) - L(\text{new}) + D(\text{new}) - (1+r)D(\text{old})$$

In equilibrium this becomes Profit = $gL - rD$. Using the balance sheet information, $L = (1 - \theta)D$, profit becomes: Profit = $[g(1 - \theta) - r]D$. In equilibrium, competition drives profit to zero. Therefore,

$$g - r = g\theta > 0. \tag{14}$$

A higher reserve requirement θ increases the spread. So the bank is able to shift some of the burden of a reserve requirement to borrowers in the form of a higher loan rate, or backwards to depositors in lowering rates on deposits. This is important because in many policy discussions some are constantly trying to impose taxes on banks or higher reserve requirements. It should be understood that banks may very well be able to shift the impact of some of these policies to borrowers and depositors.

We can add the other parts of the model. There are some savers and some borrowers and there is no uncertainty. Savers are endowed (w, 0), have log utility, and the only asset is deposits so $d = \beta w/(1+\beta)$ is deposits and Nd is total deposits. Borrowers

[9] If other financial firms and banks believe a particular bank is in trouble, they can buy swaps speculating on the bonds issued by the troubled bank. Rumors can spread, just like in an old fashioned bank run, and other banks may be unwilling to extend the troubled bank credit in the short run, causing an immediate crisis at the troubled bank.

borrow b to invest in k so b = k, and total loans are L = Nb = Nk. In the absence of uncertainty, optimal investment satisfies $f'(k) = 1 + g$.

First notice that if g – r = θg from the banking system, and there is an increase in θ, the gap between g and r increases; banks charge more on loans and pay less to depositors. If $f'(k) = 1 + g$, then an increase in the loan rate g will reduce investment. We can think of the reserve requirement as a tax, in a sense. An increase in this tax increases the rate spread g – r and may adversely affect investment.

Since L = (1 - θ)Nd by the balance sheet of the banks, and L = Nb, b = k, it follows that k = (1 - θ)d or

$$k = (1 - \theta)\beta w/(1 + b).$$

From this we can obtain the result that an increase in the reserve requirement lowers investment. It does this by taking funds out of the banking system that would have been used for loans.

For investment banks there is a capital requirement instead of a reserve requirement. A capital requirement acts like a cushion that protects the solvency of a bank in the case of a run on its assets or a sudden drop in the value of its assets. Investment banks get their funds by borrowing from various sources. This borrowing constitutes their liability. Their assets stem from how they invest those borrowed funds. If they invest in assets that earn a normal rate of return, then all is well and good. However, if some of the bank's assets lose value, as they did in the financial crisis of 2007 – 2008, then the bank has its capital requirement as a cushion. If the crisis is deep enough it may break the safety of the cushion and cause the bank to become insolvent like Bear Stearns or Lehman Bros.

6. Liquidity and intermediation

We wish to model the liquidity of money relative to other assets like long term investments. Some assets like money are very liquid while others are not. Yet they are all stores of value. Is it possible that some assets serve one purpose better than others? Is money valuable because of its liquidity? We also want to see what role banks might play in intermediating an illiquid asset, i.e., converting liquid deposits into a long term asset. Is this efficient? Is there something we can devise that is better?

Consider the following set up. The population is fixed. People live for three periods, have endowments of the one good in the first period but none in the other periods, (w, 0, 0), the same preferences, $U(c_1, c_2, c_3)$, and there is a technology whereby if k is invested now, (1+x)k becomes available in two periods. We will assume capital is highly productive and so an individual would like to invest in it to get the high return but they must wait for two periods. However, they also want to consume in all three periods. Given that agents are only endowed in the first period, they need a liquid asset to carry over for one period, in addition to the capital investment they want to make.

So we will assume $1+x > (1+r_m)^2$, so if someone holds money for two periods they will not do as well if they only invested in the capital for two periods. So agents want to make capital investments to earn the higher return. Since agents want to consume in the second period they may hold money, or some other liquid asset.

A. Money as a liquid asset.

Suppose that an individual can perfectly monitor an investment made for a long term gain at no cost. This means they can invest directly without an intermediary to check on the investment. In addition to the capital investment, assume there is also fiat money, where the stock of money is fixed so $1+r_m = 1$. Money serves as a liquid asset since it can be used after only one period. However, it may be dominated in its rate of return, yet agents will still hold money because of its liquidity properties. The two assets are no longer perfect substitutes.

The agent's constraints are

$c_1 = w - m_1/p_1 - k,$

$c_2 = (1+r_m)(m_1/p_1) - m_2/p_2,$

$c_3 = (1+x)k + (1+r_m)(m_2/p_2).$

The agent chooses money in both periods and capital investment to maximize utility subject to these constraints. They do so in order to smooth their income earned in the first period across the rest of their life cycle.

Intuitively, the MRS between periods 1 and 2 is U_1/U_2, the MRS between periods 2 and 3 is U_2/U_3, and the MRS between periods 1 and 3 is U_1/U_3. The MRT for periods 1 and 2 and periods 2 and 3 when the consumer is holding money is $1+r_m$, and for periods 1 and 3, $(1+r_m)^2$, when they hold money for two periods. Capital is very productive so we will assume

$$1+x > (1+r_m)^2 = 1 \qquad (15)$$

So we have the first order conditions pairing up MRSs and MRTs when the agent maximizes utility,

$U_1/U_2 = 1+r_m,$

$U_2/U_3 = 1+r_m,$

$U_1/U_3 = (1+r_m)^2$ if they hold money for two periods,

$U_1/U_3 = 1+x$ if they hold capital for two periods.

Since (15) holds, the consumer will only hold capital for two periods not money. So the consumer will hold money as a liquid asset to finance c_2 and invest in capital to finance c_3. The constraints become,

$c_1 = w - m_1/p_1 - k,$

$c_2 = (1+r_m)(m_1/p_1),$

$c_3 = (1+x)k.$

We can drop the time subscripts on m/p since they are not needed. Since the two assets are not perfect substitutes we can actually solve for the individual asset demand functions, which we cannot do if they are perfect substitutes. We do this in the Appendix. With a log utility function, we obtain,

$k = \beta^2 w/(1+\beta+\beta^2),$

$m/p = \beta w/(1+\beta+\beta^2).$

We can aggregate to get,

$K = Nk = N\beta^2 w/(1+\beta+\beta^2).$

$M/p = Nm/p = N\beta w/(1+\beta+\beta^2).$

The first equation is total capital investment, while the second equation instructs us that the quantity theory holds in this model.

Notice that the two period rate of return to capital investment is 1+x. What is the one period return? Zero. What is the one period return to hold money? $1+r_m > 0$. What is money's two period return? $(1+r_m)^2$. So $1+r_m > 0$ means that money dominates capital over one period, while capital dominates money over two periods since $1+x > (1+r_m)^2$. The two assets are no longer perfect substitutes. The ***equality of rates of return*** only holds if the two assets are ***perfect substitutes***.

B. Short term borrowing and lending

Suppose lenders can monitor borrowers without cost, in addition to being able to monitor their investment in capital. The young agents, who are the only one's with an endowment, can make loans to middle aged agents at rate 1+r. The middle aged borrowers repay when they are old and earn 1+x from their capital investment. So in the first period a young consumer makes a loan of l and a capital investment of k. When middle aged they borrow b and receive loan repayments (1+r)l. When old they repay what was borrowed and earn their capital return. The constraints are

$$c_1 = w - k - l$$
$$c_2 = (1+r)l + b$$
$$c_3 = (1+x)k - (1+r)b$$

Intuitively, the returns from period 1 to 2, 2 to 3, and 1 to 3 imply

$$U_1/U_2 = 1+r,$$
$$U_2/U_3 = 1+r,$$
$$U_1/U_3 = 1+x.$$

Multiplying the first two equations,

$$(U_1/U_2)\,(U_2/U_3) = (1+r)^2,$$

or,

$$U_1/U_3 = (1+r)^2.$$

Suppose initially that $1+x > (1+r)^2$. Then people will lend less when young in order to invest more in capital. As they lend less in the short term credit market the supply falls and the rate rises. In addition, borrowers will want to borrow more at the low credit rate since the high return to capital makes it easy to repay a loan when $1+x > (1+r)^2$ so this will also raise the rate on credit. The rate on credit will rise until there is an equality of rates of return between loans and investment in capital.

C. Banks and intermediation

Consider yet another institution, banks. Suppose it is very costly for an individual to monitor a loan made in the credit market, or an investment they make, but that a bank can spread the costs of monitoring. Then it will be efficient for banks to borrow short term by receiving deposits and make long term loans that get invested in capital. If banks can provide liquidity and intermediation, which involves breaking up a large illiquid asset like capital investment into liquid deposits, it is possible no one will hold the government's money.

Suppose we consider our earlier model of banking extended to three periods, where there are savers endowed in the first period (w, 0, 0), borrowers endowed (0, 0, y) with y = f(k), where dfdk = 1+x, and banks, who receive deposits and make loans. Suppose a saver deposits d_1 in the first period at a bank and earns 1+r next period, and then deposits d_2 in the second period and earns 1+r in the third period. Their constraints become

$c_1 = w - d_1$
$c_2 = (1+r)d_1 - d_2$
$c_3 = (1+r)d_2$.

And the first order conditions are the same as well,

$U_1/U_2 = 1+r$,
$U_2/U_3 = 1+r$,

Which implies

$U_1/U_3 = (1+r)^2$.

What does the bank's balance sheet look like? Who is making deposits? Young agents deposit d_1, middle aged agents earn 1+r on their d_1 and redeposit d_2, and old agents receive $(1+r)d_2$. Suppose the bank makes loans to investors who invest in k. The balance sheet of the bank is very simple,

Bank

Assets	Liabilities
L	D

L = D

Where $D = N(d_1 + d_2)$ and L = K is total capital investment.

Borrowers borrow b to invest in k for two periods, b = k. They pay (1+g) in interest each period on the loan for two periods. And receive 1+x = df/dk, where x is decreasing in k because of diminishing marginal returns. Profit is as before in previous sections, therefore, when the borrower maximizes profit, $f'(k) = (1+g)^2$, the marginal benefit of borrowing will equal the marginal borrowing cost for two periods.

The bank's cash flow each period is (1+g)L(old) – L(new) + D(new) – (1+r)D(old) = (g – r)D, as in previous sections. Competition among banks implies g = r. Since g = r, we have the result

$f'(k) = (1+r)^2 = 1+x$.

This strongly suggests that banking operations that intermediate a long term investment using liquid deposits can be efficient. This may dominate the government's fiat money if $1+x = (1+r)^2 > (1+r_m)^2$. In that case, the government may try to impose regulations that restrict the ability of banks to intermediate in order to create a demand for its money.

Exercise: Suppose there is a transactions fee h the bank pays in servicing loans that reduces the return on 1 + g - h. Find the rate spread. How does the cost h affect it?

Exercise: Consider the model of bank risk in section 3B and assume the bank is not only experiencing risk but also must meet a reserve requirement. Find the rate spread. What does it depend on?

In comparing credit with fiat, or outside, money there are several cases to consider. If the credit market is such that $1+r > 1+r_m$, the agent trades at a higher rate of return using inside money rather than outside money, and is better off than if they acquire the government's outside money! So private credit may dominate fiat money in its rate of return and force money out of the economy as an asset. This is like good money driving out bad money! On the other hand, suppose $1+r < 1+r_m = 1$. Then we might observe people holding outside money. But we have already described a mechanism that increases the rate on credit to $(1+r)^2 = 1+x > 1$. If $1+x > (1+r)^2 = (1+r_m)^2$, agents will lend less and hold less money in order to make large capital investments in the first period. $1+r$ will rise. If the return to money is fixed, $1+r > 1+r_m$, and people will no longer hold money, but use inside money instead. They will only hold it if $(1+r_m)^2 = 1+x$. If the return to capital is not fixed but responds to market conditions, then it is possible to observe $1+x = (1+r)^2 = (1+r_m)^2$ and m, k, l = b or d > 0. But money loses its special use as a liquid asset if the private sector can invent an asset that is equally liquid but pays interest.

Appendix: Advanced analysis

Suppose $U = \ln(w - m/p - k) + \beta \text{Ln}((1+r_m)(m/p)) + \beta^2 \text{Ln}((1+x)k)$

Differentiate, and simplify,

$$(1+\beta)m/p = \beta(w - k)$$

$$(1+\beta^2)k = \beta^2(w - m/p)$$

Solving we obtain,

$$k = \beta^2 w/(1+\beta+\beta^2),$$

$$m/p = \beta w/(1+\beta+\beta^2).$$

More generally, suppose the agent also holds money, as in section 6b. In a sense, m/p and loans l are similar in carrying purchasing power from period 1 to 2 so they are perfect substitutes. Let $s = m/p + l$. But l is physically a loan to a borrower so $b = l$. In a general equilibrium, savings in money and loans is $S(w, 1+r, 1+x)$ and $b(w, 1+r, 1+x)$ is borrowing. We have $S = m/p + l = m/p + b$. After aggregating,

$$NS(w, 1+r, 1+x) = M/p + Nb(w, 1+r, 1+x). \quad \text{(A)}$$

And capital investment is $k(w, 1+r, 1+x)$ and $1+x = (1+r)^2$. Since x is fixed, $1+r$ is fixed by this equality of rates condition. But this also means that S and b are determined. Finally, equation (A) is a version of the quantity theory in the long run.