Part IIA - Monetary Policy
Additional Notes

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Supervision 7: Monetary Transmission

This note aims to consolidate knowledge of the monetary transmission mechanism using both the standard IS-LM framework and Bernanke and Blinder (1988) model. To aid transparency this is done using graphs, balance sheets and equations with a focus on explicitly including the bond market into the analysis.

1 IS-LM

The IS-LM model has a long history in economic thought and featured prominently in introductory macroeconomics courses. At a 1936 conference discussion devoted to mathematical explanations of Keynes' 1936 text *The General Theory of Employment, Interest, and Money*, Harrod (1937), Hicks (1937) and Meade (1937) presented similar interpretations, which largely relied upon the same fundamental structure. However, only Hicks' paper used a graphical approach to explain this static mathematical setting, leading to the popular adoption of this interpretation, notably by Hansen (1949, 1953), which persists today.[1] Hicks' paper was subsequently extended by Modigliani (1944) to include labour market and production functions. A full introduction to ISLM may be found in the Mankiw (2019) textbook.

The standard IS-LM model has three markets (money; bonds and goods) and four agents (households; firms; government and the central bank). For the pur-

[1]The IS-LM model is sometimes referred to as the Hicks-Hansen model for this reason.

poses of this note we extend the list of economic agents to include commercial banks. In this setting, the central bank may issue base money (reserves) and hold bonds as assets on it's balance sheet. Commercial banks simply covert base money (reserves) into broad money (deposits), which may be used by households. Therefore, for now, commercial banks have a minimal role. Households face a portfolio allocation problem of how much wealth to allocate into broad money (deposits) and how much to hold as bonds.[2] Firms have access to capital stock to produce, but must issue bonds if they wish to finance investment projects for subsequent periods. Finally, the central government may issue bonds or tax households to finance spending. Stylised balance sheets are shown in nominal terms in Table 1, highlighting the stock of money (both base and broad) and bonds held by each agent. We next discuss each of the markets in turn.

Table 1: IS-LM Nominal Balance Sheets

Government		Central Bank		Commercial Banks		Households		Firms	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Tax Base	Bonds, $p^{\mathrm{B}}B^{\mathrm{G}}$	Bonds, $p^{\mathrm{B}}B^{\mathrm{CB}}$	Reserves, R	Reserves, R	Deposits, D	Deposits, D Bonds, $p^{\mathrm{B}}B^{\mathrm{HH}}$	Tax base	Capital Stock	Bonds, $p^{\mathrm{B}}B^{\mathrm{F}}$

Notes: Stylised nominal balance sheets for the IS-LM model with firms and a commercial bank. Net worth has been normalised to 0.

Goods Market

Equilibrium in the goods market arises through the Keynesian cross.[3] This details how *planned expenditure* may differ from *actual expenditure* only as a result of inventory, or investment, changes. Planned expenditure, PE, rises less than linearly with income, Y, as households decide to save some fraction of their income. Their Marginal Propensity to Consume (MPC) is below 1. This situation is captured by the relationship:

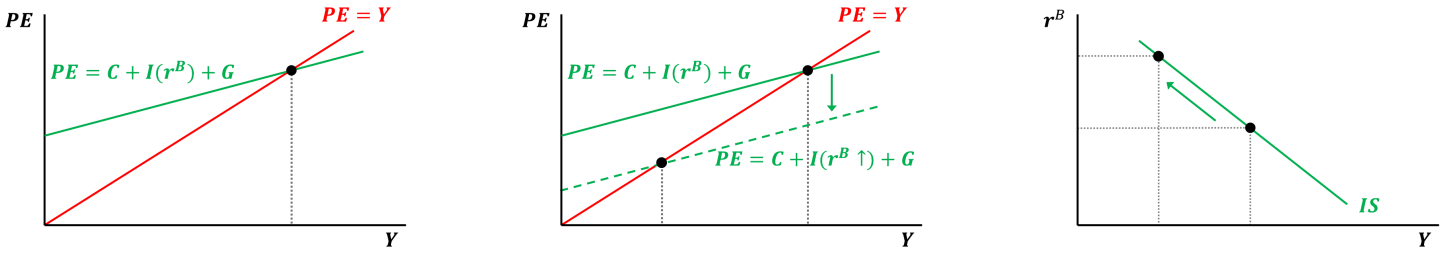
$$PE = C(Y - T) + I(\underline{r}) + G.$$

[2] In reality household's bond portfolios are typically held at specialist banks or pensions funds, but we omit this for simplicity. In this setting we normalise cash holdings to 0, these being indistinguishable from deposits here.

[3] Popularised by Samuelson (1948) and Hansen (1953).

Equilibrium in the goods market thus arises whenever $PE = Y$, as shown in Figure 1, panel (a).

Figure 1: Goods Market and IS Curve



(a) Goods market. (b) Higher level of r^B. (c) IS curve.

We are interested in demand in the goods market is influenced by changes in the real interest rate. A higher value of the real interest rate will be associated with lower investment demand from firms, as projects with a lower rate of return will not longer be worthwhile pursuing, when bonds issued to finance these sell for a lower price. A rise in the level of the real interest rate is therefore associated with a fall in planned expenditure, and a lower overall equilibrium level of income, Y. This change in the goods market is shown in (PE, Y)-space in Figure 1, panel (b), and in (r^B, Y)-space in panel (c). Repeating this exercise for multiple values of r^B, we may trace out an equilibrium relationship for the goods market, a relationship known as the **IS curve**. We may therefore write:

$$Y = PE = C(Y - T) + I(\underline{r}) + G = \alpha - i^B. \qquad \text{(IS)}$$

where the final equality specifies this relationship to have a linear functional form and for simplicity we have normalised government spending and necessary consumption, such that their steady state levels are captured in the intercept, α.

Money Market (Deposits)

Household's face two problems. Firstly, how much income to consume today, and how much to save. This is resolved through the goods market equilibrium, which, in determining the level of household consumption, implicitly generates

the level of household saving in the model. Secondly, after the decision of how much to save, households face a related asset allocation problem: how many of their assets to hold as broad money (as deposits), and how much to invest in bonds. As concisely stated by Tobin (1969):

"The key behavioral assumption of this procedure is that spending decisions and portfolio decisions are independent – specifically that decisions about the accumulation of wealth are separable from decisions about its allocation. As savers, people decide how much to add to their wealth; as portfolio managers, they decide how to distribute among available assets and debts the net worth they already have."

Households do not consider money and bonds as perfect substitutes. Either market may resolve the portfolio allocation problem, for a given overall level of saving. In lectures this trade-off is motivated through both the liquidity preference and the Baumol (1952)-Tobin (1956) inventory theories of money demand. Money (deposits) pay no interest, yet are still attractive due to the need to make purchases with liquid assets. Both theories may be summarised by a money (deposit) preference function over bond holdings:

$$\frac{M}{P} = L(\underset{-}{i}, \underset{+}{Y}).$$

Noting that in the current setting the only form of broad money available to households are deposits (there is no cash), and normalising and fixing the current price level at 1, we may write current household deposit demand as:

$$D^D = L(\underset{-}{i}, \underset{+}{Y}).$$

where the function $L(\cdot)$ is known as the liquidity function.[4]

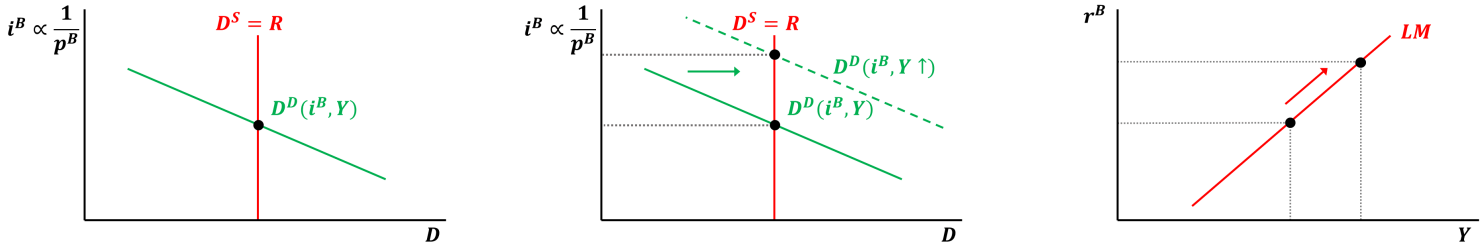
Turning to supply, the role of commercial banks is greatly simplified in this setting. These merely transform central bank reserves into deposits, and therefore deposit supply is inelastic at:

$$D^S = R,$$

[4]Assuming away the constant price level is a somewhat innocuous assumption here as the overall goal of the model is to explain short-run behaviour. Similarly all analysis in asset markets will be done using the nominal interest rate. With fixed inflationary expectations, short-run changes in the nominal interest rates will map directly into changes in the real interest rate.

In assuming commercial banks do not hold bonds, and in this IS-LM setting with commercial banks not issuing loans either, minimum and excess reserves are commensurate. For simplicity commercial bank demand for central bank reserves will intersect the supply curve on the inelastic region and therefore this market is not discussed in any detail. This situation is shown in Figure 2, panel (a), showing the point of equality between broad money (deposit) demand and supply.

Figure 2: Money Market and LM Curve



(a) Money market. (b) Higher level of Y. (c) LM curve.

This equilibrium point in the money market has been determined for a given level of household income, Y. We may therefore consider what happens when this level of income increases. When output is higher, households will demand additional real money balances, through their transactions or liquidity motive. In this way the demand for money (deposits) will shift outwards. Alternatively put, households will both consume and save more, since with $MPC < 1$ some of their additional current income is saved. When saving increases a proportion of this is held as money (deposits) and this the transactions demand for money (deposits) increases. At every level of the interest rate, more broad money (deposits) are demanded by households who need additional resources on-hand to spend this higher amount. This shift is shown in Figure 2, panel (b). Given inelastic supply, this causes an increase in the nominal interest rate. By repeating this exercise for multiple values of Y, we may capture a series of points consistent with equilibrium in the money market. This traces out a relationship known as the **LM curve**, which may be written as:

$$R = D^S = D^D = L(\underset{-}{i}, \underset{+}{Y}) = Y - i^B, \qquad \text{(LM)}$$

where the second equality has specified a linear functional form for the liquidity function.

Bond Market

Finally, we consider the bond market. For simplicity we assume government and corporate bonds are perfect substitutes. Both the central government and firms may issue bonds, and supply is upwards sloping in the bond price level, p^B, (as in lectures). Alternatively put, we will assume interactions take place in the primary debt market. Thus bond supply can be described as:

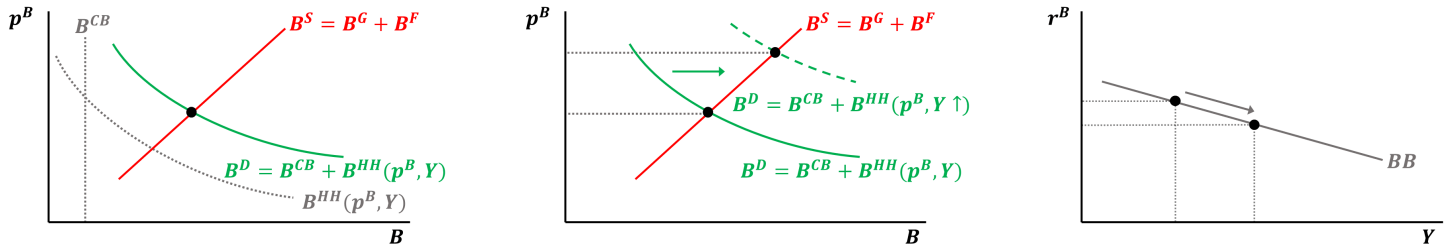
$$B^S = \underset{+}{B^{\text{G}}(p)} + \underset{+}{B^{\text{F}}(p)}.$$

The demand for bonds comes from two sources. Firstly the central bank sets a fixed level of bonds it wishes to purchase, B^{CB}. This source of demand is perfectly inelastic. Secondly households hold bonds. As in lectures, the demand for bonds is downwards sloping in their price, $\underset{-}{B^{\text{HH}}}(p, \underset{+}{Y})$. Bond demand is also taken to be positively related to the current level of output. This arises since whenever current income increases households will save more in all assets, both money (deposits) and in bonds.[5] This situation is shown in Figure 3, panel (a). The total demand for bonds is the sum of inelastic central bank demand and downward sloping household demand.

Again, equilibrium in this asset market is derived for a given level of household income, Y. In Figure 3, panel (b), we show how a higher level of income will result in an increase in bond demand, through a higher level of desired saving. This may again be traced out in (r^B, Y)-space, as shown in 3, panel (c), a relationship known as the **BB curve**. For simplicity, this final curve is usually omitted from IS-LM analysis.

[5]This feature of the model is usually left unstated, instead being implicitly imposed through the money liquidity function and use of Walras' law. For this reason many textbook analyses will leave out the bond market entirely. Note that in addition to bond demand responding positively to *current* income, total lifetime wealth should also has a positive impact on demand, as discussed in lectures.

Figure 3: Bond Market and BB Curve

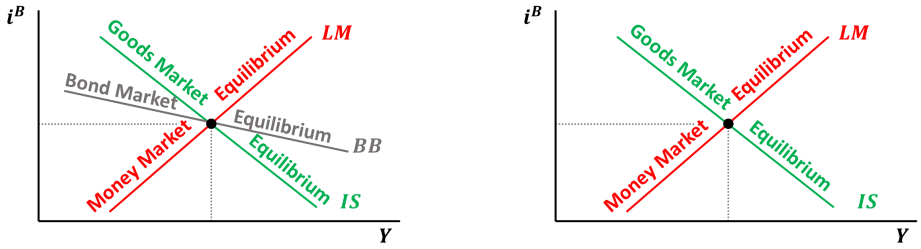


(a) Money market. (b) Higher level of Y. (c) BB curve.

General Equilibrium

General equilibrium arises whenever all three markets simultaneously clear simultaneously. From the graphical analysis presented thus far, this arises whenever the IS, LM and BB curves intersect. This situation is shown in Figure 4, panel (a). Standard analysis ignores the bond market, and BB curve, entirely. Hence showing equilibrium as in Figure 4, panel (b). This results from an appreciation of Walras' law, which infers equilibrium in two markets necessarily implies equilibrium in the third. It has become convention to ignore the bond market.

Figure 4: IS-LM Equilibrium



(a) IS-LM-BB. (b) IS-LM.

Notes: Equilibrium arises in the model whenever all three curves intersect. Inspection of the nominal budget constraints shows how equilibrium in two markets must imply equilibrium in the third.

To state this more clearly, we first show the nominal budget constraints of

each agent as:

$$
\begin{aligned}
PG &= PT + p^{\mathrm{B}} B^{\mathrm{G}}, && \text{(Government)} \\
R^{\mathrm{CB}} &= p^{\mathrm{B}} B^{\mathrm{CB}}, && \text{(Central Bank)} \\
D &= R, && \text{(Commerical Banks)} \\
PY &= PC + PT + D^{\mathrm{HH}} + p^{\mathrm{B}} B^{\mathrm{HH}}, && \text{(Households)} \\
PI &= p^{\mathrm{B}} B^{\mathrm{F}}. && \text{(Firms)}
\end{aligned}
$$

Together these may be used to show that excess nominal demand in the bond market may be written as the sum of excess demand in the goods and money markets:

$$
\begin{aligned}
p^{\mathrm{B}} B^{\mathrm{D}} - p^{\mathrm{B}} B^{\mathrm{S}} &= \underbrace{p^{\mathrm{B}} B^{\mathrm{HH}}}_{PY-PC-PT-D^{\mathrm{HH}}} + \underbrace{p^{\mathrm{B}} B^{\mathrm{CB}}}_{R^{\mathrm{CB}}=D} - \underbrace{p^{\mathrm{B}} B^{\mathrm{G}}}_{PG-PT} - \underbrace{p^{\mathrm{B}} B^{\mathrm{F}}}_{PI}, \\
&= PY - PC - D^{\mathrm{HH}} + D - PG - PI, \\
&= PY - PC - PI - PG + D - D^{\mathrm{HH}}, \\
p^{\mathrm{B}}(B^{\mathrm{D}} - B^{\mathrm{S}}) &= P(Y^{\mathrm{S}} - Y^{\mathrm{D}}) + P(D^{\mathrm{S}} - D^{\mathrm{D}}).
\end{aligned}
$$

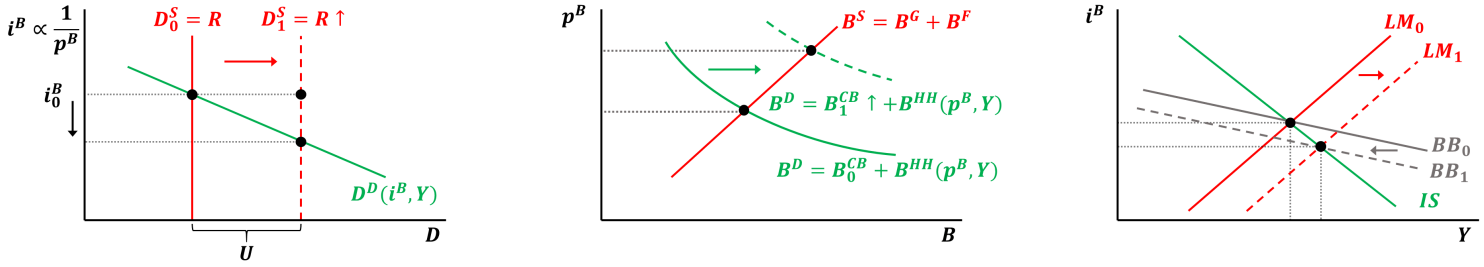
Hence, whenever two markets clear (e.g. goods and money), this infers the third market (e.g. bonds) must also clear.

Monetary Expansion in IS-LM

When the central bank expands the size of it's balance sheet, it generates central bank reserves and uses these to purchase bonds from the open market. Ultimately these will be purchased from households or induce an expanded bond supply. As a result of this operation, a higher supply of central bank reserves are held on the balance sheet of commercial banks who use these to extend the money supply (supply of deposits), Figure 5, panel (a). Simultaneously, demand for bonds shifts out, Figure 5, panel (b).

At the initial equilibrium interest rate and level of output, while the goods markets clears (this still represents a position on the IS curve), asset markets no longer clear. In the money market at this interest rate $D^S > D^D$ and we have *unwanted* real money balances (and also an excess demand for bonds). For a fixed

Figure 5: IS-LM Monetary Expansion



(a) Money market. (b) Bond market. (c) General equilibrium.

Notes: After a monetary expansion by the central bank, demand for bonds increases and an increase in the supply of deposits from commercial banks introduces *unwanted* real money balances in the money market at interest rate, i_0^B. These are labelled U in panel (a), where $D_1^S > D^D(i_0^B, Y_0)$. These simultaneous effects cause the price of bonds to increase and interest rate to fall. The LM curve shifts outwards, while the BB curve shifts inwards. General equilibrium is associated with a lower interest rate and higher level of output.

level of output (the initial level), restoring equilibrium in asset markets would require bond prices to increase and yields to fall, given this new demand from the central bank. Hence the LM curve shifts outwards (down), while the BB curve shifts inwards (down).

As the nominal interest rate start to fall (and bond prices start to rise), under sticky prices, this stimulates higher demand from the goods markets, through investment channels, represented as a movement of the economy along the IS curve. In equilibrium asset prices therefore do not fall by the full extent of the LM curve shift (assuming some elasticity in IS). In the bond and money markets this increase in output causes a second-order expansion of money and bond demand, though higher saving. This situation is shown graphically in Figure 5, panel (c). The new nominal balance sheets shown in Table 2.

In our IS-LM model, equilibrium is determined by:

$$Y = \alpha - i^B. \tag{IS}$$

$$R = Y - i^B, \tag{LM}$$

Table 2: IS-LM Monetary Expansion

Government		Central Bank		Commercial Banks		Households		Firms	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Tax Base	Bonds, $p^{\text{B}}B^{\text{G}}$	Bonds, $p^{\text{B}}B^{\text{CB}}+x$	Reserves, $R+x$	Reserves, $R+x$	Deposits, $D+x$	Deposits, $D+x$ Bonds, $p^{\text{B}}B^{\text{HH}}+y-x$	Tax base	Capital Stock	Bonds, $p^{\text{B}}B^{\text{F}}+y$

Notes: Stylised nominal balance sheets for the IS-LM model for a monetary expansion. For simplicity government bond supply is assumed inelastic. We may assume that $y < x$, such that supply responds by less than the initial change in demand from the central bank.

which infers that the equilibrium arises at:

$$i^{B,*} = \frac{\alpha - R}{2},$$
$$Y^* = \frac{\alpha + R}{2}.$$

After a monetary expansion, of x, the LM curve shifts down linearly by x, as:

$$R + x = Y - i^B, \qquad \text{(LM}_1\text{)}$$

while the equilibrium interest rate and level of output change by a smaller amount, given that:

$$i^{B,*} = \frac{\alpha - R}{2} - \frac{x}{2},$$
$$Y^* = \frac{\alpha + R}{2} + \frac{x}{2}.$$

The change in household's bond holdings depends upon how the central government and firm's bond supply responds to the change in bond prices.

2 Bernanke and Blinder (1988)

In their seminal paper, Bernanke and Blinder (1988), proposed a simple extension to the IS-LM framework, introducing a loan market. This change to the balance sheets is reflected in Table 3, with commercial banks able to supply loans which are demanded by firms.

Table 3: IS-LM Nominal Balance Sheets

Government		Central Bank		Commercial Banks		Households		Firms	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Tax Base	Bonds, $p^{\text{B}}B^{\text{G}}$	Bonds, $p^{\text{B}}B^{\text{CB}}$	Reserves, R	Reserves, R Loans, L	Deposits, D	Deposits, D Bonds, $p^{\text{B}}B^{\text{HH}}$	Tax base	Capital Stock	Bonds, $p^{\text{B}}B^{\text{F}}$ Loans, L

Notes: Stylised nominal balance sheets for the IS-LM model with firms and a commercial bank. Net worth has been normalised to 0.

In addition to the household asset allocation problem (between money and bonds), with a distinction drawn between the bond and loan market as a source of financing for firms, two further asset allocation problems are now important. Commercial bank's must consider how many loans to offer, relative to their level of reserves, while firms must decide how many loans to take, relative to their bond issuance, to finance investment projects. In this way the Modigliani and Miller (1958) irrelevance theorem is relaxed as bonds and loans are no longer prefect substitutes. For simplicity, in contrast to lectures and the problem set, here I assume banks do not hold bonds. Instead they simply mandated to hold $R = \tau D$, but strictly prefer to issue loans than hold reserves. In this case loan supply is given as:

$$L^S = D - R = \frac{(1-\tau)}{\tau} R,$$

The capacity for firms to undertake investment projects now depends upon both of their sources of financing:

$$I(\underset{-}{r^B}, \underset{-}{r^L}) = B^{\text{F}}(\underset{+}{p^B}, \underset{+}{r^L}) + L^{\text{D}}(\underset{-}{p^B}, \underset{-}{r^L}),$$

Higher interest rates for either financing option will reduce overall investment, while a change in the relative price will shift funds towards the cheaper source

of financing. Equilibrium in the loan market may therefore be written as:

$$\frac{1-\tau}{\tau}R = L^S = L^{\mathrm{D}}(\underset{-}{p^B}, \underset{-}{r^L}) = i^B - i^L, \qquad \text{(Loan)}$$

where the final equation uses a specific functional form. For simplicity here loan demand is assumed not to depend upon the current level of income.

Due to the alteration of the investment function, the goods market equilibrium also changes to account for the impact of loan price changes, while as deposits are no longer the sole use of central bank reserves, equilibrium in the money market changes to become:

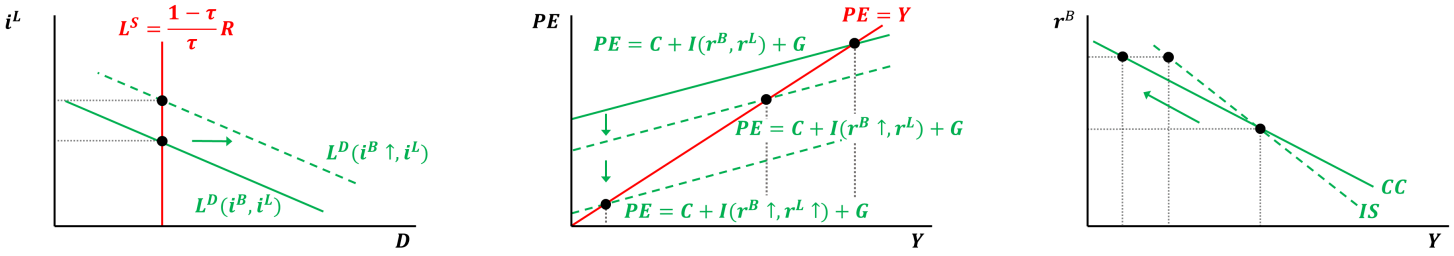
$$Y = PE = \alpha - i^B - i^L. \qquad \text{(IS)}$$

$$\tau R = D^S = D^D = Y - i^B. \qquad \text{(LM)}$$

The addition of a fourth market complicates how equilibrium may be represented graphically. To address this problem Bernanke and Blinder (1988) propose construction of a **CC-curve**, representing equilibrium in both the goods and loan markets simultaneously. Then all markets will clear whenever the CC curve intersects with LM, again appealing to Walras' law to clear the bond market. To derive the CC-curve a change in r^B is considered in the loan and goods markets. This causes a shift outwards in the demand for loans, as the relative gain to firms from issuing bonds to finance investment projects is now lower. This is shown in Figure 6, panel (a). In the goods market, the higher level of r^B reduces the demand for investment and hence PE shifts downwards. At the same time a further shift downwards arises due to the increase in r^L in the loan market, which also discourages investment. This is highlighted in Figure 6, panel (b). Thus, when the implications of a change in r^B for the loan and goods markets are considered together they cause a fall in output. This is shown in Figure 6, panel (c). In our example the CC curve should have a lower slope than the IS curve. This arises as although the loan market is unaffected by changes in output, the goods market experiences an additional fall in output associated with the change in i^L from the loan market. In general whether the CC curve of IS curve has a larger slope depends upon the balance of these effects.

To derive the CC curve mathematically we therefore us the goods and loan

Figure 6: Loan Market and CC Curve



(a) Loan market, higher r^B. (b) Goods market, higher r^B and r^L. (c) CC curve.

market clearing conditions simultaneously to show:

$$Y = \alpha - i^B - \left[i_B - \frac{1-\tau}{\tau}R\right] \quad \Rightarrow \quad i_B = \frac{\alpha\tau + (1-\tau)R}{2\tau} - \frac{Y}{2}, \qquad \text{(CC)}$$

$$\tau R = Y - i^B. \qquad \text{(LM)}$$

Alongside the change to the LM curve, this infers equilibrium arises at:

$$i^{B,*} = \frac{\alpha}{3} - \frac{\tau^2 - 2\tau + 2}{3\tau}R,$$
$$Y^* = \frac{\alpha}{3} + \frac{2\tau^2 - \tau + 1}{3\tau}R,$$

Monetary Expansion in Bernanke and Blinder (1988)

In this new setting, when the central bank expands the size of it's balance sheet, it again generates central bank reserves and uses these to purchase bonds from the open market. Again, ultimately these bonds must either be purchased from households or induce an expanded bond supply. As a result of this operation, a higher supply of central bank reserves are held on the balance sheet of commercial banks who use these to both extend the money supply (supply of deposits) and to extend loans to firms. The new nominal balance sheets shown in Table 4.

The **asset price** channel of transmission through the money market is analogous to the IS-LM scenario, as shown earlier in Figure 5, with an outwards shift in the LM curve. In addition, as some of the increase in reserves is used by com-

Table 4: Bernanke and Blinder (1988) Monetary Expansion

Government		Central Bank		Commercial Banks		Households		Firms	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Tax Base	Bonds, $p^{\mathrm{B}}B^{\mathrm{G}}$	Bonds, $p^{\mathrm{B}}B^{\mathrm{CB}}+x$	Reserves, $R+x$	Reserves, $R+x$ Loans, $L+\frac{(1-\tau)x}{\tau}$	Deposits, $D+\frac{x}{\tau}$	Deposits, $D+\frac{x}{\tau}$ Bonds, $p^{\mathrm{B}}B^{\mathrm{HH}}+y-\frac{x}{\tau}$	Tax base	Capital Stock	Bonds, $p^{\mathrm{B}}B^{\mathrm{F}}+y$ Loans, $L+\frac{(1-\tau)x}{\tau}$

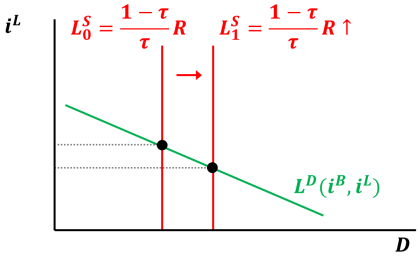
Notes: Stylised nominal balance sheets for the Bernanke and Blinder (1988) model for a monetary expansion. For simplicity government bond supply is assumed inelastic. Again, we may assume that $y < x$, such that supply responds by less than the initial change in demand from the central bank.

mercial banks to extend loans to firms, a **credit channel** of monetary transmission has been introduced to the model. A higher level of reserves increase loan supply, reducing the interest rate on loans, as shown in Figure 7, panel (a). In turn this impacts the goods market through a higher level of investment, as loans are now cheaper for every bond price. This increases planned expenditure and hence shifts the CC curve outwards as shown in Figure 7, panels (b) and (c). When combined with the shift outwards of the LM curve, arising through the money market, the new general equilibrium is associated with a higher level of output, as shown in 7, panels (d). As shifts in the LM and CC curve have opposing effects on the bond interest rate, the change in bond prices is generally ambiguous.

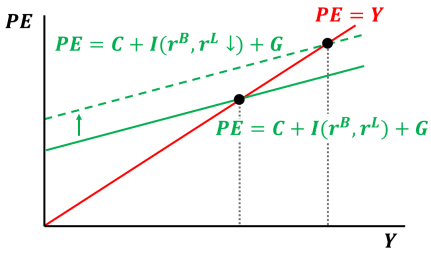
3 Further Reading

The lecture notes and textbook, Mishkin et al. (2013), remain the primary sources the course. Mankiw (2019) provides a good overview of the IS-LM framework, which you should be comfortable with from Part I. In a gentle introduction, McLeay et al. (2014a) detail how money creation works through loan creation in the banking systems of most advanced economies, while McLeay et al. (2014b) outline more broadly how the role of money has evolved over time and what counts as money in the modern economy. An excellent textbook treatment of both IS-LM and the Bernanke and Blinder (1988) model may be found in Freixas and Rochet (2008), Chapter 6. An early extension of the Bernanke and Blinder (1988) model to fit the banking sectors of other countries including the UK was developed in Dale and Haldane (1993, 1998).

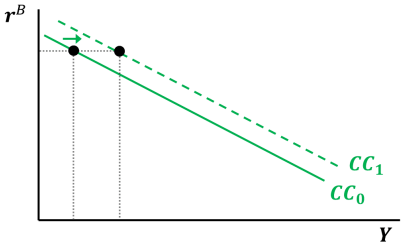
Figure 7: Bernanke and Blinder (1988) Monetary Expansion



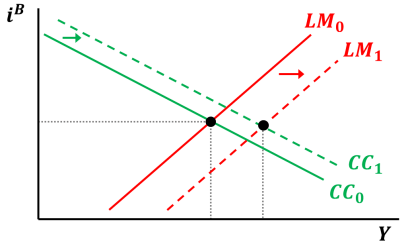
(a) Loan market.



(b) Goods market.



(c) Goods and loan market.



(d) General equilibrium.

Notes: After a monetary expansion by the central bank, the supply of loans from commercial banks increases. This increases planned expenditure in the goods market, and hence shifts the CC curve outwards. When combined with the standard LM curve shift, the general equilibrium is associated with higher level of output. The overall impact on the nominal interest rate for bonds is ambiguous.

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