University of Connecticut
College of Arts and Sciences
Department of Economics
Christian Zimmermann

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ECON 219 Supplementary notes for Chapter 3

"Business Cycle Measurement"

These notes are to supplement the book in the following respect:

1. More complete description of what a business cycle is.
2. Overview of statistical methods.
3. More on stylized facts, in particular their robustness.

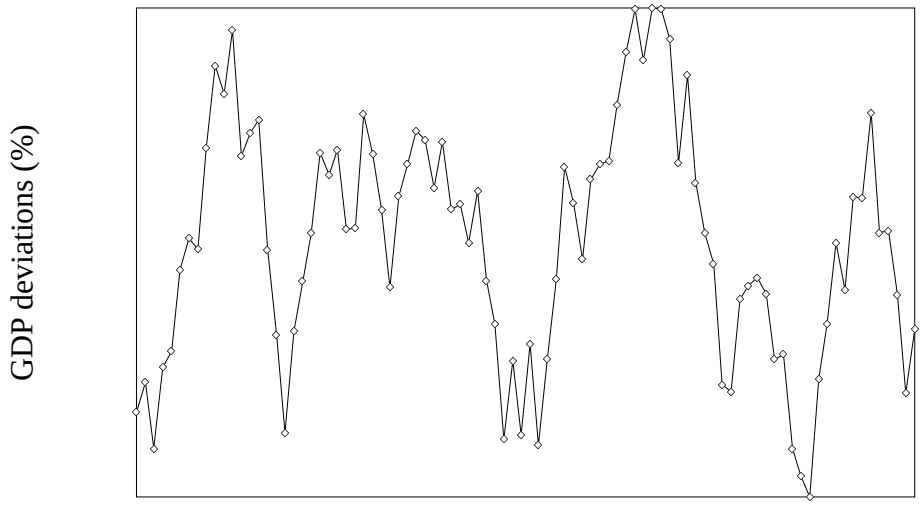
If you notice any errors, omissions or typos, or if you have any other comments about these notes, please relay them to me so that I can improve upon them for future generations.

1 What is a business cycle?

There are many cycles: a pendulum swings, air vibrates to create a sound, economic activity fluctuates, etc. We need to find what are the distinguishing characteristics of the business cycle so that when presented with several types of cycles we could recognize it. As we will see, this is essentially a matter of definition, and as long as everyone agrees on the definition. As with all cycles, we will look at the frequency and the amplitude of the business cycle, as well as some other characteristics.

Let us first look at what GDP looks like. Indeed, this is the macroeconomic aggregate most closely associated with the business cycle. The standard practice, when considering business cycles, is to discard long term trends, thus keeping only the fluctuations around the trend: **cyclical components** or **deviations** from trend. We will see later how to do this. Figure 1 shows a hypothetical series of

Figure 1: A hypothetical series of cyclical components

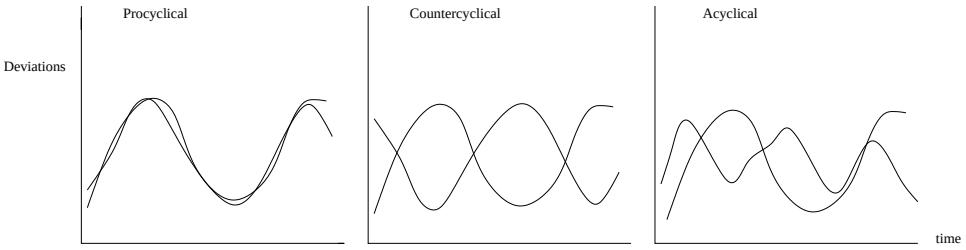


cyclical components that has been computed by assuming that it has the same statistical properties as real data.

As can easily be seen, it does not resemble any graph of a cycle we may remember from physics. Still, economists recognize this as a business cycle. How? First, they recognize that business cycles are comprised of a succession of **peaks** and **troughs**, and the time from peaks to peaks can be anywhere between two and eight years. Let us emphasize that this flexible span is a matter of definition. One could decide that a business cycle last from one to four years, and this would mean we have to change some statistical tools. Second, business cycles are bumpy, that is there is no smooth ride from peak to trough to peak. There may even be a double peak or a double trough.

Try to identify the peaks and troughs in the graph. You will find it difficult in some cases. Economists need some rather complex statistical standards to figure them out. Thus it is only lately that consequent analysis of the business cycle has appeared, with the work of Burns and Mitchell at the National Bureau of Economic Research (NBER, 1946). This work is still pursued by the NBER by publishing "official" dates for US recessions and expansions. Note that this is not entirely based on the analysis of the GDP, but also what is happening in various sectors of the economy as well as to employment.

Figure 2: Business cycle comovements



Now, let us refine some definitions of the business cycle. A trough is the lowest value of the cyclical components within a specific time window (two to eight years), a peak is the largest value with such a time window. A **contraction** is whenever GDP increases at a lower rate than average, in other words when its cyclical components decrease. Thus, we can have a contraction even when GDP increases. A **recovery** happens when GDP increases more than average, or when its cyclical components increase. The **amplitude** of the business is measured by the vertical distance of cyclical components between trough and peak. Generally, we say there is a **recession** when there is a contraction two quarters in a row. This definition is, however, subject to many qualifications, as the NBER dates can show.

Indeed, we do not just want to look at GDP. It turns out that several other series have some peculiar properties in relation with GDP: their cyclical components tend to move in a particular fashion, loosely synchronized with GDP. We call these properties **comovements**, and they can be classified in the following way (see Figure 2):

- **procyclical** comovement: the series move in the same direction as GDP (here we abuse some language, as we really mean the cyclical components of each series);
- **acyclical** comovement: there is no discernible relationship between their movements;
- **countercyclical** or **anticyclical** comovement: the series move in opposite directions.

Usually this is done by comparing GDP with another series, i.e. we may say that consumption is procyclical, meaning that the cyclical components of consumption and GDP usually move in the same direction. For a visual recognition

Figure 3: Business cycle comovements

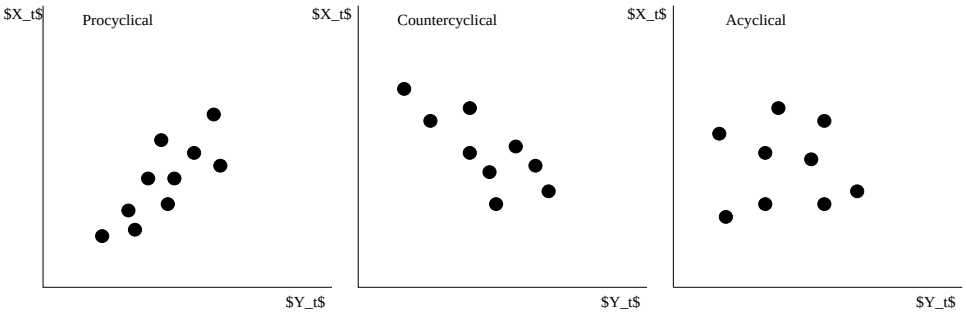
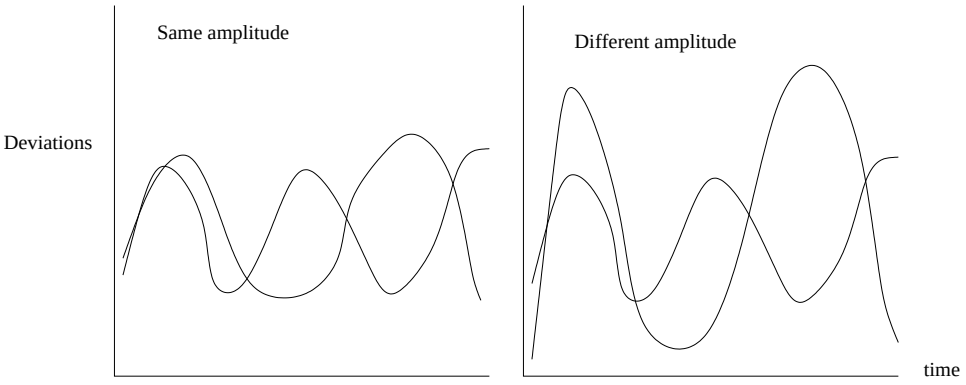


Figure 4: Business cycle amplitudes



of comovements, it is sometimes easier to work with a **scatter plot**: instead of graphing two series against time, we graph them against each other, as in Figure 3. The examples show how comovements may appear.

Not all aggregates fluctuate with the same amplitude, that is some fluctuate more than others. Usually we compare the amplitude of a series with that of GDP. Figure 4 provides some examples.

We already mentioned that we define the length of the business cycle to be between two and eight years. They can on average be close to two years or close to eight years. In the first case, we say the business cycle has high **frequency** or low **persistence**. Examples are in Figure 5.

Finally, economists care in which way economic aggregates are synchronized, in particular with respect to GDP. Figure 6 provides examples of a series **leading** or **lagging** another one.

Figure 5: Business cycle frequencies

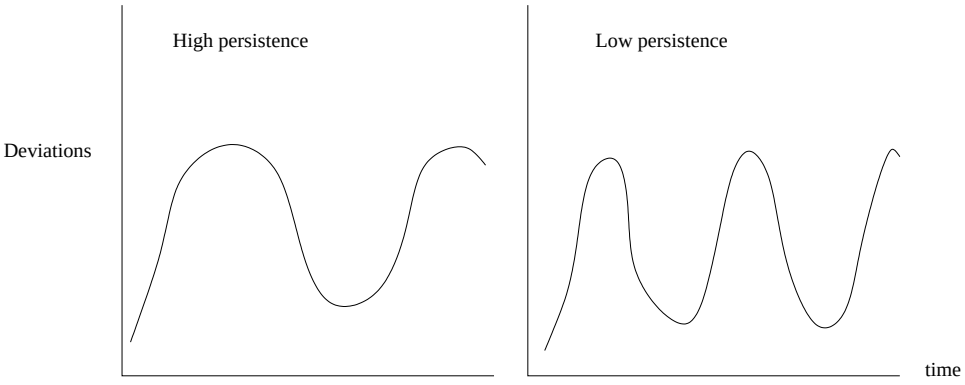
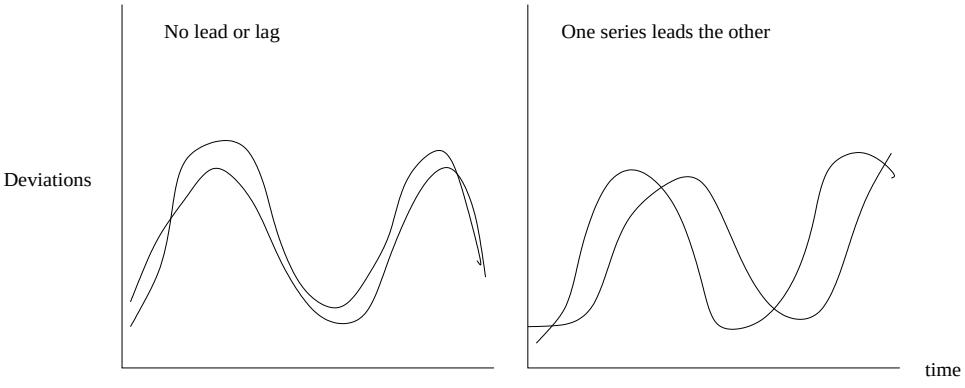


Figure 6: Leads and lags in business cycles



2 Statistical tools

The figures shown so far are examples drawn to determine easily the characteristics of economic aggregate. Unfortunately, real data does not cooperate that well. Indeed, when we look at Figures 2-6, we subconciously looked at the **turning points** (peaks and troughs) and compared them across series: how far apart they are, how frequently they occur, how they coordinate through time. In real data, finding turning points can be quite tricky. For example, try to determine them in Figure 1. We therefore need some more precise tools that help us in determining the characteristics of the business cycle: statistics. This is a research field in itself, but we can go a long way with some relatively simple tools: standard deviations and correlations.

The **standard deviation** measures the volatility of a series. Technically, it measures how much the series deviates from its average value. A series with a high standard deviation is very volatile. Note that a standard deviation is measured in the same units as the measured aggregates ($, '000$, etc.).

The **correlation** measures the comovement of two series. It is valued between 1 and -1, 1 meaning a perfect synchronization, and 0 none. Thus, a correlation close to 1 between GDP and another aggregate means the latter is procyclical, if the correlation is close to -1, the aggregate would be countercyclical, and if the correlation is close to 0, the aggregate is acyclical. Usually, the threshold between pro- and acyclical is set a 0.30, while it is -0.30 between counter- and acyclical. Note that a correlation of 1 does not imply the two series are equivalent as they may have a different standard deviation. Technically, a correlation measures something like a propensity for a series to move above (below) its average value when the other is above (below) its average value.

With these two statistics, we have the necessary tools to look at all the business cycle characteristics we mentioned before:

- Comovement: As mentioned above, we measure comovement with correlations, usually with GDP. But some other comovements may be of interest as well.

- Amplitude: A standard deviation does not mean much by itself. This is why we usually compare the standard deviation of a series with that of GDP to see which aggregates are more volatile than GDP.

- Persistence (frequency): One way to measure persistence is to correlate a series with itself, but delayed one period. That is, we would compare GDP

with GDP a year ago. For example, a correlation would be computed using the following pairs: (GDP_{1980}, GDP_{1979}), (GDP_{1981}, GDP_{1980}), (GDP_{1982}, GDP_{1981}), etc. We call this **autocorrelation** of order 1.

- Leads and lags: To determine whether there are leads or lags between two series, we start by computing their correlation. Then we delay or advance one of the series one or more times (like we did for persistence) to see which correlation is highest. If, for example, it turns out that the correlation between X_t and Y_{t-2} is the highest, we say Y_t leads X_t by two periods, or X_t lags Y_t by two periods. We will see some examples later.

All statistical software, spreadsheets and many calculators have the formulas for these statistics incorporated. In case you need to compute them by yourself, here are the formulas, including some other statistics useful for intermediate steps:

- *Mean*: $\bar{X} \equiv \frac{1}{T}\sum_{t=1}^{T} X_t$
- *Variance*: $\text{Var}(X_t) \equiv \sigma_x^2 \equiv \frac{1}{T}\sum_{t=1}^{T}\left(X_t - \bar{X}\right)^2$
- *Standard deviation*: $\sigma_x \equiv \sqrt{\sigma_x^2}$
- *Covariance*: $\text{Cov}(X_t, Y_t) \equiv \sigma_{xy} \equiv \frac{1}{T}\sum_{t=1}^{T}\left(X_t - \bar{X}\right)\left(Y_t - \bar{Y}\right)$
- *Correlation*: $\text{Corr}(X_t, Y_t) \equiv r_{xy} \equiv \frac{\sigma_{xy}}{\sigma_x \sigma_y}$
- *Autocovariance of order j*: $\text{Cov}(X_t, X_{t-j}) \equiv \frac{1}{T-j}\sum_{t=j+1}^{T}\left(X_t - \bar{X}\right)\left(X_{t-j} - \bar{X}\right)$
- *Autocorrelation of order j*: $\text{Corr}(X_t, X_{t-j}) \equiv \frac{\text{Cov}(X_t, X_{t-j})}{\sigma_x^2}$

Now we have established which statistical tools are appropriate, are we ready to look at the data? Unfortunately, no. Data is full of pitfalls that can lead you to erroneous conclusions, and we need to make sure that we really look at relevant data. The first is to make sure that the data measures what we want it to measure. Let us go step by step through the requirements.

Step 1: Have data in real terms

When we want to see how much GDP has increased in a given year, we typically have two measures: real GDP and nominal GDP. The latter measures the value of GDP at current prices, thus an increase in nominal GDP reflects both an

increase in the prices of goods and an increase in the quantities of those goods. A better measure of economic activity is real GDP, as it traces quantities net of price changes. This is essentially done by holding the prices of the goods constant when computing the statistic. Thus, in most cases, we will care about real GDP. The same applies to other economic aggregates, we want to use their real values. Exceptions may be monetary aggregates, interest rate (sometimes) and, obviously, prices.

Step 2: Deseasonalize the data

As we concentrate here on business cycles, we do not want cycles at other frequencies to "taint" the data. One such cycle is the seasonality of some aggregates. Typically, sales are stronger in December than during other months. Tourism is stronger in the Summer. Housing starts are lower in the Winter. There are statistical techniques that remove these seasonal components from the data. Macroeconomic aggregate are usually offered "seasonally adjusted" or "deseasonalized" (SA, SAAR), but make sure not to use a series that has not been treated in this way.

Step 3: Remove trends

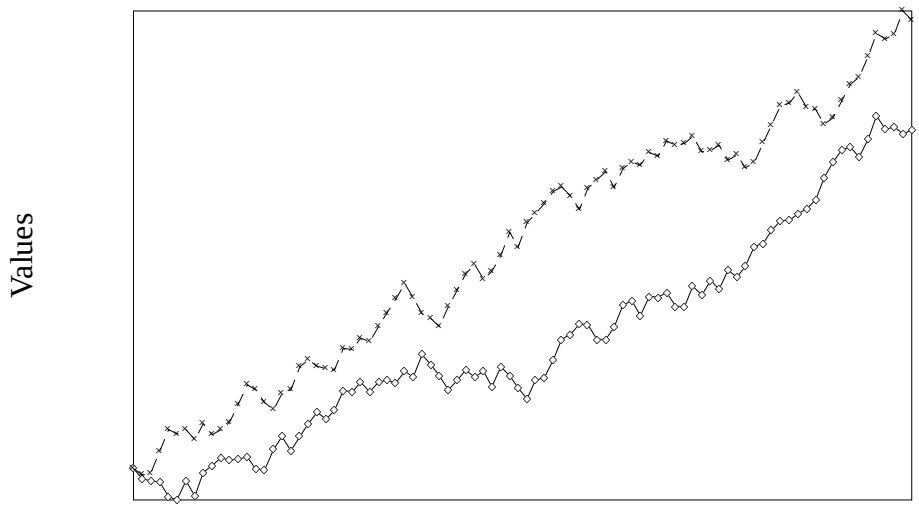
Another frequency we want to net out are the long term movements. Thus we have to find some way to remove those trends. Doing so is quite important, as the following experiment will show. Let us construct two artificial series that are completely independent from each other:

$$\begin{aligned} X_t &= 0.1 + X_{t-1} + a_t \\ Y_t &= 0.1 + Y_{t-1} + b_t \end{aligned}$$

where a_t and b_t are random and uncorrelated. Figure 7 shows an example of two such series, and they indeed look independent of each other. Yet, they have a correlation of 0.95, which would indicate a very strong comovement between them. Why is this? Remember that a correlation measures how often two series are above or below their averages at the same time. Essentially, they are both below the average during the first half of the sample and above it during the second half. Obviously, this is not what we want to capture when we think of business cycle comovements. What triggers this **spurious correlation** is the fact that X_t and Y_t have a common trend, and most macroeconomic series have common trends. Thus we need to find some ways to remove those trends. There are several ways.

The simplest one is to look at **growth rates**. In our example above, we would correlate $\frac{X_t - X_{t-1}}{X_{t-1}}$ with $\frac{Y_t - Y_{t-1}}{Y_{t-1}}$, which in this case yields 0.13. This procedure

Figure 7: An example of spurious correlation



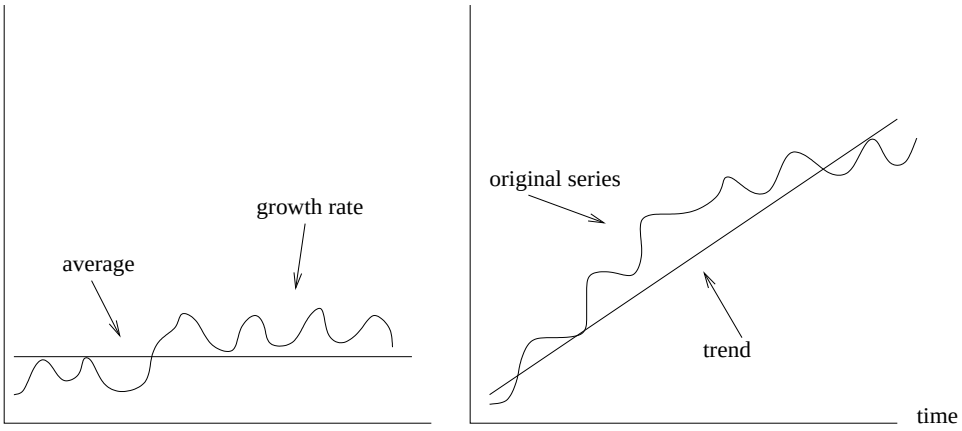
does fine as long as growth rates fluctuate around a constant value. But if there are changes in the trend growth rates, we face the same problem again in the sense that business cycle correlation are pushed aside by phenomena at other frequencies. Figure 8 provides some examples of such trend breaks. This is not a vacuous concern, as the 1970's and 1980's have observed a general slowdown of growth that was beyond a business cycle movement.

Obviously, when such trend breaks are present, one would like to draw a trend that is not a straight line. One popular technique nowadays is the so-called **Hodrick-Prescott filter**, or HP-filter. Essentially it is a smoothing technique that allows changes in the slope of the trend that are not too abrupt. An example of its application (with real GDP in Canada) is in Figure 9. The HP-filter is not commonly found in popular software. Most econometric software packages feature it, though. Its precise definition is the following:

$$\min_{\{X_t^*\}_{t=1}^T} \sum_{t=1}^{T} (X_t - X_t^*)^2 + \lambda \sum_{t=2}^{T-1} \left[\left(X_{t+1}^* - X_t^* \right) - \left(X_t^* - X_{t-1}^* \right) \right]^2,$$

where X_t is the raw series, X_t^* is the trend, and λ is a "penalty" that determines the degree of smoothing. With quarterly data, which is typically used for business cycle analysis, a penalty of 1600 is standard. Once the trend has been found,

Figure 8: Examples of trend breaks



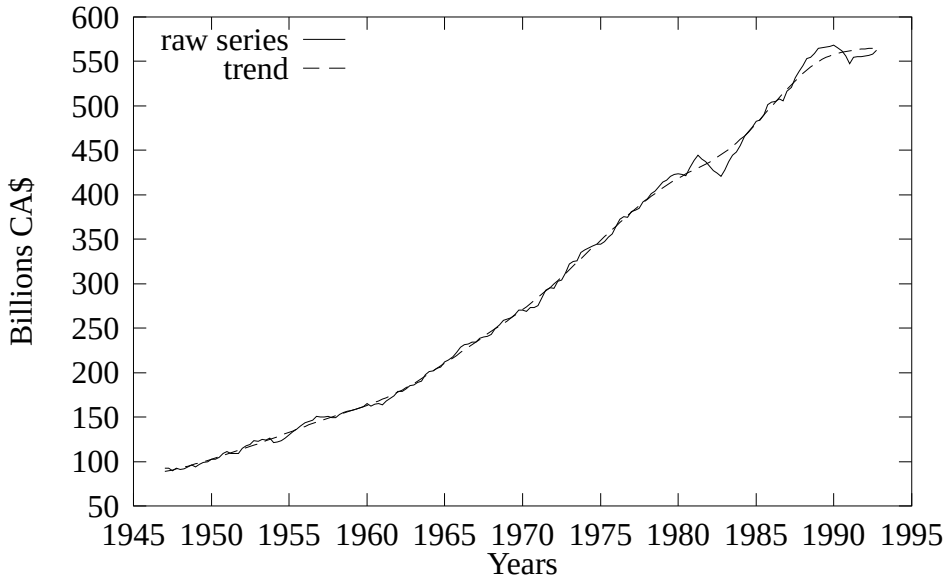
we simply obtain the cyclical components by substracting the trend from the raw series. Those cyclical components are then used to obtain standard deviations and correlations.

One final note of caution should be added. A cyclical component of $100 billion is not the same in 1900 or in 2000. In 1900 and in the United States, it would represent about 22% of GDP whereas nowadays it is less than 1%. This is why we usually take the **logarithm** of a series before using the HP-filter, as the cyclical components are then expressed as percent deviations. To understand why, note that $\frac{X_t - Y_t}{Y_t}$ is approximately equal to $\ln X_t - \ln Y_t$, as long as X_t and Y_t are not too far apart. The following table gives you some examples for $Y_t = 100$:

X_t	$\frac{X_t - Y_t}{Y_t}$	$\ln X_t - \ln Y_t$
100	0.00	0.00000
101	0.01	0.00995
102	0.02	0.01980
103	0.03	0.02956
104	0.04	0.03922
105	0.05	0.04879
107	0.07	0.06766
110	0.10	0.09531
120	0.20	0.18232
150	0.50	0.40547

Thus, HP-filtered cyclical components from logarithms can be expressed as %, and their standard deviation is also measured in %, which can be interpreted.

Figure 9: Application of the HP-filter



Note that taking logarithms is not appropriate for some series: those that are already measured in %, like interest rates, and those that have negative values, like the trade balance. In the latter case, we usually take their ratio with GDP. Finally, differences of logs can also be used instead of growth rates, if this simplifies calculations.

3 Stylized facts

We are now ready to look at data. In the following, the HP-filter has been applied to logarithms of economic aggregates. By default, the data was real, not nominal, and seasonally adjusted. The following series are not in real terms: prices and monetary aggregates. The following are not in logarithms: changes in inventories, net exports (both taken as a ratio to output), interest rates. We start with quarterly US data, and then venture into data from other countries.

Table 1 reports a large number of statistics for the United States. From all these numbers we will be trying to crystallize the most apparent characteristics, which we will call the **stylized facts** of the business cycle. Later we will see whether theses facts are robust, in the sense that they are also found in other economies around the world. Note that we use GNP, not GDP. Their business cycle behavior

Table 1: Economic fluctuations in the US, 1954:I–1991:II

Variable	SD%	Correlation of GNP with x_{t-5}	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}	x_{t+5}
GNP	1.72	.02	.16	.38	.63	.85	1.0	.85	.63	.38	.16	.02
Consumption:												
- total	1.27	.25	.42	.57	.72	.82	.83	.67	.46	.22	-.01	-.20
- non dur., serv.	0.86	.22	.40	.55	.68	.78	.77	.64	.47	.27	.06	-.11
- durables	4.96	.24	.37	.49	.65	.75	.78	.61	.38	.11	-.13	-.31
Investment												
- total	8.24	.04	.19	.38	.59	.79	.91	.76	.50	.22	-.04	-.24
- fixed	5.34	.08	.25	.43	.63	.82	.90	.81	.60	.35	.09	-.12
- non residential	5.11	-.26	-.12	.05	.30	.57	.79	.88	.83	.60	.46	.24
- residential	10.7	.42	.55	.65	.72	.74	.63	.39	.11	-.14	-.33	-.43
- ch. inventories	17.3	-.03	.07	.22	.38	.53	.67	.51	.27	.04	-.15	-.30
Govt expenses	2.04	.03	-.01	-.03	-.01	-.01	.04	.08	.11	.16	.25	.32
Exports	5.53	-.48	-.42	-.29	-.10	.15	.37	.50	.54	.54	.52	.44
Imports	4.88	.11	.19	.31	.45	.62	.72	.71	.52	.28	.04	-.18
Labor (household survey)												
- total hours	1.59	-.06	.09	.30	.53	.74	.86	.82	.69	.52	.32	.11
- average hours	0.63	.04	.16	.34	.48	.63	.62	.52	.37	.23	.09	-.05
- employment	1.14	-.10	.04	.23	.46	.69	.85	.86	.76	.59	.40	.18
- GNP/tot. hours	0.90	.06	.14	.20	.30	.33	.41	.19	.00	-.18	-.25	-.24
Labor (establishment survey)												
- total hours	1.69	-.12	.07	.38	.54	.78	.92	.90	.78	.63	.42	.21
- average hours	0.48	.14	.26	.42	.58	.68	.62	.45	.22	.05	-.15	-.30
- employment	1.41	-.19	-.01	.22	.47	.72	.89	.92	.86	.73	.55	.34
- GNP/tot. hours	0.73	.35	.44	.44	.45	.34	.34	.10	-.09	-.30	-.38	-.42
- hourly earnings	0.76	.20	.35	.47	.58	.66	.68	.59	.46	.29	.12	-.03
Hourly compens.	0.55	.24	.25	.21	.14	.09	.03	-.07	-.09	-.09	-.09	-.10
Prices												
- GNP deflator	0.88	-.52	-.63	-.69	-.70	-.65	-.57	-.44	-.31	-.17	-.04	.08
- CPI	1.43	-.57	-.66	-.71	-.72	-.65	-.52	-.35	-.17	.02	.19	.34
Money												
- M0	0.84	.22	.33	.39	.42	.37	.30	.21	.15	.07	.03	.02
- M1	1.52	.16	.24	.33	.41	.39	.33	.21	.12	.05	.03	.02
- M2	1.46	.51	.58	.62	.62	.50	.33	.10	-.08	-.21	-.29	-.37

Source: Frontiers of Business Cycle Research, Thomas F. Cooley (ed.), Princeton University Press 1995. Compiled from various chapters.
Note: the sample for the establishment survey is 1964:I–1991:II.

is essentially equivalent.

Let us first concentrate on standard deviations (the SD% column). There we want to compare GNP's standard deviation of 1.72% to the standard deviation of other aggregates. We notice that consumption is less volatile, especially the consumption of non durables and services. The standard deviation of durables is a multiple of that of GNP, in fact it is in a similar range with fixed investment. Indeed, household durables can be thought of as investment, given that they encompass cars, household appliances and similar items. Note also that all components of investment are much more volatile than GNP. Government expenses (at all levels) are roughly as variable as GNP, while exports and imports are again in the same ballpark as investment.

Turning to labor, we see that whatever the source of the data, total hours are about as volatile as GNP, and this volatility is mostly attributed to employment, not average hours. Labor earnings and labor productivity (as measured by GNP over total hours) are less volatile than GNP. Prices and monetary aggregates tend to be less volatile, but this depends on the definition.

Let us now look at correlations and let us first concentrate on the middle column ("x_t"). There we see that all components of GNP are procyclical, with one exception: government expenses. Note that some of the correlations are very high, for example total investment, and consumption. Imports are much more procyclical than exports. Labor aggregates are procyclical as well, in particular total hours and employment. Labor earnings and labor productivity tend to be procyclical. Prices are countercyclical, while monetary aggregates are mildly procyclical.

The remaining columns of Table 1 help us determine whether any aggregate leads or lags the business cycle. The columns to the left give correlations of aggregates leading the business cycle, while they lag in the right columns. Our task is now to figure out for each aggregate whether they lead or lag by looking at the highest correlation. The norm is that they do not lead or lag, they are contemporaneous. But this is no exact science, as some correlations are very close to each other. Witness consumption, that may possibly lead, as the one-period ahead correlations are essentially equivalent to the contemporaneous ones. If we had monthly data, we may have found a lead, but we cannot conclude that this is the case with quarterly data. There is certainly not a lag.

An interesting case is investment. While total or fixed investment are resolutely contemporaneous, this is not the case for the components: non residential investment is lagging the cycle while residential investment is leading the cycle (this is why economists are always so interested in housing starts as an indicator of things to come). A similar story appears with labor aggregates. Total hours are

contamporaneous, but average hours lead the cycle while employment lags the cycle. It is easy to build a theory justifying this: employers can adjust the total labor hours rapidly with overtime (or undertime), but it takes some time to adjust the number of employees. A case can also be made that prices lead the cycle (in their countercyclical nature), and that some definitions of money lead the cycle, which can give some credit to theories stating that money is an important trigger of business cycles. This is unlike government expenses which do not seem to be correlated with GNP within a five quarter window (there may be a lag of more than five quarters, though).

Within this table we can measure persistence only for one aggregate, GNP, as it is the only one to feature autocorrelations. With 0.85, the autocorrelation of order one clearly indicates that a high degree of persistence is visible at quarterly frequency.

Obviously, we will never be able to find in this class theories that can replicate all this facts, especially theories matching precisely the figures of Table 1. Given that we will not cover the international sector and that we will not be able to look a leads or lags in this class, let us focus on a limited number of stylized facts. The facts should guide us through the evaluation of successive theories, and we will put them to an immediate test by looking at other countries. Here are the facts:

1. Consumption is less volatile than output.
2. All other components of GNP are more volatile.
3. The labor input is as volatile as output.
4. Average hours fluctuate less than employment.
5. All components of GNP are procyclical (except government expenses).
6. All labor aggregates are procyclical.
7. Labor productivity is procyclical.
8. Labor earnings are procyclical.
9. Prices are countercyclical.
10. Money is (weakly) procyclical.

Table 2: Economic fluctuations in the world, standard deviations (national accounts), 1960:I–1991:II

Country	Outp.	Cons.	Invest.	Gov. Exp.	Net Exp.	Export	Import
Australia	1.53	1.11	6.15	0.69	1.35	5.79	7.22
Austria	1.21	1.48	3.69	2.79	1.11	3.38	4.16
Canada	1.54	1.43	5.10	1.66	0.77	5.03	5.43
Denmark	2.04	2.76	8.41	?	1.37	2.67	4.58
Finland	2.05	1.99	6.52	5.11	1.74	6.03	6.98
France	1.40	0.89	2.77	0.69	0.80	2.81	4.06
Germany	1.65	2.22	4.77	2.04	0.81	3.73	3.86
Greece	1.57	2.76	7.19	8.63	2.90	8.82	11.21
Italy	1.66	1.31	4.75	0.68	1.28	3.58	5.60
Japan	1.47	1.32	3.55	2.80	0.89	4.66	5.65
Netherlands	1.56	1.27	6.37	2.04	1.48	2.75	3.29
Norway	2.31	2.32	15.70	2.39	3.40	4.11	5.86
Portugal	1.80	1.89	7.31	?	3.13	4.42	6.65
South Africa	1.63	2.14	6.26	3.22	3.25	4.32	10.32
Spain	1.06	1.13	3.95	1.01	1.30	3.28	4.86
Sweden	1.31	1.64	3.17	1.39	1.14	3.53	3.97
Switzerland	1.99	1.37	4.45	2.60	1.35	3.34	4.77
UK	1.58	1.81	4.13	1.41	1.15	4.38	5.44
USA	1.75	1.30	5.47	1.94	0.43	5.09	5.71

Note: Some samples are shorter. Private consumption encompasses durable goods.

Table 3: Economic fluctuations in the world, correlations with output (national accounts), 1960:I–1991:II

Country	Cons.	Invest.	Gov. Exp.	Net Exp.	Export	Import
Australia	0.65	0.71	-0.55	-0.22	0.07	0.53
Austria	0.40	0.34	-0.07	-0.43	0.53	0.56
Canada	0.83	0.65	-0.22	-0.35	0.60	0.80
Denmark	0.75	0.80	?	-0.47	0.10	0.68
Finland	0.79	0.71	0.05	-0.34	0.35	0.69
France	0.63	0.81	0.13	-0.25	0.62	0.80
Germany	0.83	0.67	0.44	-0.28	0.58	0.76
Greece	0.44	0.62	0.14	-0.03	0.21	0.28
Italy	0.82	0.86	0.11	-0.64	0.23	0.79
Japan	0.70	0.82	0.32	-0.26	-0.04	0.44
Netherlands	0.49	0.63	-0.12	0.06	0.44	0.28
Norway	0.30	-0.01	0.02	0.35	0.48	0.16
Portugal	0.78	0.72	?	-0.40	0.00	0.50
South Africa	0.68	0.60	0.12	-0.60	-0.07	0.75
Spain	0.72	0.80	0.34	-0.32	0.25	0.64
Sweden	0.42	0.51	0.27	-0.08	0.51	0.43
Switzerland	0.55	0.67	0.16	-0.64	0.51	0.73
UK	0.74	0.68	-0.01	-0.32	0.44	0.60
USA	0.82	0.90	0.18	-0.36	0.38	0.75

Note: Some samples are shorter. Private consumption encompasses durable goods.

We now turn to Table 2 that looks at the standard deviations of GNP components in several economies. Do the results we got for the United States still hold? In many cases consumption is less volatile than output, but there are exceptions. But we have to keep in mind that these statistics have been computed with total consumption. If we could focus on the consumption of non durables and services (which is possible in a few cases only), our stylized fact would still be found. The fact that all other components of GNP are more volatile holds as well, except for government expenses, which are all over. Apparently, different countries have different policies.

Table 3 repeats the exercice with correlations. In every country, consump-

Table 4: Standard deviations (σ) of employment (n), hours per worker (h) and total hours (nh) in the world, 1960:I–1991:II.

Country	σ_h	sample	σ_n	sample	σ_{nh}	$\frac{\sigma_h}{\sigma_{nh}}$	$\frac{\sigma_n}{\sigma_{nh}}$	$\frac{\sigma_h}{\sigma_n}$
Australia	1.92	1969.III–1991.II	1.10	1964.II–1991.II	2.63	0.73	0.46	1.60
Austria	1.12	1965.I–1991.II	0.72	1965.I–1991.II	2.12	0.53	0.34	1.56
Canada	0.82	1960.I–1991.II	1.31	1960.I–1991.II	3.44	0.24	0.38	0.63
Denmark	0.67	1971.I–1991.II	1.45	1971.I–1991.II	1.96	0.34	0.74	0.46
Finland	1.40	1960.I–1991.II	1.21	1960.I–1991.II	1.67	0.84	0.73	1.16
France	0.46	1970.I–1991.II	0.77	1968.I–1991.II	0.95	0.48	0.80	0.61
Germany	1.10	1960.II–1991.II	2.14	1960.I–1991.II	2.87	0.38	0.75	0.51
Greece	1.57	1961.IV–1991.II	1.52	1962.I–1991.II	2.28	0.69	0.67	1.04
Italy	—	—	0.87	1960.I–1991.II	—	—	—	—
Japan	0.74	1960.I–1991.II	0.70	1960.I–1991.II	1.01	0.70	0.69	1.06
Netherlands	—	—	0.96	1969.I–1991.II	—	—	—	—
Norway	1.58	1966.I–1991.II	1.03	1966.I–1991.II	1.77	0.89	0.58	1.53
Portugal	—	—	1.00	1969.II–1991.II	—	—	—	—
South Africa	—	—	1.44	1970.I–1991.II	—	—	—	—
Spain	1.55	1970.I–1991.II	2.08	1963.I–1991.II	3.05	0.51	0.69	0.73
Sweden	0.45	1963.III–1991.II	0.74	1961.II–1991.II	1.69	0.26	0.41	0.64
Switzerland	—	—	1.38	1965.I–1991.II	—	—	—	—
United Kingdom	1.09	1960.I–1991.II	1.11	1960.I–1991.II	1.76	0.62	0.63	0.98
United States	0.93	1960.I–1991.II	1.07	1960.I–1991.II	1.75	0.53	0.61	0.87

tion is procyclical, in all but one, investment is procyclical, in the overwhelming majority imports are procyclical, exports tend to be procyclical, just as for the United States. But, again, government expenses are all over, and no clear pattern emerges. Note that net exports tend to be countercyclical, indicating that a trade balance deficit is rather a characteristic of an economy in a boom. We have thus confirmed that the stylized facts 1, 2, and 5 are valid in other economies as well.

Let us look at fact 4 with Table 4. For it to be verified in other countries, we would need $\frac{\sigma_h}{\sigma_n} < 1$, signifying that employment is more volatile than average hours. The last column of the table does not corroborate this, by far. Indeed this statistic ranges from 1.60 to 0.46, an amazingly broad spectrum. We can hypothesize that this reflects varied labor market institutions or traditions. We can also use this table, combined with Table 2 to see whether total hours are about

Table 5: G7 correlations for some aggregates, 1960:I–1989:IV

Aggregate	US	Canada	Japan	Germany	France	UK	Italy
Employment	.83	.67	.27	.29	.60	.43	.35
Empl./output	.83	.52	.90	.61	.78	.76	.85
Real wages	.49	-.17	.21	-.15	-.50	.35	-.12
GDP deflator	-.63	-.34	-.43	-.15	-.60	-.57	-.33
CPI	-.55	-.32	-	-.39	-.55	-.43	-.32
M1	.29	.09	.12	-.05	.01	.13	.35
M2	-	-.08	.18	.25	.27	-.03	.39
M3	.48	-	-	-	.17	-	-
Real interest rate	.11	.17	.08	.28	-.07	-.03	.04

Source: Riccardo Fiorito and Tryphon Kollintzas, Stylized Facts of Business Cycles in the G7 from a Real Business Cycle Perspective, European Economic Review, 1994, Vol. 38 (2), pages 235–269.

as volatile as output, our fact 3. Again, we do not see a clear pattern. Note that differences in definitions and measurements are especially strong for labor market data, which can partly explain the lack of robustness.

We still have a few stylized facts to verify, and Table 5 helps us in this endeavour. First, we see that employment is procyclical in all G7 countries, although not necessarily as much as in the United States (fact 6). The same applies to labor productivity (fact 7). But real wages are far from being uniformingly procyclical (fact 8). Even in the US, this was not obvious, depending on the measure used. Prices are uniformly countercyclical (fact 9), and monetary aggregates are (very) weakly procyclical (fact 10). We did not report so far about real interest rates, the evidence here is that they are essentially acyclical.

Robustness of stylized facts should not just be verified through space, but also through time. Indeed, it could happen that a fact that is valid for some period is not valid for another, in particular if there could be some different policy regimes. Instead of going through another lengthy set of tables which would just show us that the facts are mostly robust through time, let us concentrate on one particular case where a stylized fact turned out not to be robust.

We have established that prices are countercyclical, in the United States as well as in other countries. Table 6 shows that this was not always the case. In particular, there is strong evidence that in the period between the two World Wars

Table 6: Correlations of GDP/GNP deflators with GDP/GNP through time for various countries (annual data)

Country	prewar	interwar	postwar
Australia	.60	.59	-.47
Canada	.41	.77	.12
Denmark	.18	-.26	-.48
Germany	-.01	.71	.01
Italy	-.02	.58	-.24
Japan	-.45	.03	-.60
Norway	.65	.16	-.63
Sweden	.15	.30	-.53
UK	.26	.20	-.50
USA	.22	.72	-.30

Source: David Backus and Patrick Kehoe, International Evidence on the Historical Properties of Business Cycles, American Economic Review, 1992, Vol. 82 (4), pages 864–888.

prices were procyclical. This is quite important for macroeconomic theory as the behavior of prices reflects what type of shock is most prominent in shaping business cycles. Think of a standard demand and supply graph and say that both demand and supply are subject to random movements. If the movements of demand are stronger, the equilibrium price will move in the same direction as equilibrium output, i.e. prices are procyclical. If the movements of supply are stronger, prices are countercyclical. Much of the debate in the 1970's and 1980's among macroeconomists essentially boiled down to this stylized fact and a disagreement over which shock is most important, before someone noticed that the cyclical behavior of prices changed.

Let us now repeat the list of stylized facts, and when necessary qualify them according to what we found through the robustness tests:

1. Consumption is less volatile than output.

2. All other components of GNP are more volatile.

3. The labor input is a volatile as output (in the US).

4. Average hours fluctuate less than employment (in the US).
5. All components of GNP are procyclical (except government expenses).
6. All labor aggregates are procyclical.
7. Labor productivity is procyclical.
8. Labor earnings are procyclical (weakly, in the US).
9. Prices are countercyclical (for the postwar period).
10. Money is (weakly) procyclical.

We will come back to these stylized facts over and over as we look at various theories of the business cycle.