Chapter 15
The Economy in the Short Run: Some Facts About Business Cycles

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Since the time of the Industrial Revolution the western world has experienced a tremendous growth of total output. The first part of our course focused on this long-run aspect of economic development. But history tells us that economic growth has been far from steady. In the short and medium term the growth rate fluctuates considerably, as you can see from Figure 15.1 which plots quarterly data for the logarithm of Danish real GDP since the beginning of the 1970s. If the growth rate of the economy were constant, the log of GDP would follow the straight line in Figure 15.1. The fact that the graph for the log of actual GDP is sometimes steeper and sometimes flatter than the straight line reflects that periods of rapid growth tend to alternate with intervals of slow growth. Indeed, the graph has frequently had a negative slope, indicating that the growth rate sometimes even becomes negative. Note that the data underlying Figure 15.1 are seasonally adjusted, so the fluctuations do not reflect the regular changes in business activity occurring with the changing seasons of the year, for example, the seasonal swings in construction activity due to changing weather conditions. Thus there are more fundamental forces causing an uneven pace of economic growth.

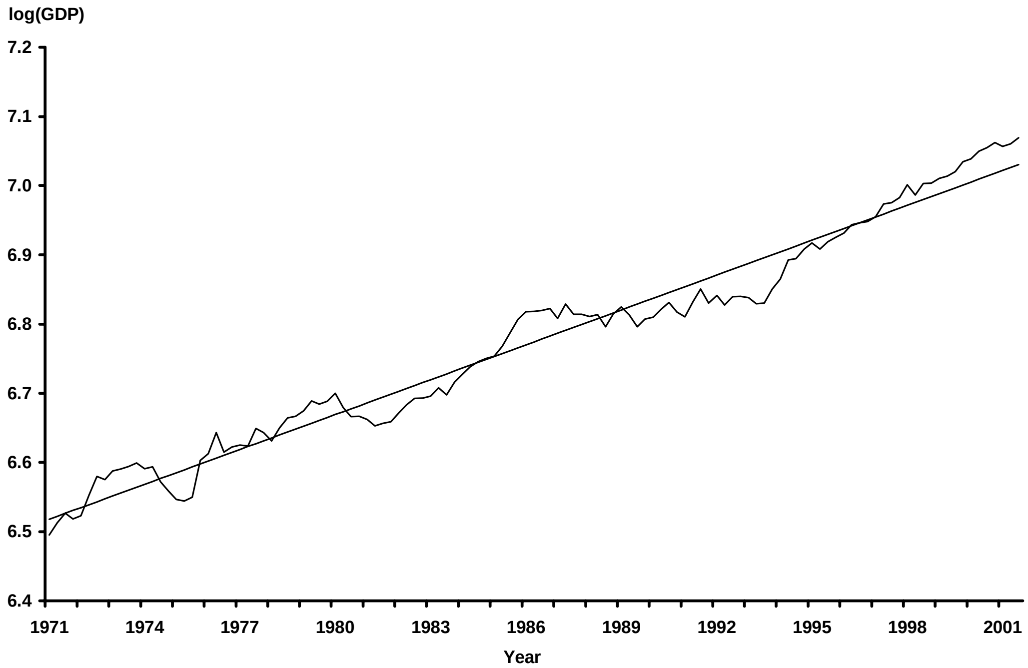

Figure 15.1: Danish economic growth, 1971-2001

Source: MONA database, Danmarks Nationalbank.

The present part of our macro course studies these short term fluctuations in economic activity, commonly known as *business cycles.* How can we explain that the state of the economy repeatedly alternates between business cycle *expansions* characterized by rapid growth, and business cycle *contractions* or *recessions* characterized by declining economic activity? To answer this question is one of the basic challenges of macroeconomic theory.

The fact that economic growth is repeatedly interrupted by recessions is a major source of concern for economic policy makers and the general public, since recessions bring considerable economic hardship to workers who lose their jobs, to entrepreneurs and homeowners who go bankrupt, and to ordinary consumers who suffer capital losses on their assets. Even for those who are not directly affected by layoffs and bankruptcies, recessions may cause a decline in well-being by generating fears of job losses and of future reductions in income and wealth. Understanding business cycles is therefore not only of academic interest; it may also help the economist to offer advice to policy makers on the possibility of reducing business fluctuations through macroeconomic *stabilization policy*, that is, active monetary and fiscal policy. Or at least an insight into the workings of the business cycle may enable the economist to suggest how policy makers can avoid *amplifying* the business cycle through misguided macroeconomic policies.

On several occasions in history, recessions have developed into severe economic *depressions* paving the way for social and political disaster. A glance at Figure 15.2 should convince you why it is important to understand the causes of depressions and the means to avoid them. The figure shows a striking correlation between the unemployment rate in interwar Germany and the share of total votes in Reichstag elections going to Adolf Hitler's Nazi party. In the 1928 election, when unemployment stood at the low level of 2.8 percent, the Nazis captured only 2.6 percent of the votes and were not considered a serious political force. But as the democratic system of the Weimar Republic proved unable to prevent the mass unemployment and human suffering caused by the Great Depression, a rapidly growing number of Germans became receptive to Hitler's radical critique of the parliamentary system. By 1933, with unemployment close to 30 percent of the labour force, Hitler obtained a vote share of almost 44 percent in the last election before he established his Nazi dictatorship and steered Germany towards the Second World War. Although there were several other factors explaining Hitler's rise to power, there is no doubt that the economic depression made it easier for him to gather support.

The Great Depression of the 1930s was exceptional in its severity and in its social and political consequences. Nevertheless we have several recent examples of economic downturns which have caused social upheaval, including the South East Asian crisis of 1997-98 which brought down the Indonesian government and led to serious civil unrest, and the economic crisis in Argentina in 2001 which forced the government to resign after riots in the streets. By studying business cycles we will not only learn more about the workings of a market economy; we will also improve our understanding of the general course of social and political events.

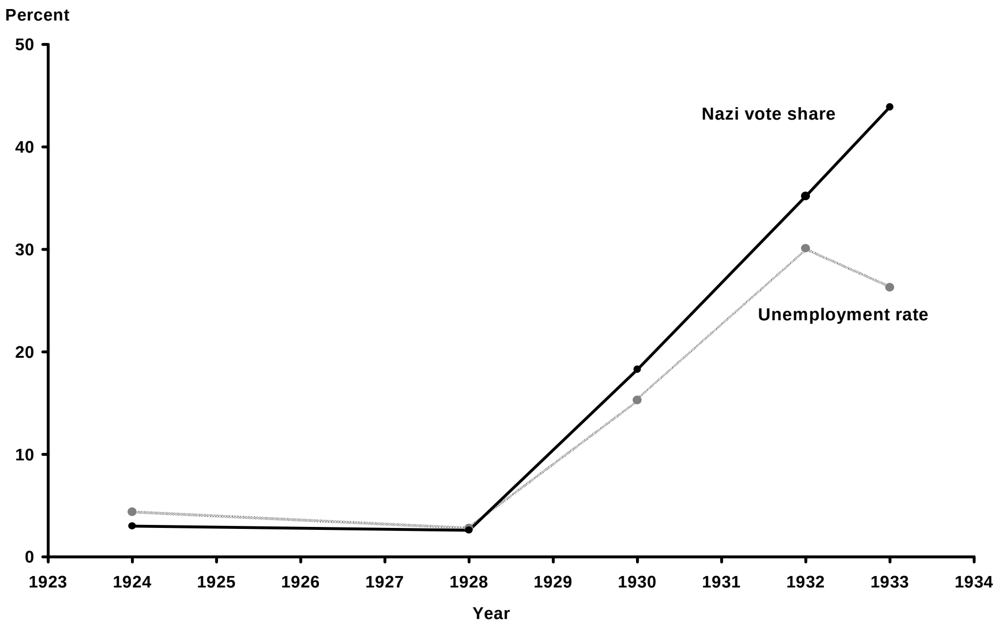

Figure 15.2: Unemployment and political extremism in Germany, 1924-1933

Note: Nazi vote share in 1932 is an average across two elections.

Sources: Unemployment rate from B.R. Mitchell, International Historical Statistics, Europe 1750-1988, Macmillan, New York 1993. Nazi vote share from Richard F. Hamilton, Who Voted for Hitler?, Princeton University Press, 1982.

The reason why it makes sense to theorize about business cycles is that, even though no two business cycles are identical, they usually have some important features in common. Nobel laureate Robert Lucas of the University of Chicago made this point in the following way:

"Though there is absolutely no theoretical reason to anticipate it, one is led by the facts to conclude that, with respect to the qualitative behavior of comovements among series (economic variables), *business cycles are all alike*. To theoretically inclined economists, this conclusion should be attractive and challenging, for it suggests the possibility of a unified explanation of business cycles, grounded in the *general* laws governing market economies, rather than in political or institutional characteristics specific to particular countries or periods."[1]

[1] Robert E. Lucas, Jr., "Understanding Business Cycles", in K. Brunner and A.H. Meltzer, eds., *Carnegie-Rochester Conference Series on Public Policy*, vol. 5, Autumn 1977, p. 10.

In the rest of this chapter we will describe some of those comovements of economic variables which are characteristic of business cycles. Before we start theorizing about business cycles, we want to get some idea of the phenomenon which our theory is supposed to explain. We will start out in the next section by restating a definition of business cycles which has become famous in the literature. We will then move on to the question how we can measure business cycles in quantitative terms. That is, how can we separate short term business cycle fluctuations in economic activity from the long term economic growth trend? Following this, we will be ready to describe in quantitative terms the comovements of important economic variables during a 'typical' business cycle.

1 Defining business cycles

In a famous book which became a milestone in empirical business cycle research, the American economists Arthur Burns and Wesley Mitchell (1946) gave the following classic definition of business cycles:

> "Business cycles are a type of fluctuations found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own"[2]

This definition of business cycles emphasizes several points.

[2]Arthur F. Burns and Wesley C. Mitchell, *Measuring Business Cycles*, New York: National Bureau of Economic Research (NBER), 1946, p. 1. Mitchell was a principal founder of the NBER, and Burns was a student of his who later became chairman of the U.S. Federal Reserve Board from 1970 until 1978.

Aggregate economic activity: Business cycles are characterized by a comovement of a large number of economic activities and not just by movements in a single variable like real GDP.

Organization in business enterprises: Business cycles are a phenomenon occurring in decentralized market economies. Although they had several other economic problems, the former socialist economies of Eastern Europe did not go through business cycles of the type known in the western world.

Expansions and contractions: Business cycles are characterized by periods of expansion of economic activity followed by periods of contraction in which activity declines.

Duration of more than a year (persistence): A full business cycle lasts for more than a year. Fluctuations of shorter duration do not have the features characteristic of business cycles. This means that purely seasonal variations in activity within a year are not business cycles. We may also say that business cycle movements display *persistence:* once an expansion gets going, it usually lasts for some time during which the expansionary forces tend to be self-reinforcing, and once a contraction sets in, it tends to breed further contraction for a while.

Recurrent but not periodic: Although business cycles repeat themselves, they are far from being strictly periodic. The duration of cycles has varied from slightly more than a year to 10-12 years, and the severity of recessions has also varied considerably, with recessions sometimes (but not always) turning into *depressions.*

2 Dating business cycles

The contribution of Burns and Mitchell was to document the movements over time of a large number of economic variables. Through their work it became possible to *identify the turning points* in economic activity and hence to offer a *dating* of U.S. business cycles.

Since the movements of the different economic variables are not perfectly synchronized, it is a matter of judgement to identify the point in time at which the business cycle reaches its peak and moves from expansion into contraction, and to determine when it reaches its trough, moving from contraction (recession) to expansion. Building on the tradition established by Burns and Mitchell, the U.S. National Bureau of Economic Research (NBER) has for many years had a Business Cycle Dating Committee consisting of experts in empirical business cycle research. The NBER committee defines a recession (contraction) as a period of significant decline in total output, income, employment, and trade, usually lasting from six months to a year, and marked by widespread contractions in many sectors of the economy. On this basis the committee has arrived at a dating of U.S. business cycles between 1854 and 2001.

This dating is reproduced in Table 15.1. The length of the business cycle is measured from trough to trough, and the last column of the table measures the duration of the expansion phase relative to the duration of the contraction phase. Table 15.1 illustrates the point stressed by Burns and Mitchell: business cycles are far from regular and periodic. The duration of the cycle varies a lot, and though the expansion phase usually lasts longer the contraction phase - reflecting the economy's long-term potential for growth - there are also examples of cycles where the contraction has lasted longer than the previous expansion. At the bottom of the Great Depression in March 1933, the U.S. economy had been contracting for 43 months. During this economic nightmare, real GDP fell by almost 30 percent, and unemployment rose to 25 percent. Notice, however, that the contraction of the 1870s lasted considerably longer than the Great Depression, although economic historians tell us that the decline in activity was less catastrophic.

The dates in Table 15.1 indicate that business cycle expansions have tended to last longer and that contractions have on average been shorter after World War II than before that time. Until recently, the expansion from February 1961 to December 1969 was the longest economic boom in U.S. history. That record was beaten by the ten-year long expansion starting in March 1991. It remains to be seen when the recession which began in March 2001 will end, but it is already clear that it will mark the longest business cycle on record in the U.S.

The long U.S. boom of the 1990s inspired many commentators to speculate about the arrival of a 'New Economy' in which the expansionary forces stemming from innovations in information technology were so strong that serious recessions would be a thing of the past, at least in the U.S. Interestingly, the long boom of the 1960s gave rise to a similar unfounded optimism. In 1967, several leading U.S. economists gathered for a conference asking: 'Is the Business Cycle Obsolete?'[3]. But the announcement on November 26, 2001 by the NBER Business Cycle Dating Committee that the latest U.S. expansion ended in March 2001 shows that the business cycle is still with us, even in the most advanced market economy in the world.

Let us therefore move from the *dating* of business cycles to the problem of *quantitative measurement* of business fluctuations.

[3]The conference participants tended to answer the question in the affirmative. The conference papers were published in Martin Bronfenbrenner (ed.), *Is the Business Cycle Obsolete?* Wiley, New York, 1969.

Business cycle reference dates			Duration in months			
Trough	Peak	Trough	1. Expansion	2. Contraction	Cycle[1]	1./2.
December 1854	June 1857	December 1858	30	18	48	1.67
December 1858	October 1860	June 1861	22	8	30	2.75
June 1861	April 1865	December 1867	46	32	78	1.44
December 1867	June 1869	December 1870	18	18	36	1.00
December 1870	October 1873	March 1879	34	65	99	0.52
March 1879	March 1882	May 1885	36	38	74	0.95
May 1885	March 1887	April 1888	22	13	35	1.69
April 1888	July 1890	May 1891	27	10	37	2.70
May 1891	January 1893	June 1894	20	17	37	1.18
June 1894	December 1895	June 1897	18	18	36	1.00
June 1897	June 1899	December 1900	24	18	42	1.33
December 1900	September 1902	August 1904	21	23	44	0.91
August 1904	May 1907	June 1908	33	13	46	2.54
June 1908	January 1910	January 1912	19	24	43	0.79
January 1912	January 1913	December 1914	12	23	35	0.52
December 1914	August 1918	March 1919	44	7	51	6.29
March 1919	January 1920	July 1921	10	18	28	0.56
July 1921	May 1923	July 1924	22	14	36	1.57
July 1924	October 1926	November 1927	27	13	40	2.08
November 1927	August 1929	March 1933	21	43	64	0.49
March 1933	May 1937	June 1938	50	13	63	3.85
June 1938	February 1945	October 1945	80	8	88	10.0
October 1945	November 1948	October 1949	37	11	48	3.36
October 1949	July 1953	May 1954	45	10	55	4.50
May 1954	August 1957	April 1958	39	8	47	4.88
April 1958	April 1960	February 1961	24	10	34	2.40
February 1961	December 1969	November 1970	106	11	117	9.64
November 1970	November 1973	March 1975	36	16	52	2.25
March 1975	January 1980	July 1980	58	6	64	9.67
July 1980	July 1981	November 1982	12	16	28	0.75
November 1982	July 1990	March 1991	92	8	100	11.5
March 1991	March 2001	?	120	?	?	?
Average for pre-World War I period (15 cycles)[2]			25	23	48	1.10
Average for interwar period (5 cycles)[3]			26	20	46	1.30
Average for post-World War II period (9 cycles)[4]			50	11	61	4.55

Table 15.1: U.S. business cycle expansions and contractions

1. The duration of the full business cycle is measured from trough to trough. 2. December 1854 to December 1914. 3. March 1919 to June 1938. 4. October 1945 to March 1991.

Source: National Bureau of Economic Research, www.nber.org/cycles.html

3 Measuring business cycles

Most economic time series fluctuate around a growing time trend. The growth trend reflects the forces described in the theory of economic growth, while the task of business cycle theory is to explain the fluctuations around that trend. For example, if Y_t is real GDP in period t, it is useful to think of Y_t as the product of a growth component Y_t^g indicating the trend value which Y_t would assume if the economy were always on its long term growth path, and a cyclical component Y_t^c which fluctuates around a long run mean value of 1:

$$Y_t = Y_t^g \cdot Y_t^c \tag{1}$$

Our assumption on the mean value of Y_t^c implies that $Y_t = Y_t^g$ on average. Equation (1) also implies that as long as the amplitude of the fluctuations in the cyclical component Y_t^c remains constant, the absolute amplitude of the business cycle fluctuations in real GDP will rise in proportion to the trend level of output so that the *percentage* deviations of actual output from trend output over the business cycle will tend to stay constant over time.

It will be convenient to work with the natural logarithms of the various variables rather than with the variables themselves, because changes in the log of some variable X can be interpreted as percentage changes in X. Taking logs on both sides of equation (1) and defining $y_t \equiv \ln Y_t$, $g_t \equiv \ln Y_t^g$, and $c_t \equiv \ln Y_t^c$, we get

$$y_t = g_t + c_t \tag{2}$$

In this section we will discuss how we can measure the trend component (growth component) g_t and the cyclical component c_t separately, given that we only have observations of y_t. Let us start by going back to Figure 15.1. The straight line in that figure is a regression line with a slope equal to the average growth rate over the period of observation.

Technically, the intercept and the slope of the regression line are chosen so as to minimize the sum of the squared deviations between the observed values of the log of GDP and the points on the line.

It might be tempting to let the straight regression line represent the trend value of output and to measure the cyclical component of GDP as the deviation from that hypothetical steady growth path. But a moment's reflection should convince you that this is not a satisfactory procedure. Recall that along the straight regression line the economy's real growth rate is constant. If we take the regression line to represent the trend growth path, we are therefore postulating that the economy would always be in a steady state equilibrium with a constant growth rate if it were not disturbed by business fluctuations. However, the theory of economic growth gives no reason to believe that the economy is always in a steady state. Conventional growth theory tells us that the economy's growth rate will decline over time if it starts out with a capital-labour ratio below the steady-state level, and vice versa. Moreover, the modern theory of endogenous growth suggests that the rate of technical progress may vary with the endogenous innovation activity of firms. Indeed, even if major technological innovations are exogenous to the economic system, they are unlikely to arrive at an equal pace over time, and this is sufficient reason to discard the assumption of a constant long term growth rate. A mere inspection of Figure 15.1 also suggests that the longer term movement of the economy does not follow a straight line, even if we abstract from the short-term ups and downs of the graph for real GDP.

Hence we need a more sophisticated method for separating the growth trend from the cyclical component of a variable like GDP. Since we do not perfectly understand how the economy works, we cannot claim that there is a single objectively 'correct' way of separating c_t from g_t. Still, our reasoning above suggests that we need a method which allows for variation over time in the underlying growth trend, but which nevertheless ensures that the short term fluctuations are categorized as temporary cyclical deviations from trend. One such method which has become widely used in recent years is the so-called *Hodrick-Prescott filter*, named after American economists Robert Hodrick and Edward Prescott who popularized its use[4]. Under this method of 'filtering' (that is, detrending) an economic time series like a series $(y_t)_{t=1}^{T}$ for the log of GDP, the growth component g_t is determined by minimizing the magnitude

$$HP = \sum_{t=1}^{T} \Bigg(\overbrace{y_t - g_t}^{c_t} \Bigg)^2 + \lambda \sum_{t=2}^{T-1} \left[\overbrace{(g_{t+1} - g_t) - (g_t - g_{t-1})}^{\substack{\text{change in trend growth rate} \\ \text{from period } t \text{ to period } t+1}} \right]^2 \tag{3}$$

with respect to all of the g_t, where observations are available for the time periods $t = 1, 2, ..., T$, and where λ is a parameter which is chosen by the observer. Note that since y_t and g_t are measured in logarithms, the magnitudes $g_{t+1} - g_t$ and $g_t - g_{t-1}$ are approximately the *percentage growth rates* of the trend value of real GDP in periods $t + 1$ and t, respectively. The term in the square bracket in (3) thus measures the change in the estimated trend growth rate from one period to the next. Note also that, by definition, the term $y_t - g_t$ in (3) measures the cyclical component c_t of log(GDP) in period t. Minimizing the expression in (3) therefore forces us to compromise between two objectives. On the one hand we want to choose the g_t's so as to minimize changes in the estimated trend growth rate over time, since this will minimize the expression in the second term in (3). On the other hand we want to bring g_t as close as possible to (the log of) actual output y_t so as to minimize the first sum in (3). The relative weight placed on each of these conflicting objectives depends on our choice of λ. Consider first the extreme case where we set $\lambda = 0$. In this special case we will obviously minimize HP by simply choosing $g_t = y_t$ for all $t = 1, 2, ..., T$, since HP will then attain its lowest possible value of zero. But this amounts to postulating that all observed fluctuations in y_t reflect changes in the underlying

[4]Robert J. Hodrick and Edward C. Prescott, "Postwar U.S. Business Cycles: An Empirical Investigation", Journal of Money, Credit, and Banking, 1997 (originally published as a working paper in 1980).

growth trend! This obviously does not make sense, unless we want to deny the existence of business fluctuations. Consider next the opposite extreme where we let λ tend to infinity. In that case the first sum in (3) does not carry any weight, and HP will then attain its lowest possible value of zero if we choose the g_t's to ensure that the estimated trend growth rate is *constant* throughout the period of observation, that is $g_{t+1} - g_t = g_t - g_{t-1}$ for all $t = 2, 3, ..., T-1$. This would give us the straight line in Figure 15.1, but we have already seen that it is unreasonable to assume that the trend growth rate is a constant.

Clearly, then, λ should be positive but finite. The greater the value of λ, the more we will try to avoid variation over time in the estimated trend growth rate, that is, the smoother will be our estimated growth trend (the closer it will be to a straight line). On the other hand, the smaller the value of λ, the smaller will be the deviation between our estimated g_t and the actual value of output y_t, that is, the greater is that part of the movement in actual output which we ascribe to changes in the underlying growth trend.

Among business cycle researchers using quarterly data it is customary to set $\lambda = 1600$. This is basically a convention, based on a concensus that this value of λ produces a fitted growth trend which a 'reasonable' student of business cycles would draw through a time plot of quarterly data for (the log of) real GDP. Figure 15.3 shows the fitted growth trend for Denmark over the last 30 years when the trend is estimated via the HP filter using $\lambda = 1600$. We see that the HP filter does indeed seem to capture the gradual changes in the growth trend which are apparent to the naked eye.

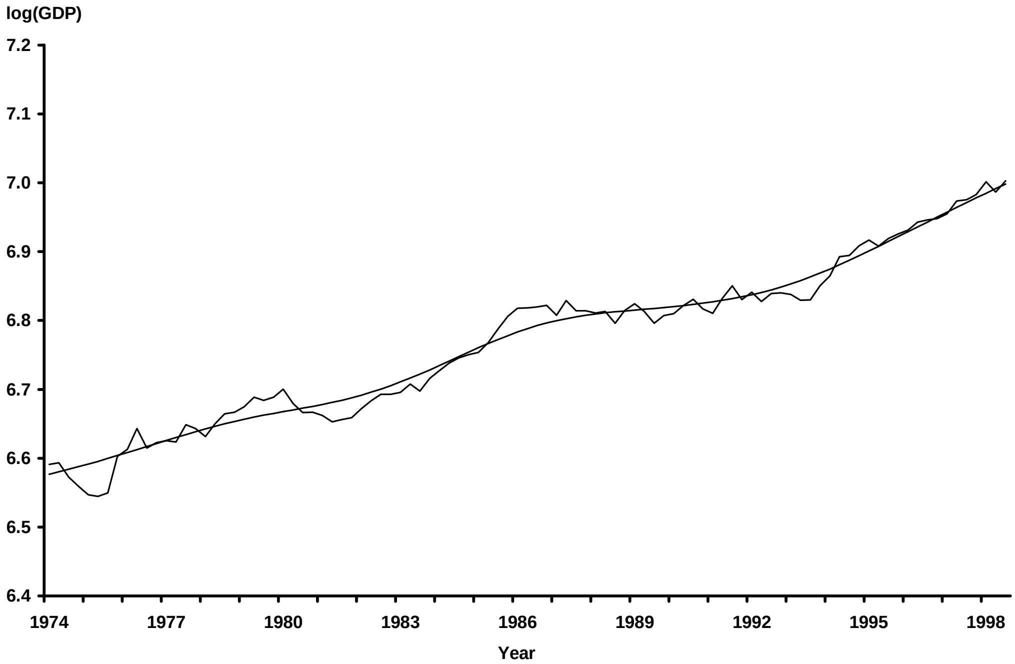

Figure 15.3: Danish GDP and HP-trend

Note: 24 observations excluded due to HP-filtering.

Source: MONA database, Danmarks Nationalbank.

Once we have fitted a growth trend using the HP filter, we immediately obtain an estimate of the cyclical component of the (log of) quarterly real GDP by rearranging equation (2) to get $c_t = y_t - g_t$. In Figure 15.4 we have plotted the resulting estimates of Danish business cycles, that is, the values of all the c_t's. The graph confirms what we have already emphasized: periods of expansion and periods of contraction tend to alternate, but the business cycles are far from periodic and regular, and even within each longer cycle there are erratic quarterly fluctuations in activity.

It is tempting to offer a dating of recent Danish business cycles based on Figure 15.4, for although business cycles involve the comovement of many economic variables (as we shall see in the next section), GDP is after all the most common single indicator of aggregate economic activity. In Figure 15.4 we have indicated six full business cycles, measured from trough to trough. The identification of business cycle troughs and peaks is based on the following simple rules of thumb[5]: 1. A trough must be followed by a peak, and a peak must be followed by a trough. 2. The expansion phase as well as the contraction phase must last for a minimum of two quarters, and 3. A business cycle must span a minimum of five quarters. If the first criterion is not met, it does not make sense to speak of a 'cycle'. The second criterion implies that we require a minimum degree of persistence in the movement of economic activity before we can speak of a systematic tendency for activity to expand or contract. The last criterion reflects the convention that fluctuations spanning only a year or less do not count as business cycles.

We see from Figure 15.4 that the Danish economy experienced serious contractions in 1974-75, in 1981-82, and 1992-93, and strong upswings in 1976, 1979, 1985-86, and 1994-95. In Exercise 2 we test your knowledge of recent economic history by asking you to mention some factors or 'shocks' which might help explain these changes in economic activity.

[5]The computer algorithm used to date the Danish business cycles was developed and kindly provided by Jesper Linaa.

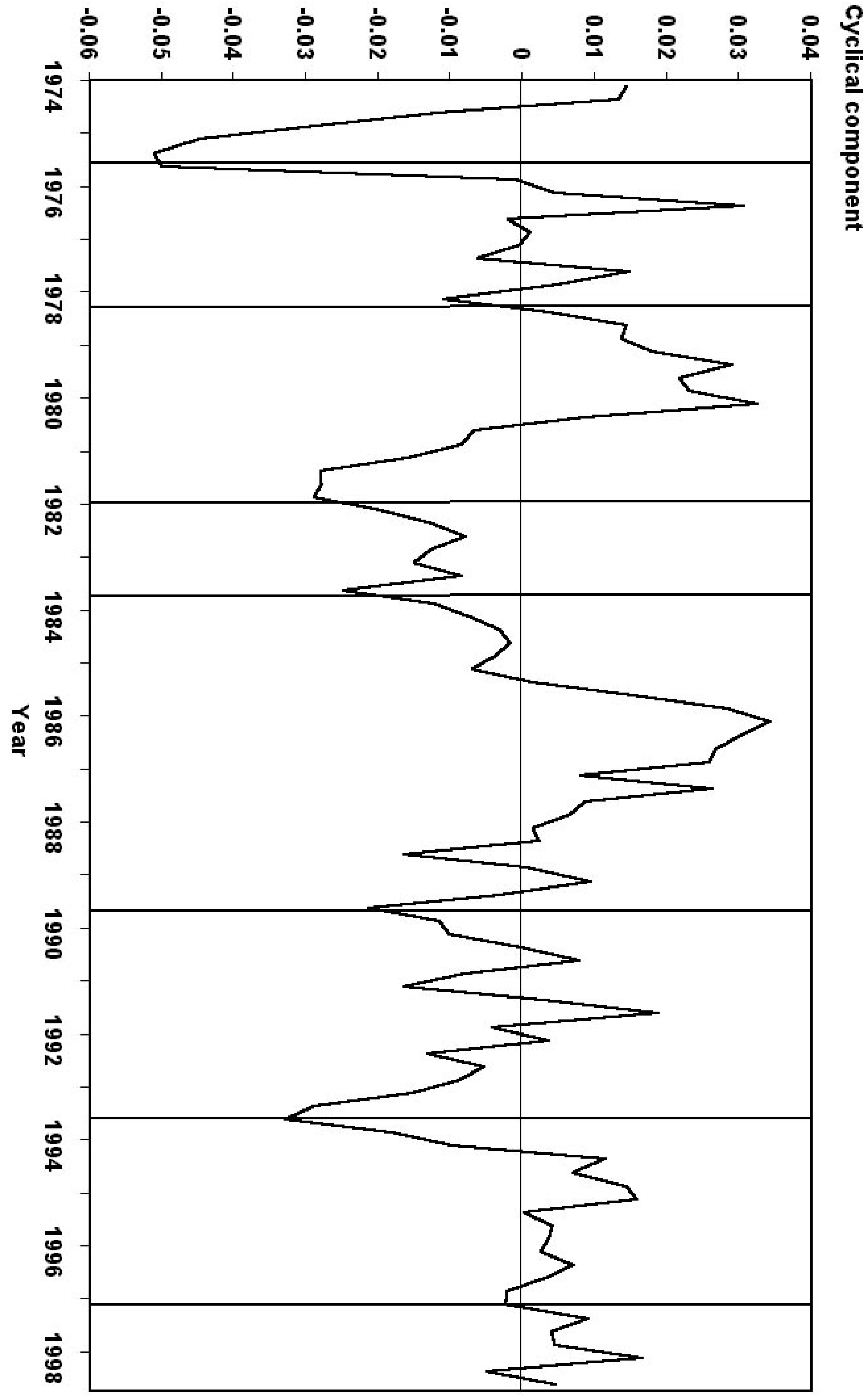

Figure 15.4: Danish business cycles, 1974–1998

Source: MONA database, Danmarks Nationalbank.

4 What happens during business cycles?

The HP filter is a useful method of eliminating the growth trend and isolating the cyclical component of an economic time series. In this section we will study the statistical properties of the estimated cyclical components of a number of time series from the Danish economy. By doing so we will get more information on what happens during business cycles.

The basis for our study is a set of seasonally adjusted quarterly data for the Danish economy covering the 30-year period from 1971 to 2001[6]. The data set includes the series for real GDP which we have already considered. The components of national income and product are measured in 1995 prices, and variables displaying a growing time trend have been transformed into logarithms and detrended by means of the HP filter.

Volatility

The first question we will ask is: what is the magnitude of the variability in different economic variables during a 'typical' business cycle? We may quantify this variability by calculating the *standard deviations* of the estimated cyclical components of the various time series. The empirical standard deviation s_x of a series of observations of variable x over the time interval $t = 1, 2, ..., T$ is defined as

$$s_x = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(x_t - \overline{x})^2}, \qquad \overline{x} \equiv \frac{1}{T}\sum_{t=1}^{T} x_t \tag{4}$$

where $\overline{x}$ is the empirical mean value of the x_t's. The empirical standard deviation measures the 'average' deviation of x_t from its mean over the period of observation. It is thus a natural indicator of the degree of *volatility* of the economic variable x_t.

[6]The data were taken from the MONA database which was kindly made available to us by Danmarks Nationalbank.

	Average share in GDP	Absolute standard deviation (%)	Relative standard deviation[1]
GDP	100%	1.73	1.00
Private consumption	51%	2.25	1.30
Private investment:	18%	10.09	5.83
- Fixed business investment	12%	8.22	4.75
- Residential investment	5%	9.52	5.50
Public consumption	26%	1.21	0.70
Public investment	2%	8.16	4.72
Exports	31%	2.61	1.51
Imports	28%	4.69	2.71
Aggregate employment		0.82	0.47
Real product wage[2]		1.56	0.90
Labor productivity[3]		1.52	0.88
Long-term real interest rate[4]		1.09	0.63

Table 15.2: Volatility in the Danish economy, 1974-1998

[1] Standard deviation relative to standard deviation of GDP.
[2] Average nominal wage deflated by GDP-deflator.
[3] Output per hour worked, manufacturing sector.
[4] Nominal interest rate minus 4-quarter moving average of the rate of consumer price inflation.

Note: Based on quarterly data from 1971q1 to 2001q3. 24 observations excluded due to detrending.

Source: MONA database, Danmarks Nationalbank. Long-term interest rate from Datastream. Own calculations.

In the second column of Table 15.2 we use the absolute standard deviation as a measure of the volatility of the cyclical components of some important economic variables. Recall that when variables are measured in logarithms, the absolute standard deviation of some variable $x \equiv \ln X$ roughly indicates the average *percentage* deviation of X from its mean. For example, the first figure in the second column indicates that, on average over the Danish business cycle, the cyclical component of real quarterly GDP deviates about 1.7 percent from its mean value.

In the third column in Table 15.2 we have measured the standard deviations of the various variables relative to the standard deviation of GDP. A figure in excess of (smaller than) 1 therefore means that the variable we consider tends to be more (less) volatile than GDP. One striking feature of Table 15.2 is that investment is about five to six times more volatile than GDP. On the other hand, employment fluctuates considerably less than GDP, as does public consumption. Private consumption is seen to be somewhat more volatile than total output. In this respect the Danish economy differs from the U.S. economy where private consumption has been found to be *less* volatile than GDP. Perhaps this difference reflects that the Danish economy is much more open and hence relies a lot more on imports than the American economy. Consequently, when private consumption changes, most of this change in demand will have to be accommodated by changes in domestic output in the U.S. economy, whereas a large part of the fluctuations in private consumption will be absorbed by changes in imports in the highly open Danish economy. This interpretation is consistent with the fact that Danish imports are quite volatile according to Table 15.2.

The main messages from Table 15.2 may be summarized as two stylized facts regarding business cycles.

Stylized Business Cycle Fact #1: *Investment is a lot more volatile over the business cycle than GDP.*

Stylized Business Cycle Fact #2: *Employment is considerably less volatile over the business cycle than GDP.*

Correlation, leads and lags

Table 15.2 tells us how much different variables fluctuate relative to the fluctuations in GDP. But we are also interested in studying whether and to what extent the cyclical component x_t of some economic variable moves in the same direction as or opposite to the cyclical component of real GDP (c_t). For this purpose we introduce the empirical *covariance* between x and c (s_{xc}), defined as

$$s_{xc} = \frac{1}{T-1}\sum_{t=1}^{T}\left(x_t - \overline{x}\right)\left(c_t - \overline{c}\right), \qquad \overline{c} \equiv \frac{1}{T}\sum_{t=1}^{T} c_t \tag{5}$$

where $\overline{c}$ is of course the mean value of the c_t's. The covariance measures the degree to which x and c move together, but its magnitude will depend on our choice of the units in which we measure x and c. To obtain an indicator which is independent of the choice of units, it is preferable to normalize the observations of $x_t - \overline{x}$ and $c_t - \overline{c}$ by the respective standard deviations s_x and s_c and to study the covariance of the normalized deviations $(x_t - \overline{x})/s_x$ and $(c_t - \overline{c})/s_c$. Following this procedure, we obtain the *coefficient of correlation* between x and c, which we have already encountered in Chapter 12, and which is defined as

$$\rho(x_t, c_t) = \frac{s_{xc}}{s_x s_c} = \frac{\sum_{t=1}^{T} (x_t - \overline{x})(c_t - \overline{c})}{\sqrt{\sum_{t=1}^{T} (x_t - \overline{x})^2} \cdot \sqrt{\sum_{t=1}^{T} (c_t - \overline{c})^2}} \tag{6}$$

It can be shown that the coefficient of correlation will always assume a value somewhere in the interval from minus one to plus one. If $\rho(x_t, c_t)$ is equal to one we say that x_t and c_t are perfectly positively correlated, and if $\rho(x_t, c_t)$ equals minus one we say that the two variables are perfectly negatively correlated. In both cases there is a strict linear relationship between the two variables. If $\rho(x_t, c_t)$ is positive but less than one, x and c will tend to move in the same direction, with the comovement being more systematic the smaller the deviation of $\rho(x_t, c_t)$ from one. On the other hand, a negative value of $\rho(x_t, c_t)$ indicates that the two variables tend to move in opposite directions. Clearly, if $\rho(x_t, c_t)$ is (close to) zero, there is no systematic relationship between x and c.

In the present context where c_t represents the cyclical component of real GDP, we say that x varies *procyclically* when $\rho(x_t, c_t)$ is substantially greater than zero, since the positive correlation indicates that x tends to rise and fall with GDP. By analogy, if $\rho(x_t, c_t)$ is negative, we say that x moves in a *countercyclical* fashion because x tends to move in the opposite direction of GDP.

As already noted, the comovements of the different economic variables are not always synchronized over the business cycle: some variables may reach their turning point before others do. To investigate whether a variable x moves out of sync with real GDP, we may measure the coefficient of correlation $\rho(x_{t-n}, c_t)$ between c_t and the value of x observed n periods earlier (x_{t-n}), and the correlation coefficient $\rho(x_{t+n}, c_t)$ between c_t and the value of x observed n periods later (x_{t+n}). If $\rho(x_{t-n}, c_t)$ is significantly different from zero and numerically greater than $\rho(x_t, c_t)$, we say that x is a *leading indicator*, because a change in x observed n periods earlier tends to be associated with a change in GDP in the current period. In other words, movements in x tend to *lead* movements in aggregate output, so a turnaround in x indicates a later turnaround in c. Similarly, we say that x is a *lagging variable* if $\rho(x_{t+n}, c_t)$ is significantly different from zero and numerically greater than $\rho(x_t, c_t)$, since this is an indication that x tends to reach its peaks and troughs later than c.

In Table 15.3 we show coefficients of correlation with GDP, including leads and lags. The middle column numbered '0' shows the value of $\rho(x_t, c_t)$, where x_t is the relevant variable indicated in the left part of the table. The first two columns show correlations between current GDP (c_t) and x_{t-2} and x_{t-1}, respectively, whereas the last two columns show correlations between y_t and x_{t+1} and x_{t+2}, respectively. Recall that the length of a time period is one quarter. From the second row of Table 15.3 we therefore infer that the coefficient of correlation between current GDP and private consumption two quarters earlier is 0.59, whereas the correlation between current GDP and private consumption one quarter later is 0.47.

X_t (Real variables)	Coefficient of correlation between GDP and X_t — Quarterly leads and lags: -2	-1	0	1	2
GDP	0.51	0.73	1.00	0.73	0.51
Private consumption	0.59	0.74	0.76	0.47	0.30
Private investment	0.46	0.64	0.85	0.70	0.44
- Fixed business inv.	0.40	0.61	0.75	0.64	0.51
- Residential inv.	0.52	0.66	0.72	0.66	0.57
Public consumption	-0.01	0.10	0.23	0.26	0.26
Public investment	0.26	0.34	0.40	0.41	0.40
Exports	-0.14	-0.11	0.06	-0.06	-0.03
Imports	0.52	0.67	0.72	0.51	0.26
Aggregate employment	0.38	0.58	0.73	0.75	0.68
Real product wage	-0.24	-0.18	-0.03	0.12	0.24
Labor productivity	0.06	0.14	0.49	0.14	-0.05
Long-term real interest rate	-0.15	-0.13	0.07	0.27	0.30
X_t (Nominal variables)					
Domestic inflation rate[1]	-0.30	-0.20	-0.22	-0.12	-0.05
Short-term nominal interest rate	-0.42	-0.35	-0.29	-0.16	-0.07
Long-term nominal interest rate	-0.43	-0.32	-0.12	0.03	0.09

Table 15.3: Leads and lags in the Danish business cycle, 1974-1998

[1] Rate of inflation of domestic producer prices.

Note: Based on quarterly data from 1971q1 to 2001q3. 24 observations excluded due to detrending.

Source: MONA database, Danmarks Nationalbank. Interest rates from Datastream. Own calculations.

Table 15.3 shows that whereas exports seem to be more or less uncorrelated with GDP, private consumption, private investment and imports are all *procyclical*, displaying a clear positive correlation with aggregate output. In particular, we see that private investment is strongly correlated with contemporaneous GDP. It is also interesting to note that public consumption and investment reveal some positive correlation with contemporaneous output. This suggests that these publicly controlled demand components have not helped to stabilize aggregate demand (in which case they should have moved countercyclically) but may in fact have tended to amplify Danish business fluctuations. The fact that exports are so weakly correlated with GDP suggests that this component of demand has not been a driving force behind Danish business cycles.

Not surprisingly, we see that employment varies procyclically, since an increase in output requires an increase in labour input. We also see that employment is a *lagging variable*, since it is more stongly correlated with the GDP of the previous quarter than with contemporaneous GDP.

Whereas employment displays a strong positive correlation with output, the correlation between real wages and real GDP is seen to be much weaker and less systematic. Average labour productivity (output per working hour) is seen to be positively correlated with contemporaneous GDP, suggesting that workers tend to work harder when the demand for output is high. The long term real interest rate - defined as the nominal interest rate minus the rate of inflation - shows little correlation with contemporaneous GDP but tends to go up after output has peaked.

All the variables discussed so far have been defined in real terms. The bottom part of Table 15.3 shows the correlation between real output and some important *nominal* variables. Movements in the domestic inflation rate have on average been countercyclical and have shown a slight tendency to lead movements in output. As we shall see in Chapter 19, this suggests that the Danish business cycle has been driven mainly by shocks to the economy's supply side in the period 1974-1998. The two bottom rows reveal that nominal interest rates are also countercyclical and that they are leading indicators. In other words, business cycle peaks have been preceded by drops in nominal interest rates, just as inflation has tended to fall prior to business cycle expansions. In Chapter 19 we shall see that there are good reasons to expect inflation and nominal interest rates to move in the same direction, as they seem to do in Table 15.3.

Let us sum up the main lessons from Table 15.3.

Stylized Business Cycle Fact #3: *Private consumption and particularly private* *investment are strongly positively correlated with GDP.*

Stylized Business Cycle Fact #4: *Employment is procyclical and more strongly correlated with GDP than real wages and labour productivity.*

Stylized Business Cycle Fact #5: *Nominal variables like inflation and nominal interest rates have tended to move countercyclically in Denmark.*

Stylized Business Cycle Fact #6: *Employment is a lagging variable whereas inflation and nominal interest rates have been leading indicators in Denmark.*

Persistence

Another interesting property of an economic variable is its degree of *persistence*. As you recall, one characteristic of business cycles is that, once the economy moves into an expansion or a contraction, it tends to stay there for a while. Persistence in some variable x means that the observed value of x in period t (x_t) is not independent of the value of x in some previous period $t-n$ (x_{t-n}), where $n \geq 1$. In other words, if x assumed a high (low) value in previous period $t-n$, there is a greater chance that it will also assume a high (low) value in the current period t. We can measure such persistence in a time series $(x_t)_{t=1}^{T}$ by calculating the coefficient of correlation between x_t and its own lagged value x_{t-n}, for $n = 1, 2, ...$ This particular correlation coefficient $\rho(x_t, x_{t-n})$ is called the *coefficient of autocorrelation* and was already introduced in Chapter 12. If $\rho(x_t, x_{t-n})$ is significantly above zero for several positive values of n, there is a high degree of persistence: once x has been pushed above or below its mean value, it tends to continue to be above or below its mean for a long time.

	Autocorrelation[1]			
	1-quarter lag	2-quarter lag	3-quarter lag	4-quarter lag
Real variables				
GDP	0.73	0.51	0.28	0.11
Private consumption	0.61	0.46	0.30	0.12
Private investment:	0.65	0.46	0.24	0.07
- Fixed business investment	0.63	0.44	0.26	0.03
- Residential investment	0.88	0.73	0.55	0.38
Public consumption	0.78	0.57	0.38	0.23
Public investment	0.68	0.54	0.38	0.33
Exports	0.48	0.40	0.15	-0.03
Imports	0.70	0.36	0.00	-0.28
Aggregate employment	0.88	0.71	0.53	0.39
Real product wage	0.65	0.50	0.36	0.23
Labor productivity	0.23	0.03	-0.04	0.00
Long-term real interest rate	0.66	0.23	-0.03	-0.17
Nominal variables				
Domestic inflation rate	-0.25	0.26	-0.04	-0.01
Short-term nominal interest rate	0.51	0.12	-0.02	-0.23
Long-term nominal interest rate	0.79	0.47	0.13	-0.15

Table 15.4: Persistence of business fluctuations in Denmark, 1974-1998

[1] Coefficient of autocorrelation

Note: Based on quarterly data from 1971q1 to 2001q3. 24 observations excluded due to detrending.

Source: MONA database, Danmarks Nationalbank. Interest rates from Datastream. Own calculations.

Table 15.4 measures the persistence of business fluctuations in Denmark by the coefficients of autocorrelation. The first figure in the first column (0.73) means that if (the log of) real GDP goes up by one unit in the current quarter, then on average 0.73 units of that increase will remain in the next quarter if the economy is not exposed to new shocks. We see from Table 15.4 that there is considerable persistence in the movements of GDP, but the most persistent variables are employment, residential investment, and real product wages. The high persistence of employment may reflect that firms are reluctant to hire and fire workers because hiring and firing is costly. The fact that spending on residential investment is so persistent is not surprising, given that the construction of new housing is a time-consuming process.

To sum up, we have

Stylized Business Cycle Fact #7: *There is considerable persistence in GDP.*

Stylized Business Cycle Fact #8: *Employment and residential investment are even more persistent than GDP.*

5 Where do we go from here?

We have now described some facts about business cycles. In the rest of our macro course our main goal will be to construct an economic model which may explain short-run fluctuations in aggregate output, employment and inflation. Specifically, we will gradually build up a model which may be summarized in the manner depicted in Figure 15.5 where real output and the rate of inflation are determined by the intersection of an upward-sloping aggregate supply curve and a downward-sloping aggregate demand curve. We will then use this model to study how the economy reacts over time to various shocks to the aggregate supply curve and the aggregate demand curve.

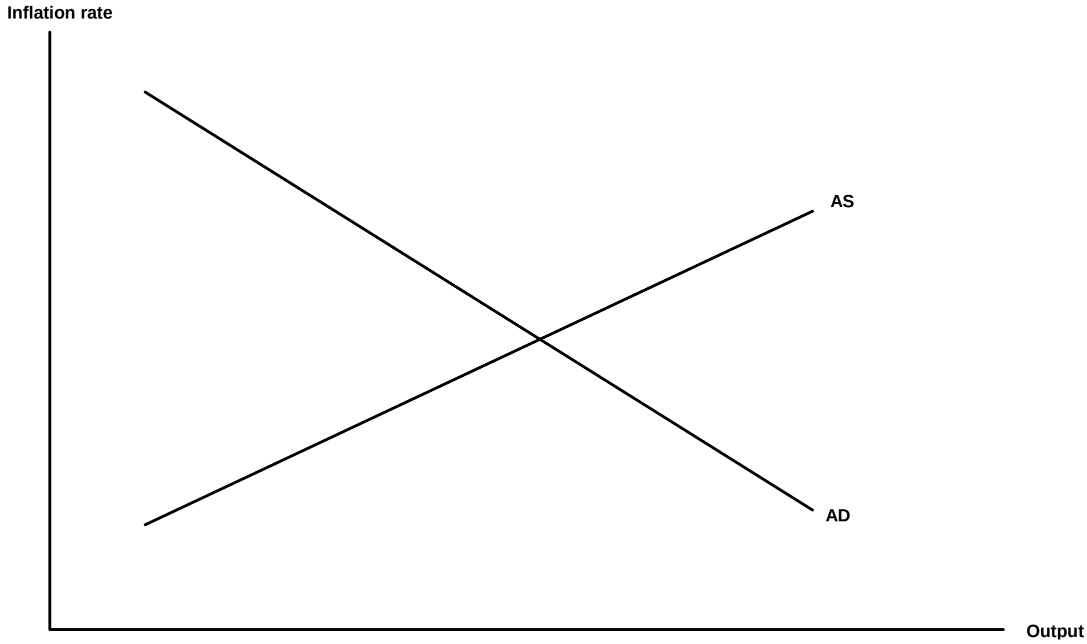

Figure 15.5: Aggregate supply and aggregate demand

Our goal is to construct a model in which the effects of aggregate demand and supply shocks tend to *persist* over time through so-called *propagation mechanisms* arising from the links between central macroeconomic variables. In this view of the world business cycles are *initiated* by random shocks to the economy such as an unanticipated change in the oil price or a change in business confidence due, say, to unexpected political events. However, the *cumulative and systematic* character of business fluctuations documented in this chapter will be explained endogenously by the properties of our macroeconomic model. We hasten to add that we cannot promise to explain all features of business cycles - economists are still far from having a perfect understanding of this complex phenomenon - but our model economy will at least have the property that random shocks tend to generate irregular cycles displaying a certain persistence.

As indicated in Figure 15.5, the aggregate demand curve and the aggregate supply curve are the central building blocks of our model. To construct the aggregate demand curve we must build a theory of private investment and private consumption. This is our agenda for Chapters 16 and 17. In Chapter 18 we study the relation between inflation and unemployment as a basis for deriving the aggregate supply curve. To complete the construction of our model, we also need to consider the conduct of monetary policy. This is done in Chapter 19 which also sets up our basic model of aggregate supply and aggregate demand for the closed economy. In Chapter 20 we extend the model to cover the case of an open economy with fixed exchange rates, and in Chapter 21 we focus on the open economy with flexible exchange rates. Our final Chapter 22 returns to the closed economy and considers how the reaction of the economy to macroeconomic stabilization policy depends on the way in which private sector expectations are formed.

6 Exercises

Exercise 15.1. In Table 15.1 of this chapter we summarized the NBER datings of U.S. business cycles. In an NBER Working Paper (no. 6692, August 1998) entitled "The Causes of American Business Cycles: An Essay in Economic Historiography", economic historian Peter Temin attempts to explain the turning points in this chronology of U.S. business cycles by identifying various demand and supply shocks to the U.S. economy. Get hold of Peter Temin's NBER Working Paper and use his study along with your knowledge of the basic AS-AD model from introductory macro to offer an explanation of the most spectacular turning points of the U.S. business cycle in the 20th century.

Exercise 15.2. Figure 15.4 of this chapter provides a dating of business cycles in the Danish economy from the early 1970s to the late 1990s. Examine recent Danish economic history to identify some of the shocks which may explain the turning points in the Danish business cycles (you may find the relevant information in the various OECD Economic Surveys of Denmark). For example, what caused the contractions of 1974-75, 1981-82, and 1992-93? How would you explain the strong expansion in 1984-86 and the subsequent turning point in 1986, and what caused the expansion after 1993? In providing your answers, you may want to draw on the basic AS-AD model from introductory macro.