12. MONETARY POLICY AND AGGREGATE DEMAND

■ **According to the classical macroeconomic theory** which dominated economic thought before the Great Depression of the 1930s, the total **level of output and employment is determined from the economy's supply side**. In the classical world, **wages and prices adjust to ensure that the available supplies of labour and capital are utilized at their "natural" rates** determined by the structure of labour and product markets.

■ In Lecture 1 we argued that this is a **useful working assumption when we analyse the long-run economic phenomena** which are the subject matter of the theory of economic growth. But **in the short and medium term economic activity often deviates from its long-run growth trend**.

■ To understand these short-run macroeconomic fluctuations, we **must explain why the aggregate demand for goods and services does not necessarily correspond to the aggregate supply** which is forthcoming when all resources are utilized at their natural rates.

Building on the previous two lectures, the present lecture therefore develops a **theory of aggregate demand**.

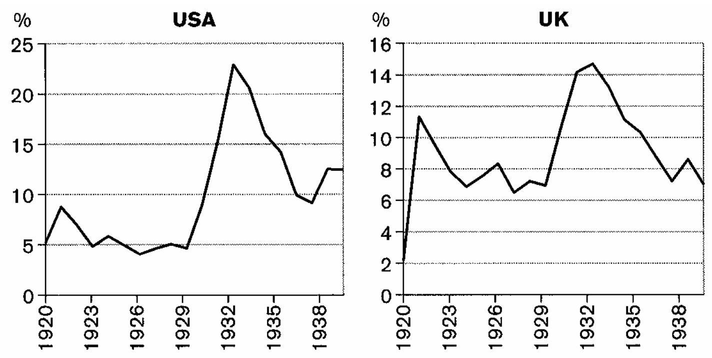
Keynes, the Classics and the Great Depression

■ The **classical economists did not literally claim that a capitalist market economy could never deviate from its natural rate of employment and output**, but they did believe that if only **market forces** were allowed to work, **such disturbances would be temporary and quite short-lived**.

■ The **classical economists therefore saw no need for the government to engage in macroeconomic stabilization policy**. In their view, the only role of monetary policy was to **secure price stability**, and the task of fiscal policy was to **avoid budget deficits** which would **crowd out private capital** formation and thereby hamper economic growth.

■ Winston **Churchill**, who was Secretary of the Treasury in Britain for several years during the 1920s, was very much in agreement with this classical view when he explained his approach to fiscal policy as follows: "It is the orthodox **Treasury dogma**, steadfastly held, that whatever might be the political or social advantages, **very little employment can, in fact, as a general rule, be created by state borrowing and state expenditure**."

■ When the **Great Depression** of the 1930s struck the Western world, this **classical laissez-faire position came under heavy attack**. The Great Depression was an economic earthquake. Due to a catastrophic combination of negative shocks and macroeconomic policy failures, output in several countries fell by 25-30 per cent between 1929 and 1932-33, with disastrous consequences for employment (see Figure 12.1).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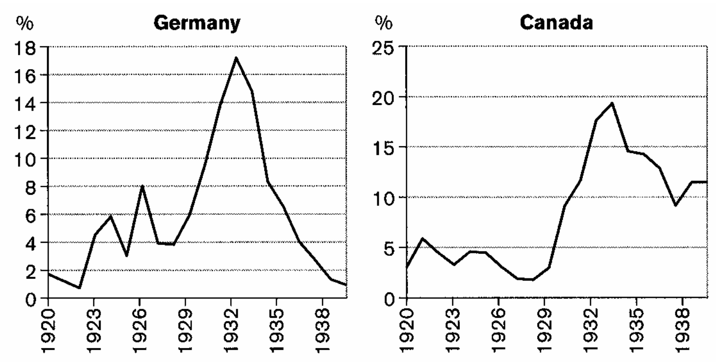
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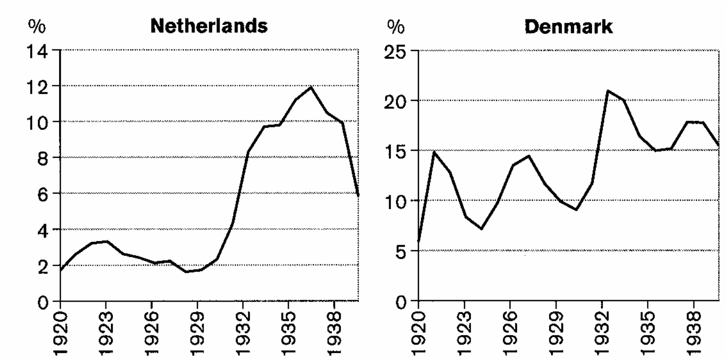


Figure 12.1: Unemployment rates, 1920-39

Note: The unemployment rate is defined as the number of unemployed persons as a percentage of the total labour force.
Source: Macroeconomic database constructed by Jacob Brachner Madsen, University of Copenhagen. The underlying sources are documented in: Jacob Brachner Madsen, "Agricultural Crises and the International Transmission of the Great Depression", *Journal of Economic History*, 61 (2), 2001, pp. 327-365.

■ For a country like the **United States**, it took almost a **decade for output to return to its pre-1929 peak**: a whole decade of economic growth lost.

■ Against this background the British economist John Maynard **Keynes** and several others **attacked the classical view that resource utilization at natural rates is the normal state of affairs**.

■ Indeed, **Keynes challenged** the time-honoured **definition of economics** as “the **study of the allocation of scarce resources to satisfy competing ends**”. Keynes' point was that **quite often resources are not scarce, they are merely underutilized due to a lack of demand**. In such circumstances the **government will be able to raise total employment and output through a fiscal or monetary policy which stimulates aggregate demand**.

■ These ideas were laid out in 1936 in **Keynes' famous book**, *The General Theory of Employment, Interest and Money*. That book is often considered to **mark the birth of modern macroeconomics**, because it revolutionized the way economists thought about the problem of business cycles.

■ Today **most macroeconomists believe that economic activity in the short and medium run is determined by the interaction of aggregate demand and aggregate supply**.

■ In the **long run** the forces of **aggregate supply** stressed by the classical economists carry the day, but **in the short run aggregate demand plays a key role** in the determination of output and employment. As a step on the way to constructing a **model of short-run macroeconomic fluctuations**, we must therefore **develop a theory of aggregate demand**.

■ We have already seen that **private investment** as well as **private consumption are influenced by the real rate of interest**. In the **long run** the **equilibrium real interest rate** – the so-called **natural rate of interest** – is **determined by the forces of productivity and thrift**, as we explained in Lecture 3.

■ However, **in the short run monetary policy can have a significant impact on the real interest rate**. Hence much of this lecture will focus on the conduct of monetary policy and how it affects aggregate demand.

■ We start our analysis by specifying the **equilibrium condition for the goods market**, drawing on the theory of consumption and investment. We then move on to a study of the monetary sector and the **conduct of monetary policy**. Incorporating our specification of monetary policy into the equilibrium condition for the goods market, we then end up **deriving a systematic link between the level of output and the rate of inflation** which must hold whenever the goods market clears.

■ This link is called the **aggregate demand curve**, and it will be one of the two central building blocks of the short-run macroeconomics model.

The goods market

Goods market equilibrium

■ **For the product market to clear, the aggregate demand for goods must be equal to total output**, Y. In this lecture we will focus on a closed economy. **Aggregate demand for**

goods then consists of the sum of real private consumption, *C*, real private investment, *I*, and real government demand for goods and services, *G*. Hence goods market equilibrium requires:

$$Y = C + I + G \qquad 12.1$$

■ Earlier we saw that private investment behaviour can be summarized in an **investment function** of the form $I = I(Y, r, K, \varepsilon)$, where r is the **real interest rate**, K is the **predetermined capital stock** existing at the beginning of the current period, and ε is a parameter capturing the "**state of confidence**", reflecting the **expected growth of income and demand**. For the purpose of short-run analysis, we may **treat the predetermined capital stock as a constant** and leave it out of our behavioural equations. We may then write **private investment demand** as:

$$I = I(Y, r, \varepsilon), \quad I_Y \equiv \frac{\partial I}{\partial Y} > 0, \quad I_r \equiv \frac{\partial I}{\partial r} < 0, \quad I_\varepsilon \equiv \frac{\partial I}{\partial \varepsilon} > 0 \qquad 12.2$$

where the **signs of the partial derivatives of the investment function** follow from the theory developed in the lecture on investment. Thus, **investment increases with current output and with growth expectations**, ε, whereas it **decreases with the real interest rate**.

■ Our theory of private consumption implies a **consumption function** of the form $C = C(Y - T, r, V, \varepsilon)$, where T denotes total tax payments so that $Y - T$ is **current disposable income**, and V is **non-human wealth**.

■ We **assume that the future income growth expected by consumers equals the growth expectations of business firms, since firms are owned by consumers**. We showed that the **market value of non-human wealth is a decreasing function of *r***, since a **rise in the real interest rate** will, *ceteris paribus*, **drive down stock prices** as well the **value of the housing stock**. In other words, $V = V(r)$ and $dV/dr < 0$.

■ To simplify exposition, we will use this relationship to **eliminate *V* from the consumption function** and simply write:

$$C = C(Y - T, r, \varepsilon), \;\; 0 < C_Y \equiv \frac{\partial C}{\partial (Y - T)} < 1, \;\; C_r \equiv \frac{\partial C}{\partial r} <> 0, \quad C_\varepsilon \equiv \frac{\partial C}{\partial \varepsilon} > 0. \qquad 12.3$$

■ The signs of the partial derivatives were explained in the lecture on consumption. From that lecture we recall that the **real interest rate has an ambiguous effect on consumption**, due to **offsetting income and substitution effects**, although the **negative impact of a higher interest rate on private wealth suggests that the net effect on consumption is likely to be negative**. The analysis also implied that the **marginal propensity to consume current income is generally less than 1**, as we assume above.

■ Let us denote **total private demand** by $D \equiv C + I$. To avoid complications arising from the dynamics of government debt accumulation, we will **assume that the government balances its budget so that $T = G$**. It then follows from (12.2) and (12.3) that the **goods market equilibrium condition** (12.1) may be stated in the form:

$$Y = D(Y, G, r, \varepsilon) + G \quad 12.4$$

Properties of the private demand function

■ We will now consider the **signs and magnitudes of the partial derivatives of the private demand function** $D(Y, G, r, \varepsilon)$. Since $D \equiv C + I$, it follows from (12.2) and (12.3) that $D_Y \equiv \partial D/\partial Y = C_Y + I_Y > 0$. The **derivative D_Y is the marginal private propensity to spend**, defined as the **increase in total private demand induced by a unit increase in income**. We will assume that the **marginal spending propensity is less than 1** so that:

$$0 < D_Y \equiv \frac{\partial D}{\partial Y} = C_Y + I_Y < 1 \quad 12.5$$

■ The **assumption that $D_Y < 1$ guarantees that the Keynesian multiplier $\widetilde{m} \equiv 1/(1 - D_Y)$ is positive**. Recall from your basic macroeconomics course that the **Keynesian multiplier measures the total increase in aggregate demand for goods generated by a unit increase**

in some exogenous demand component, provided that interest rates and prices stay constant.

■ The **Keynesian multiplier captures the phenomenon that once economic activity goes up, the resulting rise in output and income induces a further increase in private consumption and investment**, which generates an additional rise in output and income that in turn causes a new round of private spending increase, and so on. Below we shall return to the role played by the Keynesian multiplier in our theory of aggregate demand.

■ Since $T = G$, we see from (12.3) that:

$$D_G \equiv \frac{\partial D}{\partial G} \equiv -\frac{\partial C}{\partial (Y-T)} = -C_Y < 0. \qquad 12.6$$

■ Given that $C_Y < 1$, it follows that the **net effect of a unit increase in government demand on aggregate (private plus public) demand will be** $1 + D_G = 1 - C_Y > 0$. In other words, a **fully tax-financed increase in public consumption will only be partially offset by a fall in private consumption, so the net effect on aggregate demand will be positive**.

■ This assumes that **at least part of the increase in taxes is expected to be temporary**, for as we saw earlier, a **permanent tax increase will tend to generate an equivalent fall in private consumption**.

■ The **effect of a rise in the real interest rate on private demand** is given by $D_r \equiv \partial D/\partial r = C_r + I_r$. The derivative D_r measures the **effect of a rise in the real interest rate on the private sector savings surplus**.

■ The **private sector savings surplus** is defined as $SS \equiv S - I$, where private saving is given by $S \equiv Y - T - C$. Hence we have $\partial SS/\partial r = -C_r - I_r = -(C_r + I_r) \equiv -D_r$. There is **strong empirical evidence** that a **higher real interest rate raises the private sector savings**

surplus. For example, Figure 12.2 illustrates a clear positive correlation between *SS* and a measure of the real interest rate in Denmark.

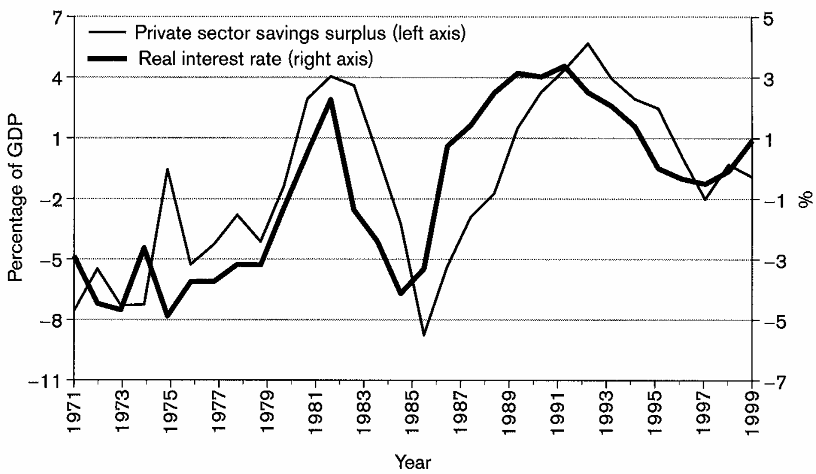


Figure 12.2: The real interest rate and the private sector savings surplus in Denmark, 1971-2000

Note: The real interest rate is measured as the after-tax nominal interest rate on ten-year government bonds minus an estimated trend rate of inflation which includes the rate of increase of housing prices.

■ Even though **economic theory does not unambiguously determine the sign of the derivative C_r**, we may therefore safely **assume that**:

$$D_r \equiv \frac{\partial D}{\partial r} \equiv C_r + I_r < 0 \qquad 12.7$$

■ Finally we see from (12.2) and (12.3) that the **effect on private demand of more optimistic growth expectations** is:

$$D_\varepsilon \equiv \frac{\partial D}{\partial \varepsilon} \equiv C_\varepsilon + I_\varepsilon > 0 \qquad 12.8$$

Restating the condition for goods market equilibrium

■ It will be convenient to **rewrite the goods market equilibrium condition** (12.4) such that **output, government spending and the confidence variable**, ε, **appear as percentage deviations from their trend values**.

■ We begin from an **initial situation in which the economy is on its long-run growth trend** so that initial output is equal to $\overline{Y}$. We then **consider a small deviation from trend**. Taking a **first-order linear approximation of the goods market equilibrium condition** (12.4), remembering that $D_G = D_T = -C_Y$, and denoting the initial trend values by bars, we get:

$$Y - \overline{Y} = D_Y(Y - \overline{Y}) - C_Y(G - \overline{G}) + D_r(r - \overline{r}) + D_\varepsilon(\varepsilon - \overline{\varepsilon}) + G - \overline{G} \Leftrightarrow$$

$$Y - \overline{Y} = \widetilde{m}(1 - C_Y)(G - \overline{G}) + \widetilde{m}D_r(r - \overline{r}) + \widetilde{m}D_\varepsilon(\varepsilon - \overline{\varepsilon}), \quad \widetilde{m} \equiv \frac{1}{1 - D_Y} \qquad 12.9$$

■ Our next step is to rewrite (12.9) **in terms of relative changes** in Y, G and ε:

$$\frac{Y-\overline{Y}}{\overline{Y}}=\tilde{m}(1-C_Y)\left(\frac{\overline{G}}{\overline{Y}}\right)\left(\frac{G-\overline{G}}{\overline{G}}\right)+\tilde{m}\left(\frac{D_r}{\overline{Y}}\right)(r-\overline{r})+\tilde{m}\left(\frac{\overline{\varepsilon}D_\varepsilon}{\overline{Y}}\right)\left(\frac{\varepsilon-\overline{\varepsilon}}{\overline{\varepsilon}}\right) \qquad 12.10$$

■ In the final step we use the fact that the **change in the log of some variable is approximately equal to the relative change in that variable**. Defining

$$y\equiv \ln Y,\quad \overline{y}\equiv \ln \overline{Y},\quad g\equiv \ln G,\quad \overline{g}\equiv \ln \overline{G},$$

we may then write (12.10) in the form:

$$y-\overline{y}=\alpha_1(g-\overline{g})-\alpha_2(r-\overline{r})+\upsilon \qquad 12.11$$

where

$$\alpha_1 \equiv \tilde{m}(1 - C_Y)\left(\frac{\overline{G}}{\overline{Y}}\right), \quad \alpha_2 \equiv -\tilde{m}\left(\frac{D_r}{\overline{Y}}\right), \quad \upsilon \equiv \tilde{m}\left(\frac{\varepsilon}{D_\varepsilon}\overline{Y}\right)(\ln \varepsilon - \ln \varepsilon) \qquad 12.12$$

■ The **magnitudes** $\overline{G}$, $\bar{r}$ and $\bar{\varepsilon}$ **are the values of *G*, *r* and *ε* prevailing in a long-run equilibrium where output is at its trend level**.

■ Thus Eq. (12.11) says that the **percentage deviation of output from trend (the output gap) can be approximated by a linear function of the *percentage* deviations of *G* and *ε* from their trend values and of the *absolute* deviation of *r* from its trend level**.

■ Of course, (12.11) is just a **particular way of stating that the aggregate demand for goods varies negatively with the real interest rate and positively with government spending and with expected income growth**.

■ Note that the long-run **equilibrium real interest rate** $\bar{r}$ can be **found from the following condition for long-run goods market equilibrium**:

$$\bar{Y} = D(\bar{Y}, \bar{G}, \bar{r}, \bar{\varepsilon}) + \bar{G} \qquad 12.13$$

■ Notice also the role played by the Keynesian multiplier $\tilde{m} \equiv 1/(1 - D_Y)$ in the definitions of the coefficients α_1 and α_2 given in (12.12). For example, **if taxes are raised by one unit to finance a unit increase in government consumption, the immediate impact is a net increase in aggregate demand equal to 1 –** C_Y**.**

■ But **when the Keynesian multiplier effect is accounted for**, the **total increase in demand adds up to** $\tilde{m} \equiv 1(1 - C_Y)$. Therefore, if public consumption increases by 1 per cent, the resulting percentage increase in total demand will be $\tilde{m} \equiv 1(1 - C_Y)(\bar{G}/\bar{Y})$, given that the initial ratio of public consumption to total output is $\bar{G}/\bar{Y}$.

■ This explains the coefficient α_1 on the percentage increase in government consumption, $g-\bar{g}$, in (12.11). Similarly, **if the real interest rate goes up by one percentage point, the resulting percentage drop in total demand is** $D_r/\bar{Y}$.

■ When this **initial fall in demand is magnified by the Keynesian multiplier**, the **total percentage fall in demand adds up to** $-\tilde{m}(D_r/\bar{Y})$, as shown by the expression for α_2 in (12.12). Thus the **familiar Keynesian multiplier theory is built into our theory of aggregate demand**.

■ Equation (12.11) is our **preliminary version of the economy's aggregate demand curve**. Below we will show that (12.11) implies a **systematic link between output and inflation, once one allows for the way monetary policy is typically conducted**. To understand this link, we must **study the relationship between inflation and the real interest rate**, and that requires taking a **closer look at the money market and the behaviour of central banks**.

The money market and monetary policy

The money market

■ From your basic macroeconomics course you will recall that **equilibrium in the money market** is obtained when

$$\frac{M}{P} = L(Y,\, i), \quad L_Y \equiv \frac{\partial l}{\partial Y} > 0, \quad L_i \equiv \frac{\partial l}{\partial i} < 0 \qquad 12.14$$

where $L(Y, i)$ is the real demand for money, i is the nominal interest rate, M is the nominal money supply, and P is the price level.

■ The left-hand side of (12.14) is the supply of real money balances which must be equal to real money demand in equilibrium. **Real money demand varies positively with income, since a rise in income leads to more transactions which in turn requires more liquidity**.

■ At the same time **money demand varies negatively with the nominal interest rate**, because a **higher interest rate raises the opportunity cost of holding money rather than interest-bearing assets**, inducing agents to economize on their money balances so as to be able to invest a larger share of their wealth in interest-bearing financial instruments.

■ For concreteness, we will assume that the **demand for real money balances can be approximated by a function of the form**:

$$L(Y, i) = kY^{\eta}e^{-\beta i}, \quad k > 0, \quad \eta > 0, \quad \beta > 0 \qquad 12.15$$

where e is the **exponential function**, η is the **income elasticity of money demand**, and β is the **semi-elasticity of money demand with respect to the interest rate**. The **semi-elasticity** measures the **percentage drop in real money demand induced by a one percentage *point* increase in the interest rate**.

■ Notice that the **interest rate *i*** appearing in the money demand function should be interpreted as a **short-term interest rate**, since the **closest substitutes for money are the most liquid interest-bearing assets with a short term to maturity**.

The constant money growth rule

■ To find the **link between output and inflation on the economy's demand side**, we need to know **how the real interest rate *r*** appearing in (12.11) is **related to these two variables**. This **depends on the way monetary policy is conducted**.

■ **Monetary policy regimes vary** across time and space. Here we shall focus on **two benchmark monetary policy rules** which have received widespread attention in the literature.

■ A **monetary policy rule** is a rule or **principle prescribing how the monetary policy instrument of the central bank should be chosen**. In practice, the **main monetary policy**

instrument of the central bank is its short-term interest rate charged or offered vis-à-vis the commercial banking sector.

■ **Through their control of the central bank interest rate, monetary policy makers can roughly control the level of short-term interest rates prevailing in the interbank market**.

■ The **interbank market** is the **market for short-term credit where commercial banks with a temporary surplus of liquidity meet other commercial banks with a temporary liquidity shortage**. The **interbank interest** rate in turn heavily **influences the level of market interest rates on all types of short-term credit**.

■ Under the **constant money growth rule** for the conduct of monetary policy the **central bank adjusts its short-term interest rate to ensure that the forthcoming money demand results in a constant growth rate of the nominal monetary base**.

■ **Assuming a constant** money multiplier (that is, a **constant ratio between the broader money supply and the monetary base**), this will also **ensure a constant growth rate of the** broader money supply which **includes bank deposits as well as base money**.

■ In an influential book *A Program for Monetary Stability* (New York, Fordham University Press, 1960) the American economist **Milton Friedman** argued that a **constant money supply growth rate would in practice ensure the highest degree of macroeconomic stability** which could realistically be achieved, since it would **imply a stable increase in aggregate nominal income**.

■ This argument was based on **Friedman's belief in a stable money demand function with a low interest rate elasticity**. To see his point most clearly, suppose for a moment that our parameter β in (12.15) **is close to 0**, and that the **income elasticity of money demand η is equal to 1**.

■ **Money market equilibrium** then roughly **requires $M = kPY$**, where k is a constant. Hence **aggregate nominal income PY must grow roughly in proportion to the nominal money**

supply *M*. Securing a stable growth rate of *M* will then secure a stable growth rate of nominal income.

■ **Friedman pointed out that we have only limited knowledge of the way the economy works**. His studies of American monetary history also suggested that **monetary policy tends to affect the real economy with long and variable lags** (see Milton Friedman and Anna Schwartz, *A Monetary History of the United States*, 1867-1960, Princeton, NJ, Princeton University Press, 1963).

■ **Friedman therefore argued that the central bank may often end up destabilizing the economy if it attempts to manage aggregate demand through activist monetary policy by constantly varying the growth rate of money supply in response to changing economic conditions**.

■ Moreover, according to Friedman, the **self-regulating market forces are sufficiently strong to ensure that real output and employment will be pulled fairly quickly towards their "natural" rates** following an economic disturbance.

■ Given that **activist monetary policy may fail to stabilize** the economy, and that the **need for stabilization is limited** anyway, Friedman concluded that his **constant money supply growth rule would be the best way to conduct monetary policy**.

■ **Friedman's arguments did not go unchallenged**, but they had a **substantial impact on many central banks**. In particular, the **German Bundesbank adopted stable target growth rates for the money supply from the 1970s**, and after the formation of the European Monetary Union the **European Central Bank has maintained a target for the evolution of the money supply to support its target for (low) inflation**.

■ **What does the constant money growth rule imply for the formation of interest rates?** To investigate this, **suppose that the central bank knows the structure of the money market** sufficiently well to be able **to implement its desired constant growth rate μ of the nominal money supply**.

■ Using (12.14) and (12.15), and denoting the **rate of inflation** by π so that $P \equiv (1 + \pi)P_{-1}$ we may then write the **condition for money market equilibrium** as:

$$\frac{(1+\mu)M_{-1}}{(1+\pi)P_{-1}} = kY^{\eta}e^{-\beta i} \qquad 12.16$$

where M_{-1} and P_{-1} are the **nominal money supply and the price level prevailing in the previous period**, respectively.

■ We want to study **how the economy behaves when it is not too far off its long-run trend**. We therefore assume that the **economy was in long-run equilibrium in the previous period**.

■ **Ignoring growth for simplicity, a long-run equilibrium requires that the real money supply be constant**, since the **variables in the money demand function**, Y and i, **must be constant in a long-run equilibrium without secular growth**.

■ **Constancy of the real money supply means that the inflation rate *π* must equal the monetary growth rate *μ***. If we assume that **trend output** $\bar{Y}$ **grows at the constant rate *x***, the **real money supply would have to grow at the rate *ηx* in a long-run equilibrium with a constant interest rate**. This in turn would imply an **equilibrium rate of inflation** π^* equal to $\pi^* = \mu - \eta x$.

■ As we shall explain more carefully later, the **approximate link between the nominal and the real interest rate is *i* = *r* + *π***, so in a long-run equilibrium where $\pi = \mu$ and $r = \bar{r}$, we have $i = \bar{r} + \mu$. If we denote the **long-run value of the real money stock by** L^*, our assumption that the money market was in long-run equilibrium in the previous period then implies that:

$$\frac{M_{-1}}{P_{-1}} = L^* = k\bar{Y}^{\eta} e^{-\beta(\bar{r}+\mu)} \qquad 12.17$$

■ Taking **natural logs** of (12.16), remembering that $M_{-1}/P_{-1} = L^*$, and using the approximations $\ln(1 + \mu) \approx \mu$ and $\ln(1 + \pi) \approx \pi$, we get:

$$\mu - \pi + \ln L^* = \ln k + \eta y - \beta i \qquad 12.18$$

where (12.17) implies:

$$\ln L^* = \ln k + \eta \bar{y} - \beta(\bar{r} + \mu) \qquad 12.19$$

■ By inserting (12.19) into (12.18) and rearranging, you may verify that:

$$i = \bar{r} + \pi + \left(\frac{1-\beta}{\beta}\right)(\pi - \mu) + \left(\frac{\eta}{\beta}\right)(y - \bar{y}) \qquad 12.20$$

■ Equation (20) shows **how the short-term nominal interest rate *i* will react to changes in inflation and output if monetary policy aims at securing a constant growth rate** μ**, of the nominal money supply**. Since η and β are both positive, we see that the **interest rate varies positively with the output gap**, $y - \bar{y}$.

■ If the **numerical semi-elasticity** β **of money demand with respect to the interest rate is not too high** ($\beta < 1$), as Friedman assumed, we also see that the **nominal interest rate will increase more than one-to-one with the rate of inflation**, implying an **increase in the real interest rate**. Note that **since the long-term equilibrium inflation rate equals the monetary growth rate, our parameter** μ **may be interpreted as the central bank's target inflation rate**.

■ In a provocative essay Milton **Friedman argued that the target inflation rate** μ **ought to be negative and numerically equal to the equilibrium real interest rate so that the nominal interest rate** $i = \bar{r} + \mu$ **becomes zero**.

■ Friedman's argument was that the **marginal social cost of supplying money to the public is roughly zero, since printing money is virtually costless**. To induce people to hold the **socially optimal amount of money balances**, the **marginal private opportunity cost of money-holding** – given by the nominal interest rate – **should therefore also be zero**.

■ **If the nominal interest rate is positive, people will economize on their money balances** to **hold more of their wealth in the form of interest-bearing assets**. The resulting **inconvenience of having to exchange interest-bearing assets for money more often** to handle the daily transactions will yield a **utility loss**. According to Friedman **this welfare loss can be avoided at zero social cost by driving the nominal interest rate to zero** so that people are no longer induced to economize on their money balances.

■ This **recommendation of a steady rate of deflation to ensure a zero nominal interest rate is sometimes referred to as the "Friedman Rule"** (see Milton Friedman, "The Optimum Quantity of Money", in *The Optimum Quantity of Money and Other Essays*, Chicago, Aldine Publishing, 1969).

■ Many economists consider **Friedman's recommendation** to be **theoretically interesting**, but dangerous in practice. They argue that a policy of **deflation can trigger a destabilizing wave of bankruptcies if debtors have not fully anticipated the future fall in prices and the resulting increase in their real debt burdens**. Later we shall consider some further reasons why a negative inflation target may be undesirable.

The Taylor rule

■ As we have mentioned, **some central banks have occasionally defined targets for the growth rate of the nominal money supply**, in accordance with Milton Friedman's recommendation.

■ However, in an influential article, American economist **John Taylor** argued that rather than worrying too much about the evolution of the money supply as such, the **central bank might as well simply adjust the short-term interest rate in reaction to observed deviations of inflation and output from their targets** (see John B. Taylor, “Discretion versus Policy Rules in Practice", *Carnegie-Rochester Conference Series on Public Policy*, 39, 1993).

■ Assuming that **policy makers wish to stabilize output around its trend level**, and denoting the inflation target by π^*, we may then specify the **monetary policy rule proposed by Taylor** as:

$$i = \bar{r} + \pi + h(\pi - \pi^*) + b(y - \bar{y}), \quad h > 0, \quad b > 0 \qquad 12.21$$

■ Equation (12.21) is the famous **Taylor rule**. Recalling that the **monetary growth rate μ may be interpreted as an inflation target**, we see from (12.20) and (12.21) that the **nominal interest rate follows an equation of the same form under the constant money growth rule and under the Taylor rule**.

■ Yet there is an **important difference**. **Under the constant money growth rule the coefficients in the equation for the interest rate depend on the parameters η and β in the money demand function**.

■ In contrast, **under the Taylor rule** the **parameters h and b in (12.21) are chosen directly by policy makers, depending on their aversion to inflation and output instability**.

■ According to Taylor it is important that the **value of h is positive so that the real interest rate goes up when inflation increases**. **If $1 + h$ is less than 1, a rise in inflation will drive down the real interest rate $i - \pi$, and this in turn will further feed inflation by stimulating aggregate demand** for goods, leading to economic instability. In fact, Taylor suggested that the parameter values **$h = 0.5$ and $b = 0.5$ would lead to good economic performance**, given the structure of the US economy.

■ Empirical studies have found that although **central bankers never mechanically follow a simple policy rule**, **central bank interest rates do in fact tend to be set in accordance**

with equations of the general form given in (12.21). As we have seen, **such interest rate behaviour is consistent with the constant money growth rule as well as the Taylor rule**.

■ However, one **problem with the former rule is that a constant monetary growth rate may not succeed in stabilizing the evolution of nominal aggregate demand if the parameters of the money demand function are changing over time** in an unpredictable fashion. Such **unanticipated shifts in the money demand function may occur when new financial instruments and methods of payment emerge as a result of financial innovation**.

■ In part because of this problem with the constant money growth rule, **monetary policy has increasingly come to be discussed in terms of the Taylor rule** in recent years. Table 12.1 shows **econometric estimates of the "Taylor" coefficients *h* and *b*** in some large OECD economies where interest rate policies have not been significantly constrained by a target for the foreign exchange rate.

Table 12.1: Estimated interest rate reaction functions of four central banks

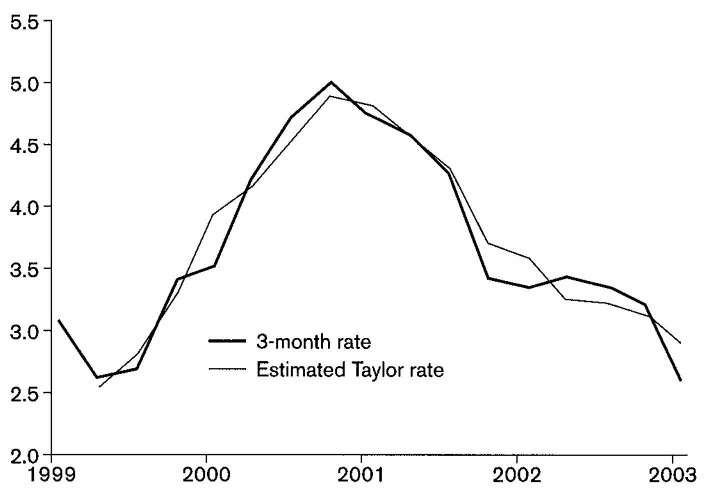
	Estimate of h	Estimate of b	Estimation period	
German Bundesbank[1]	0.31	0.25	1979:3–1993:12	(monthly data)
Bank of Japan[1]	1.04	0.08	1979:4–1994:12	(monthly data)
US Federal Reserve Bank[1]	0.83	0.56	1982:10–1994:12	(monthly data)
European Central Bank[2]	0.74	0.82	1999:1–2003:1	(quarterly data)

1. Source: Richard Clarida, Jordi Gali and Mark Gertler, 'Monetary Policy Rules in Practice – Some International Evidence', *European Economic Review*, **42**, 1998, pp. 1033–1067.

2. Source: Centre for European Policy Studies, *Adjusting to Leaner Times*, 5th Annual Report of the CEPS Macroeconomic Policy Group, Brussels, July 2003.

■ We see from the table that in recent years **all of the four central banks have followed Taylor's recommendation that *h* should be substantially above zero** to ensure a rise in the real interest rate in response to a rise in inflation.

■ Figure 12.3 (a) shows the **estimated interest rate** reaction function **of the European Central Bank** compared to the actual three-month interest rate in the Euro area.


5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1999
2000
2001
2002
2003
3-month rate
Estimated Taylor rate

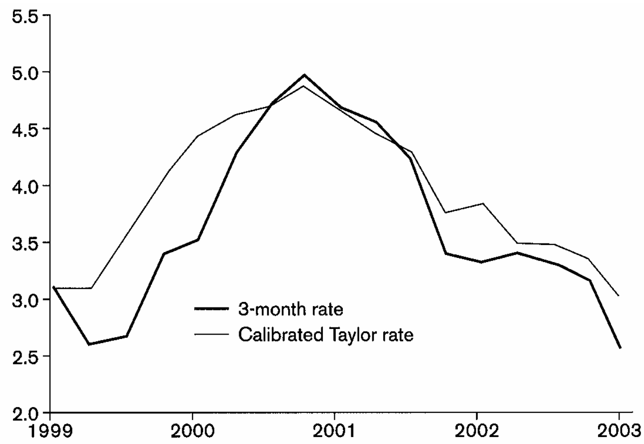


Figure 12.3: (a) Three-month rate and the estimated Taylor rate in the Euro area; (b) Three-month rate and the calibrated Taylor rate in the Euro area

Source: Centre for European Policy Studies, *Adjusting to Leaner Times*, 5th Annual Report of the CEPS Macroeconomic Policy Group, Brussels, July 2003, p. 53.

■ In Figure 12.3 (b) we compare the **evolution of the actual short-term interest rate to the interest rate which would have prevailed if the ECB had simply followed a Taylor rule** of the form (12.21) **with coefficients** $h = 0.4$, $b = 0.6$, $\pi^* = 1.5$ per cent and $\bar{r} = 2$ per cent. We see that in both cases the **Taylor rule gives a fairly good description of actual monetary policy in the Euro area**.

Monetary policy and long-term interest rates: the yield curve

■ The **central bank can control the current short-term interest rate via the choice of its own borrowing and lending rate**. However, the **incentive to invest in a real asset depends on the expected cost of capital over the entire useful life of the asset**. This lifetime may be **many years if the asset is, say, a house, a vehicle, or a piece of machinery**.

■ The crucial question is: **to what extent can monetary policy affect the incentive to acquire the long-lived assets which make up the bulk of investment?**

■ Consider a firm which is contemplating investment in a real asset with an expected lifetime of n periods. Suppose first that the firm plans to **finance the investment with short term debt which is "rolled over"** in each period so that the **interest rate varies with the movements in the short-term interest rate**.

■ For simplicity, suppose further that the **firm does not need to pay any interest until time *t* + *n* when the entire loan is paid back with interest**. If one euro of debt is incurred in period t, the **expected amount A^s to be repaid at time** $t + n$ will be:

$$A^s = (1 + i_t) \times (1 + i^e_{t+1}) \times (1 + i^e_{t+2}) \times \cdots \times (1 + i^e_{t+n-1}) \qquad 12.22$$

where i_t is the **current short-term (one-period) interest rate** which is known at the time the debt is incurred, and i^e_{t+j} is the **future short-term interest rate** expected to prevail in period $t + j$.

■ As an **alternative**, the firm may **finance the investment by a long-term loan with *n* terms to maturity** (i.e., a loan lasting for *n* periods) where the **interest rate per period, i^l, is fixed at time *t* when the debt is incurred**. Assuming again that no interest is paid until the loan expires at time $t + n$, the **amount A^l to be repaid** at that time will then be:

$$A^l = (1 + i_t^l)^n \qquad 12.23$$

■ **If the firm is risk-neutral**, it will **not worry about the uncertainty pertaining to the future short-term interest rates but will simply choose the mode of finance with the lowest expected cost**. Thus, **if $A^l > A^s$**, the firm will choose to **finance the investment by a variable-interest rate loan**, but **if $A^l < A^s$** it will **prefer the long-term loan with a fixed interest rate**.

■ **In the latter case it would seem that monetary policy has no influence at all on the cost of investment finance**, since the short-term interest rate controlled by the central bank does not enter the expression for A^l. However, **this ignores that the arbitrage behaviour of financial investors creates a link between short-term and long-term interest rates**.

■ We will now explore this link. **Suppose that financial investors consider short-term debt instruments** (with one term to maturity) and **long-term debt instruments** (with n terms to maturity) **to be perfect substitutes** for each other. Since **short-term and long-term instruments have different risk characteristics**, **perfect substitutability requires that investors be risk neutral**.

■ In that case the **effective interest rate on the long-term instrument must adjust to ensure that the expected returns on short-term and long-terms instruments are equalized**. In a **financial market equilibrium** investors must thus expect to **end up with the same stock of wealth at time $t + n$ whether they buy a long-term instrument and hold it until maturity, or whether they make a series of n short-term investments, reinvesting in short-term instruments** every time the instrument bought in the previous period matures. At the beginning of period t we therefore have the **financial arbitrage condition**:

$$(1+i_t^l)^n = (1+i_t)\times(1+i_{t+1}^e)\times(1+i_{t+2}^e)\times\cdots\times(1+i_{t+n-1}^e) \quad 12.24$$

■ The term on the **left-hand** side of (12.24) is the **investor's wealth at time *t* + *n* if he invests in the long-term instrument** at time *t* and holds on to his investment. The **right-hand** side of (12.24) measures the **wealth he expects to accumulate if he makes a series of short-term investments, reinvesting his principal plus interest** in each period until time *t* + *n*. In equilibrium the **two investment strategies must be equally attractive**, given the perfect substitutability of short-term and long-term financial instruments.

■ Equations (12.22)-(12.24) obviously imply that $A^s = A^l$, so **under risk neutrality the cost of long-term finance is identical to the (expected) cost of short-term finance**. This means that the **long-term interest rate is influenced by the short-term interest rate controlled by the central bank**.

■ More precisely, according to (12.24) the **current long-term interest rate depends on the current and the expected future short-term interest rates**. This is referred to as the **expectations hypothesis**.

■ If the length of our period is, say, a year, a quarter, or a month, the interest rates appearing in (12.24) will not be far above 0, and the approximation ln(1 + *i*) ≈ *i* will be fairly accurate. Taking **logs** on both sides of (12.24) and **dividing through by *n***, we then get:

$$i_t^l \approx \frac{1}{n}(i_t + i_{t+1}^e + i_{t+2}^e + \cdots + i_{t+n-1}^e) \qquad 12.25$$

■ Equation (12.25) says that the **current long-term interest rate is a simple average of the current and the expected future short-term interest rates**. This relationship assumes that investors are risk neutral. **If they are risk averse, one must add a risk premium to the right-hand side** of Eq. (12.25) to account for the **greater riskiness of long-term bonds whose prices are more sensitive to changes in the market rate of interest and hence more volatile**.

■ We have so far **considered only two different debt instruments**. In reality a **large number of securities with many different terms to maturity are traded in financial**

markets. But the reasoning which led to Eq. (12.25) is valid for any $n \geq 2$, so (12.25) **determines the entire term structure of interest rates**, that is, the **relationship between the interest rates on securities with different terms to maturity** (different values of n).

■ From the term structure equation (12.25) one can derive the so-called **yield curve** which shows the **effective interest rates on instruments of different maturities at a given point in time**. According to (12.25) we have:

$$i_t^l = i_t \quad \text{if and only if} \quad i_{t+j}^e = i_t \quad \text{for all } j = 1,2,\ldots, n-1 \qquad 12.26$$

■ In other words, **if financial investors happen to expect no changes in future short-term interest rates** – a situation sometimes described as "**static expectations**" – the **interest rates on long-term and short-term instruments will coincide**, and the **yield curve will be quite flat**. For example, Figure 12.4 shows that the yield curve in Denmark did in fact look this way in the beginning of January 2001.

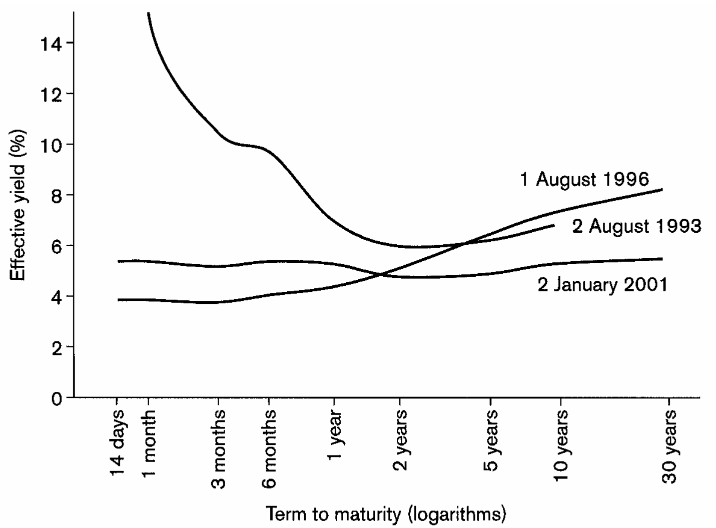


Figure 12.4: The term structure of interest rates in Denmark

Source: Danmarks Nationalbank.

■ As we move **from left to right on the horizontal axis**, we **consider instruments with increasing terms to maturity**. The first point on the yield curve shows the market interest rate on interbank credit with **14 days** until maturity. This interest rate is almost perfectly controlled by the interest rate policy of the Danish central bank. The last point on the yield curve plots the effective market interest rate on **30-year** Danish government bonds. The **flatness of the yield curve suggests that investors in Denmark roughly expected constant short-term interest rates** at the beginning of 2001.

■ A rather **flat yield curve is often considered to represent a “normal” situation where investors have no particular reason to believe that tomorrow will be much different from today**. But sometimes the situation is not normal. Figure 12.4 shows that **short-term interest rates were far above long-term rates on 2 August 1993**. Around that date Denmark and many other European countries **suffered from the speculative attack on the European Monetary System**, the fixed exchange rate system that existed before the formation of the European Monetary Union. **To stem the capital outflow generated by fears of a devaluation** of the Danish krone, **Danmarks Nationalbank drove up the 14-day**

interbank interest rate to the exorbitant height of 45 per cent p.a. The fact that **long-term interest rates remained much lower** indicates that **investors did not expect the extreme situation at the short end of the market to last long**.

■ In contrast, the **yield curve had an unusually steep upward slope on 1 August 1996**, as illustrated in Figure 12.4. At that time it was **widely expected that the pace of growth in the European economy was about to increase significantly**. Market participants therefore **expected future monetary policy to be tightened to counteract inflationary pressures**, and the **expectation of higher future short-term interest rates drove current long-term rates significantly above the current short rate**.

■ As mentioned earlier, in practice **risk averse investors will require some risk premium on long-term bonds to compensate for the fact that their market prices are more volatile than the prices of short-term bonds**. In an equilibrium where the market does not expect any changes in future monetary policy, the **yield curve will therefore typically have a slightly positive slope**.

Implications for monetary policy

■ **What does all this imply for monetary policy?** Recall that the left-hand side of (12.25) reflects the cost of financing investment by long-term debt while the right-hand side represents the cost of financing investment through a sequence of short-term loans. Moreover, **even if a real investment is financed by equity, the cost of finance is still represented by either of the two sides of (12.25), since the opportunity cost of equity finance is the rate of interest which the owners of the firm could have earned if they had chosen instead to invest their wealth in the capital market**.

■ Regardless of the mode of finance, (12.25) thus implies that **monetary policy can only have a significant impact on the incentive to invest in long-lived real assets if it affects expectations about future short-term interest rates**.

■ For example, **if the central bank engineers a unit increase in the current short rate i_t which the market considers to be purely temporary, the expected future interest rates** appearing on the right-hand side of (12.25) will be unaffected, and the interest rate on **long-term debt with *n* periods to maturity will only increase by 1/*n***.

■ If the short-term rate applies to an instrument with a term of one month, and the long-term rate relates to a 30-year bond, *n* will be equal to 12 x 30 = 360. In that case a one-percentage point increase in the short term interest rate will only raise the long-term bond rate by a negligible 0.0028 percentage points, i.e., less than 0.3 basis points.

■ Thus there is **hardly any impact on the incentive to invest in long-lived real assets, regardless of whether the investment is financed by long-term bond issues or by a sequence of short-term loans**. At the other end of the spectrum is the **situation where a change in the current short-term interest rate is expected to be permanent**. According to (12.25) the **long-term interest rate will then rise by the full amount of the increase in the short rate**. This corresponds to the assumption of static expectations in (12.26).

■ The **difficulties of controlling the cost of long-term investment finance through central bank interest rate policy** are illustrated in Figure 12.5. Despite the many successive cuts in the target short-term interest rate of the US Federal Reserve Bank (the Federal funds target rate) undertaken during 2001 in reaction to economic recession, the **long-term interest rate refused to come down significantly**. This suggests that market **participants expected a quick economic recovery** which would induce the Federal Reserve Bank to raise its interest rate again.

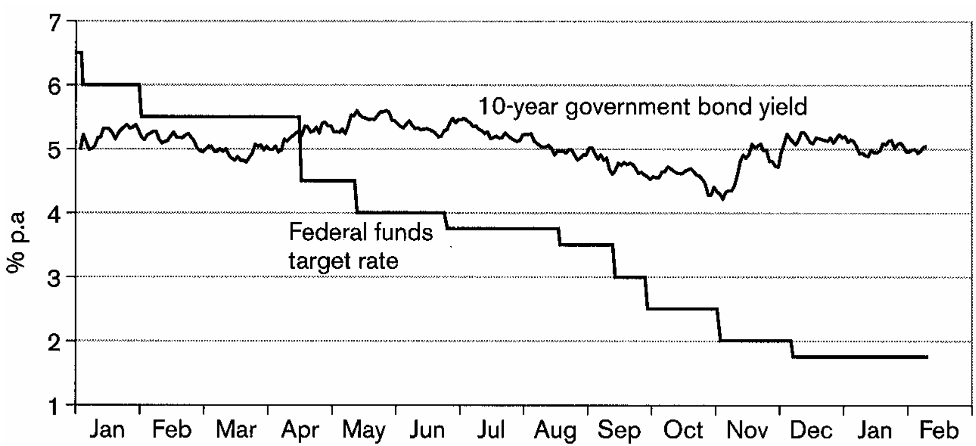


Figure 12.5: The decoupling of short-term and long-term interest rates in the United States, 2001-2002

Source: Danmarks Nationalbank.

■ The fact that **monetary policy works to a large extent through its impact on market expectations** explains why **central banks care so much about their communication strategies**, and why market **analysts scrutinize every statement by central bankers to find hints about future monetary policy**. In any given situation, the **transmission from a change in the central bank interest rate to the change in long-term market interest rates will depend on market expectations**. These in turn will depend on **context and historical circumstances**.

■ In the analysis below we will **ignore the complication that long-term interest rates do not always move in line with the current short-term rate controlled by monetary policy**. In fact, we will **assume that financial investors have static expectations** so that $i_t^l = i_t$, in accordance with (12.26). As the preceding analysis makes clear, this is a **strong simplification**.

■ Yet we should **not exaggerate the loss of generality implied by the assumption of static interest rate expectations**. Figure 12.6 shows that the **long-term market rate and the central bank interest rate do tend to move in tandem over the longer run**, even though they **may be out of line in the short run**. Moreover, since a **part of household saving is invested in short-term interest-bearing assets**, and since **some business credit is short term in nature**, the **short-term interest rate has a direct impact on some components of private aggregate demand**.

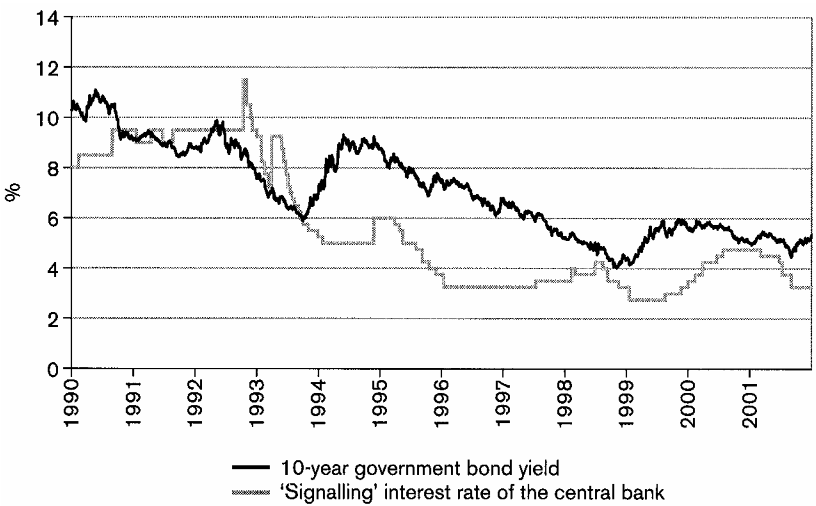


Figure 12.6: The "signalling" interest rate of the central bank and the ten-year government bond yield in Denmark

Source: Danmarks Nationalbank.

The aggregate demand curve

The real interest rate: ex ante versus ex post

■ We are now ready to derive the **relationship between the inflation rate and the aggregate demand** for goods and services. This relationship, called the **aggregate demand (AD) curve**, will be **one of the two cornerstones of our model of the macro economy**.

■ The first step in our derivation of the AD curve is the **specification of the relationship between the nominal interest rate, the real interest rate and inflation**. We have previously used the **popular definition according to which the real interest rate is given by $r = i - \pi$**, but now we **need to be more precise**.

■ For a saver or a borrower the **actual real interest rate r^a earned or paid between the current period and the next** one is given by:

$$1 + r^a \equiv \frac{1+i}{1+\pi_{+1}} \qquad 12.27$$

■ The reasoning behind (12.27) is this: **if the current price level is *P*, giving up one unit of consumption today will enable you to invest the amount *P* in the capital market**. Your **nominal wealth one year from now will then be *P*(1 + *i*)**.

■ **With an inflation rate π_{+1} between the current and the next period, a unit of consumption tomorrow will cost you $P(1 + \pi_{+1})$**, so the **purchasing power of your wealth** one year from now will be only $P(1+ i)/P(1 + \pi_{+1}) = (1+ i)/(1 + \pi_{+1})$. Thus your **real rate of return** is $r^a = (1 + i)/(1 + \pi_{+1}) - 1$, which is just another way of writing (12.27).

■ The variable r^a **is called the *ex post* real interest rate**, because it measures the **real interest rate implied by the actual rate of inflation**, measured after the relevant time period has passed ("*ex post*"). However, since **saving and investment decisions must be made "*ex ante*", before the future price level is known with certainty**, the **real interest rate**

affecting aggregate demand for goods is the so-called *ex ante* real interest rate (r) which is based on the rate of inflation π_{+1}^{e} expected to prevail over the next period:

$$1 + r \equiv \frac{1+i}{1+\pi_{+1}^{e}} \qquad 12.28$$

■ You may easily verify that:

$$r = \frac{i - \pi_{+1}^{e}}{1+\pi_{+1}^{e}} \approx i - \pi_{+1}^{e} \qquad 12.29$$

where the **latter approximation holds as long as** π_{+1}^{e} **does not deviate too much from zero**.

■ In the **special case of static inflation expectations** where agents assume that the **rate of price increase over the next period will correspond to the rate of inflation experienced between the previous and the current period,** we have $\pi_{+1}^{e} = \pi$.

■ It then follows from (12.29) that the ***ex ante*** **real interest rate may be proxied by** $\boldsymbol{r = i - \pi}$, **corresponding to the popular definition of the real interest rate**. Still, you should keep in mind that the more correct specification of the real interest rate influencing saving and investment decisions is given by (12.29).

Deriving the aggregate demand curve

■ In many countries **consumer and/or business surveys** provide an **estimate of the rate of inflation expected by the private sector**. Several countries also have **markets for indexed bonds whose principal is automatically adjusted in accordance with the change in some index of the general price level**.

■ **For such bonds the interest rate does not have to include an inflation premium to compensate the creditor for the erosion of his real wealth caused by inflation**. By **comparing the interest rate on indexed bonds to that on conventional non-indexed bonds of similar maturity, one may therefore obtain an estimate of the expected rate of inflation**.

■ In one of these ways the **central bank will usually be able to measure the private sector's expected rate of inflation**. We will therefore **assume that the central bank can observe the expected inflation rate** π^e_{+1}.

■ **Alternatively**, we might assume that the **central bank forms its own estimate of the future inflation rate** and uses this as a proxy for the private sector's expected inflation rate. **If the central bank and the private sector are using the same information, they will arrive at roughly the same value of** π^e_{+1}.

■ Furthermore, since **private demand depends on the *ex ante* real interest rate** $r = i - \pi_{+1}^{e}$, we will assume that the **central bank sets the short-term nominal interest rate in accordance with the following slightly modified version of the Taylor rule**:

$$i = \bar{r} + \pi_{+1}^{e} + h(\pi - \pi^{*}) + b(y - \bar{y}) \quad 12.30$$

implying:

$$r = \bar{r} + h(\pi - \pi^{*}) + b(y - \bar{y}) \quad 12.31$$

■ Equation (12.31) shows that **if the central bank has a good estimate of the expected inflation rate, it can control the *ex ante* real interest rate in the short run**. We may now **insert the monetary policy rule** (12.31) **into the log-linearized version of the goods market equilibrium condition** (12.11). We then get:

$$y - \bar{y} = \alpha_1(g - \bar{g}) - \alpha_2 \overbrace{[h(\pi - \pi^*) + b(y - \bar{y})]}^{r - \bar{r}} + \upsilon$$

which is **equivalent to the aggregate demand curve**:

$$y - \bar{y} = \alpha(\pi^* - \pi) + z \qquad 12.32$$

$$\alpha \equiv \frac{\alpha_2 h}{1 + \alpha_2 b} > 0, \quad z \equiv \frac{\upsilon + \alpha_1(g - \bar{g})}{1 + \alpha_2 b} \qquad 12.33$$

■ We see from (12.32) and (12.33) that the **aggregate demand curve is downward-sloping in the (*y*, *π*) space**: a **higher rate of inflation is associated with lower aggregate demand for output**, as illustrated in Figure 12.7 where the aggregate demand curve is denoted by AD.

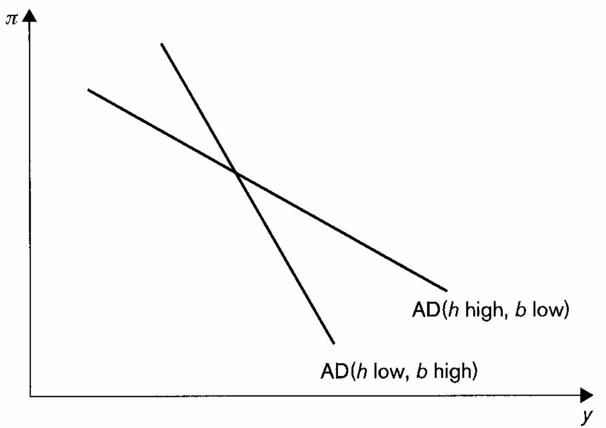


Figure 12.7: The aggregate demand curve

■ The **reason for the negative slope** is that **higher inflation induces monetary policy makers to raise the real interest rate**, given that the parameter h in the central bank's reaction function (12.31) is positive. The **higher real interest rate in turn dampens aggregate private demand** for goods and services.

■ To identify the **determinants of the position and the slope of the AD curve** in the (y, π) plane, it is convenient to rearrange (12.32) as:

$$\pi = \pi^* + (1/\alpha)z - (1/\alpha)(y - \bar{y}) \qquad 12.34$$

■ The **variable *z*** on the right-hand side of (12.34) **captures aggregate demand shocks**. From the definition of z given in (12.33) we see that **aggregate demand shocks may come from changes in fiscal policy**, reflected in g, or from **changes in private sector confidence affecting the variable *υ*** (see the definition of υ in (12.12)).

■ A **more expansionary fiscal policy** (a rise in g), or **more optimistic growth expectations** in the private sector (a rise in ε) will **shift the aggregate demand curve upwards** in the (y, π) plane. Given our definitions of υ and z in (12.12) and (12.33), the **value of *z* will be zero**

under "normal" conditions where **public spending** and **private sector growth expectation**s are **at their trend levels**.

■ According to (12.34) the **position of the aggregate demand curve is also affected by the central bank's inflation target** π^*. **If the central bank becomes more "hawkish" in fighting inflation, the aggregate demand curve will shift downwards**.

■ **Monetary policy influences the slope of the aggregate demand curve** $(1/\alpha)$ **as well as its position**. **If the central bank puts strong emphasis on fighting inflation** and little emphasis on stabilizing output, the parameter ***h* in the Taylor rule will be high**, and the parameter ***b* will be low**. Since $\alpha \equiv \alpha_2 h/(1 + \alpha_2 b)$, this means that the aggregate demand curve will be flat (α will be high).

■ On the other hand, **if monetary policy reacts strongly to the output gap and only weakly to inflation, we have a low value of *h* and a high value of *b***, generating a **steep aggregate demand curve**. These results are illustrated in Figure 12.7.

■ The **aggregate demand curve is one of the two key relationships in our short-run model of the macro economy**. To identify the point on the AD curve in which the economy will settle down, we need to bring in the **aggregate supply side**. This is the topic of the next lecture.

Summary

■ The aggregate demand curve (the AD curve) is derived by combining the aggregate consumption and investment functions with the goods market equilibrium condition that total output must equal the total demand for output consisting of private consumption, private investment and government demand for goods and services. Goods market equilibrium implies that aggregate saving equals aggregate investment. The AD curve assumes that the private sector savings surplus (savings minus investment) is an increasing function of the real rate of interest. The evidence supports this assumption.

■ Because aggregate demand depends on the real rate of interest, it is crucially influenced by the interest rate policy of the central bank. Historically some central banks have followed

Milton Friedman's suggested constant money growth rule, setting the short-term interest rate with the purpose of attaining a steady growth rate of the nominal money supply. More recently, the interest rate policy of many important central banks has tended to follow the rule suggested by John Taylor according to which the central bank should raise the short-term real interest rate when faced with a rise in the rate of inflation or a rise in output. If the money demand function is stable, the constant money growth rule has similar qualitative implications for central bank interest rate policy as the Taylor rule.

■ The central bank can control the short-term interest rate, but not the long-term interest rate. The expectations hypothesis states that the long-term interest rate is a simple average of the current and expected future short-term interest rates. If a change in the short-term interest rate has little effect on expected future short-term rates, it will also have little effect on the long-term interest rate. The ability of the central bank to influence the long-term interest rate therefore depends very much on its ability to affect market expectations.

■ The incentive to invest in a real asset depends on the expected cost of finance over the lifetime of the asset. Under debt finance a long-lived asset may be financed by a long-term loan or by a sequence of short-term loans. Risk neutral investors will choose the mode of finance which has the lowest expected cost. When the expectations hypothesis holds, the expected cost of finance is the same whether real investment is financed by equity, by long-term debt, or by a sequence of short-term loans. As a consequence, the ability of the central bank to influence incentives for long-term real investment depends on its ability to influence the long-term interest rate which in turn hinges on its ability to affect market expectations of future short-term rates.

■ When expectations are static, the expected future short-term interest rates are equal to the current short-term rate. A change in the current short-term rate will then cause a corresponding change in the long-term interest rate, and the yield curve showing the interest rates on bonds with different terms to maturity will be completely flat. The AD curve is derived on the simplifying assumption that expectations are static so that the central bank can control long-term interest rates through its control over the short-term rate.

■ Because of its empirical relevance, our theory of the aggregate demand curve also assumes that monetary policy follows the Taylor rule which implies that the central bank raises the real interest rate when the rate of inflation goes up. A higher rate of inflation will therefore be accompanied by a fall in aggregate demand, so the AD curve will be downward-sloping in (y, π) space. The AD curve will shift down if the central bank lowers its target rate of inflation or if the economy is hit by a negative demand shock, due to a tightening of fiscal policy or a fall in private sector confidence.