Chapter 1

Stylised monetary facts

1.1 Motivation

In this lecture we outline some simple summary statistics regarding the cyclical behaviour of real and nominal variables and their interactions. It provides an empirical reference point to help guide us in our subsequent analysis of how important money is for the business cycle. While informative, we interpret the following results as preliminary. Before they could be considered as definitive we would need to do substantial extra work in establishing their robustness across data periods, data definitions and empirical techniques.

1.2 Key readings

Walsh (1999), *Monetary Theory and Practice*, Chapter 1. This is an excellent graduate textbook.

Cooley (ed.) (1995), *Frontiers of Business Cycle Research*, Chapter 7, Sections 1 and 2. This is also a very good reference.

1.3 Related reading

Cogley and Nason (1994), "Effects of the Hodrick-Prescott filter on trend and difference stationary time series: Implications for business cycle research", Journal of Economic Dynamics and Control, 19, 253-278.

Harvey and Jaeger (1993), "Detrending, stylised facts and the business cycle", Journal of Applied Econometrics, 8, 231-247

Hodrick and Prescott (1980), "Postwar US business cycles: An empirical investigation", Discussion Paper 451, Carnegie Mellon University. Unpublished.

Holland and Scott (1998), "The determinants of UK business cycles", Economic Journal, 108, 1067-92

King and Plosser (1993), "Low frequency filtering and real business cycles", Journal of Economic Dynamics and Control, 17, 207-232

Nelson and Kang (1981), "Spurious periodicity in inappropriately detrended time series", Econometrica, 49, 741-751

1.4 Tools for analysis

Business cycle theorists face a problem - namely what does the business cycle component of the data look like. Observed macroeconomic data reflects many different components - an underlying trend, the business cycle component, seasonality, as well as purely random fluctuations - but business cycle theorists are interested in only one component. Effectively what is required is a filter, something which ignores everything other than the business cycle component.

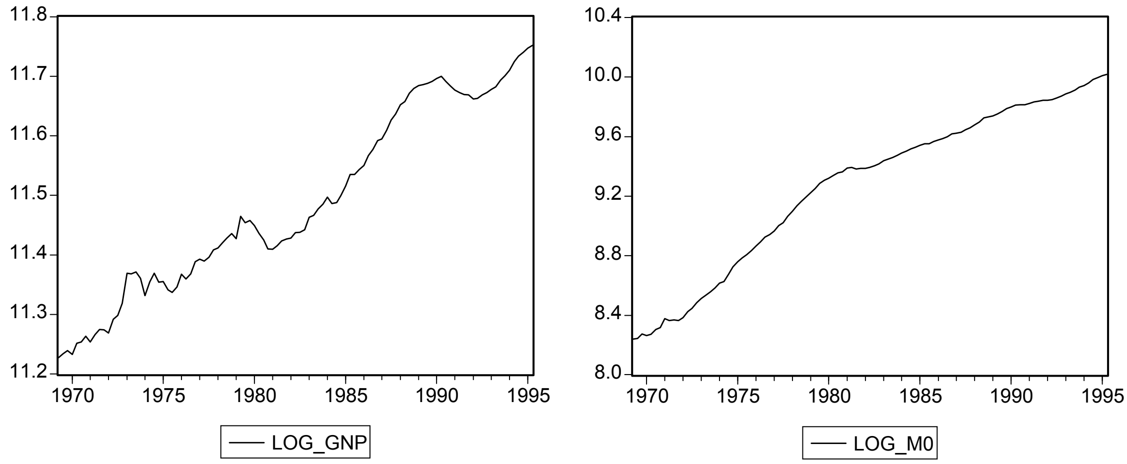

Figure 1.1: GNP and M0 in the UK

Figure 1.1 shows the logarithm of GNP and narrow money M0 for 1969q2 to 1994q4[1]. At present the figure is not very informative and it is difficult to see the interactions between real and nominal variables. To make things clearer there are an infinite number of different filters that can be used. Unfortunately because we can never know what the true business cycle component actually looks like we can never with complete certainty claim that one filter is better than another. Instead we have to choose a particular filter because it is plausible given certain beliefs about what a business cycle filter should do. Ideally, the cyclical component extracted from any dataset should not vary greatly between different filters. However, as we shall see this is not the case.

In the modern macroeconomics literature one filter has been used almost exclusively. This filter is based on an unpublished paper by Hodrick and Prescott (1980). The idea behind this filter is that the data consists of a trend and a business cycle. Hodrick and Prescott's starting point is that the trend must be a smooth time series - in other words, it does not make sense to think of a trend which fluctuates wildly

[1] This dataset was used in Ellison and Scott (JME, 2000). You can download the data as an Eviews file from the course homepage. It would be a very useful exercise for you to load this into Eviews and replicate the results seen in the lecture.

from quarter to quarter. However, the trend (which we will denote by τ_t) must follow the observed data (y_t) closely. They therefore infer the trend from the following minimisation problem.

$$\min_{\{\tau_t\}_{t=1}^{T}} \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} \left[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\right]^{\ 2}$$

The first part of the minimisation problem ensures that the trend component tracks the data fairly well. The constraint however prevents the change in the trend being too volatile. The larger the value of λ the smoother the changes in the growth of the trend have to be. Hodrick and Prescott suggest a value of $\lambda = 1600$ for quarterly data. Although, as pointed out many critics many critics, the choice of λ is likely to vary from variable to variable. Figure 1.2 shows UK GNP and Hodrick-Prescott trends for different smoothing parameters.

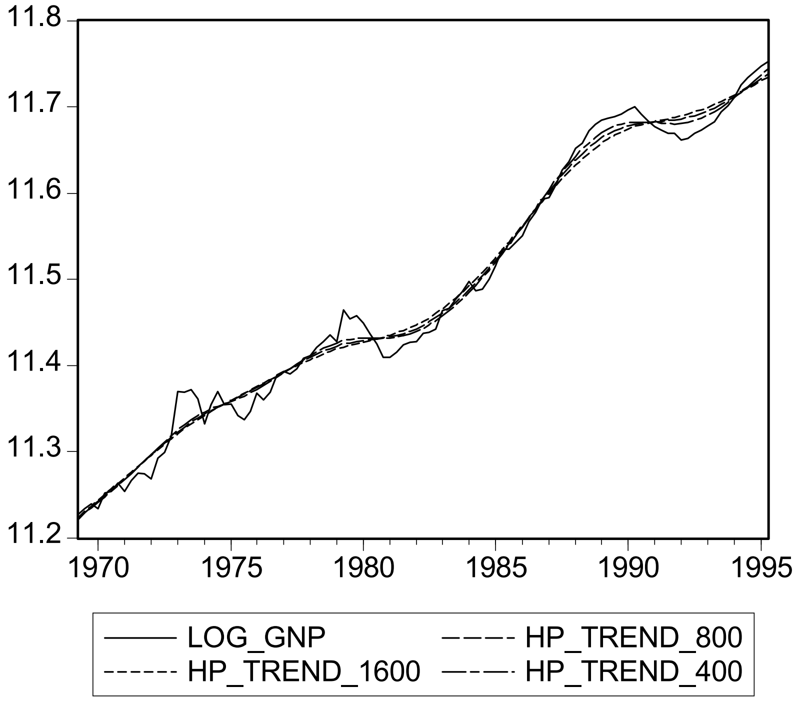

Figure 1.2: UK GNP and Hodrick-Prescott trends

Having solved this minimisation problem to arrive at an estimate of the trend, the cyclical component is defined as $y_t - \tau_t$. As shown in King and Plosser (1993) the Hodrick-Prescott filter has the ability to successfully detrend any series of an order of integration less than or equal to I(4). As mentioned above, the Hodrick-Prescott filter is now the industry standard approach towards detrending. However, there is widespread concern about its use.

(i) Business cycle facts are not invariant to the detrending filter used.

(ii) Other filters may be more optimal (see for instance Harvey and Jaeger (1993)). A little bit of thought will reveal that if variables have different stochastic properties then a different detrending filter should be applied. Therefore we cannot expect any one technique to be optimal for all variables. The crucial thing is whether one particular technique is a better approximation across a wider range of variables than another.

(iii) The Hodrick-Prescott filter may produce spurious cycles. This is the subject of Cogley and Nason (1994). A well-known result in the econometrics literature is the "spurious cycle" result of Nelson and Kang (1981). They show that if a linear time trend is fitted to a series which follows a random walk then the detrended data will display spurious cycles. In other words, if the researcher mistakenly thinks the trend is deterministic then the cycles derived will be misspecified. Cogley and Nason (1994) show that under incorrect assumptions about the stochastic behaviour of a variable, the HP filter will exaggerate the pattern of long term growth cycles at cyclical frequencies and depress the influence of cycles at other frequencies. The result is that the HP filter may exaggerate the importance of business cycles.

Even more striking they show that in the context of the Frisch-Slutsky paradigm the HP filter can be dramatically misleading. Observed stylised facts about the business cycle reflect three factors: (i) an impulse (ii) a propagation mechanism and (iii) the data being detrended by the HP filter and the certain statistics reported. Cogley and Nason (1994) show that for a typical macroeconomic model (ii) is unnecessary - merely assuming a process for the shock and applying the HP filter will be enough to generate business cycle patterns **even if they are not there in the model**. In other words, so called "stylised facts" are nothing more than artifacts. This is why some call the HP filter the Hocus Pocus filter - it simply creates business cycles from nothing. However, some words of caution are necessary here. The reason why the HP filter goes wrong is that the researcher makes the wrong assumption about the trend behaviour of a series and so applies the wrong filter. It is not so much the HP filter that produces the wrong result but the misspecification of the trend by the researcher. Using another detrending filter aside from the HP does not remove the risk of misspecification.

These are clearly serious criticisms of simple stylised facts calculated from the HP filter. Some efforts have been made to put this literature on a more secure statistical footing. However, it still remains the case that nearly every quatitative macroeconomic paper attempts to justify itself by using stylised facts constructed using the HP filter. Be warned.

1.5 Stylised facts

Figures 1.3 and 1.4 plot detrended real GNP alongside M0 and M4 (all variables are in logarithms) for the period 1969q3 - 1994q4. Figure 1.3 shows a strong positive relationship between GNP and M0, whilst Figure 1.4 has a less strong but nonetheless pronounced relationship between GNP and M4. Interpreting detrended data should always be done with caution, but visual inspection strongly suggests that M4 *lags* GDP by 18-24 months while Figure 1.3 suggests that M0 is more contemporaneous. There would appear to be little evidence that money *leads* output, consistent with the empirical findings in Holland and Scott (1998).

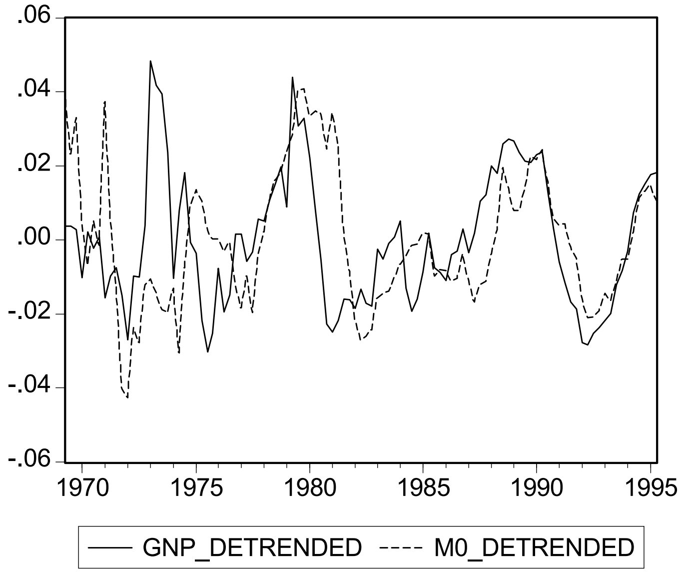

Figure 1.3: Detrended GNP and M0

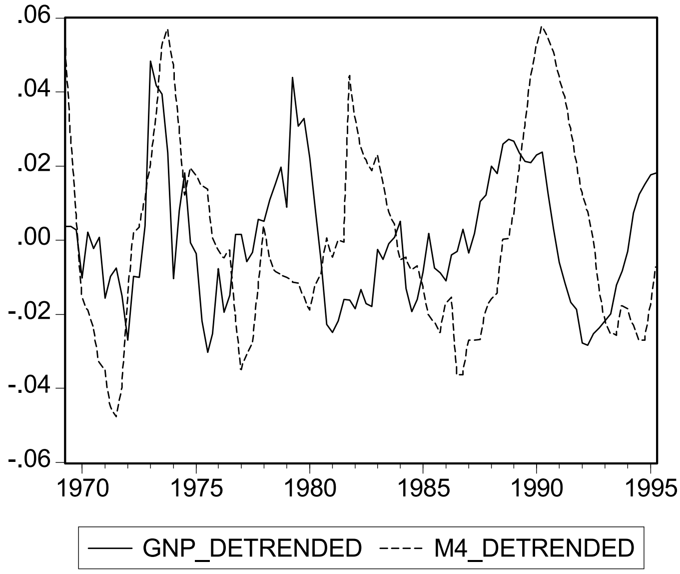

Figure 1.4: Detrended GNP and M4

Table 1.1 shows a more complete description of the relationships amongst real and nominal variables. We report the standard deviations (SD%), the first order autocorrelation coefficient on each variable (rho) and cross correlations at various leads and lags with real GNP. The positive correlations in Table 1.1 show M0 and M4 to be strongly procyclical. As Figures 1.3 and 1.4 suggest, M0 has a stronger contemporaneous correlation with output than M4. In addition, M4 is a more volatile series than output, whose standard deviation is similar to M0. The cross correlations of money and output show strong evidence that both M0 and M4 lags output (the correlations in the right half of the table being larger). This contrasts with US evidence surveyed by Cooley and Hansen (1995) which suggests that money is strongly correlated with output but with a lead. As commented earlier, these results would need to be robustly established using different detrending filters before they could be considered as stylised facts of the UK business cycle. However, Figures 1.3 and 1.4 and Table 1.1 are strongly suggestive that variations in money are **not** an important cause of UK business cycles.

Table 1.1 suggests that the price level is countercyclical with negative contemporaneous and cross correlations with output. This is a similar result as for the US, and suggests the preponderance of supply shocks during this period, see Holland and Scott (1998) for support of this proposition using UK data. The contemporaneous relationship between output and inflation is very weak, becoming positive for leading output, negative for lagged. This differs from the US, where there is a strong positive correlation between cyclical output and inflation. This lack of a well defined correlation for the UK questions the existence of strong cyclical movements along a Phillips curve.

Nominal interest rates show a varied correlation with output. Contemporaneous short term nominal rates are positively related to output, whilst long term rates have virtually no correlation. The larger absolute values in the left half of the table suggest it is higher long term interest rates and not short term rates that are followed by lower cyclical output. The velocity of money is strongly counter-cyclical.

There is a positive correlation between M0 growth and output, also for hours, investment and consumption. There is a negative correlation between prices and money growth and a smaller negative correlation between money growth and nominal interest rates. The relatively small correlation coefficient between M0 growth and interest rates suggests that the liquidity effect in the UK is small.

1.6 Summary

We can tentatively conclude 5 stylised facts for the UK monetary economy.

1. Examining the cyclical component of UK data we find evidence which suggests that M4 *lags* GDP by around 2 years and M0 either lags or is contemporaneous with GDP.

2. We find little evidence that short term nominal interest rates are negatively correlated with future output but we do find such a correlation for long term rates.

3. There is a small negative correlation between contemporaneous money growth and short term interest rates.

4. The velocity of money is strongly counter-cyclical.

5. We find (a) little evidence in favour of a short run Phillips curve and (b) the price level is counter-cyclical, suggesting the post-war predominance of supply side shocks.

Variable	SD%	rho	VariableCross-correlation of output with:							Correlation with M0 growth
			t-3	t-2	t-1	t	t+1	t+2	t+3	
Output	1.66	0.81	0.434	0.624	0.810	1.000	0.810	0.624	0.434	0.233
Consumption	1.95	0.80	0.425	0.564	0.671	0.763	0.637	0.558	0.458	0.177
Investment	4.00	0.74	0.382	0.486	0.587	0.695	0.665	0.573	0.454	0.235
Labour input	1.11	0.57	0.297	0.371	0.479	0.605	0.441	0.239	0.054	0.157
Capital stock	0.23	0.97	-0.505	-0.410	-0.291	-0.146	0.024	0.186	0.333	-0.094
Prices										
GDP deflator	2.32	0.90	-0.439	-0.544	-0.605	-0.611	-0.524	-0.391	-0.216	-0.214
RPI	2.37	0.86	-0.560	-0.648	-0.667	-0.587	-0.420	-0.291	-0.120	-0.262
Inflation	1.03	0.36	-0.244	-0.240	-0.144	-0.019	0.171	0.266	0.360	-0.064
Money										
M0	1.84	0.84	-0.076	0.093	0.246	0.343	0.433	0.463	0.489	0.022
M4	2.73	0.94	-0.063	0.020	0.082	0.136	0.216	0.273	0.284	-0.016
Velocity	1.89	0.89	-0.486	-0.627	-0.717	-0.734	-0.668	-0.609	-0.500	-0.407
Interest rates										
10 year	0.96	0.75	-0.489	-0.333	-0.164	-0.016	0.114	0.227	0.294	-0.095
3 month	1.63	0.79	-0.330	-0.140	0.063	0.230	0.346	0.444	0.472	-0.123

Table 1.1: Cyclical behaviour of the UK economy 1965-1994