

The goal of this project is to show how key economic variables navigate over time. The project consists of three main components:

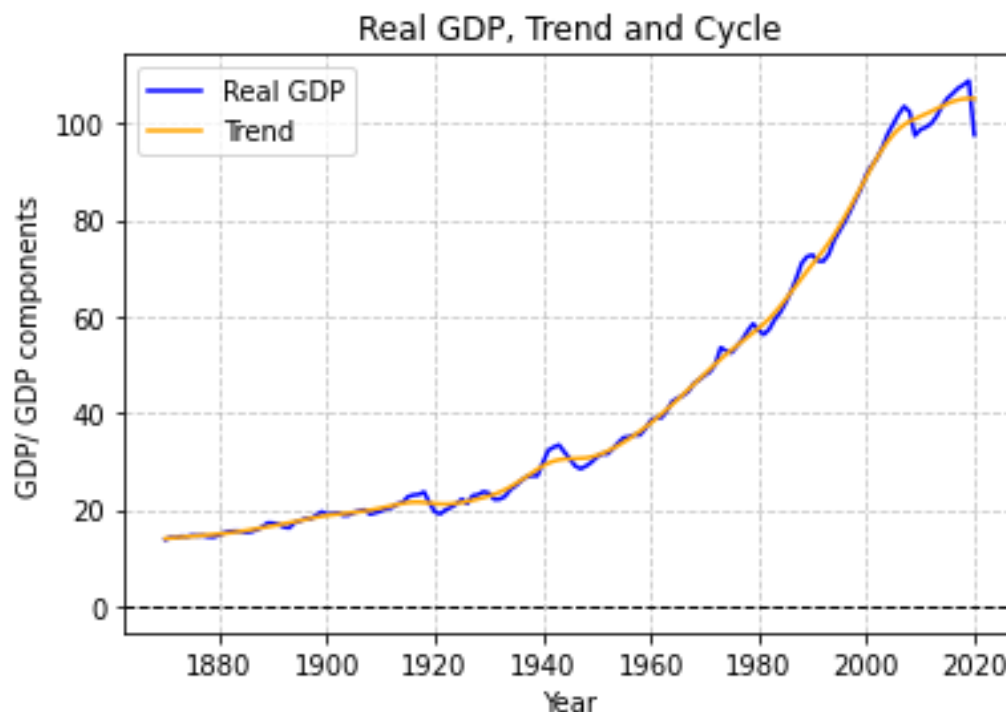
- 1) Business Cycle Analysis
- 2) Monetary Cycle Analysis
- 3) Fiscal Sustainability Analysis

I personally chose to work with data from the United Kingdom, a group of countries, with strong economic and financial activity over the years. Our observation period starts from 1870 until 2020, which gives us the opportunity to investigate the cycles that the main economic variables go through, and how they navigate through times of war, economic uncertainty, energy crises and much more.

A. Business Cycle Analysis

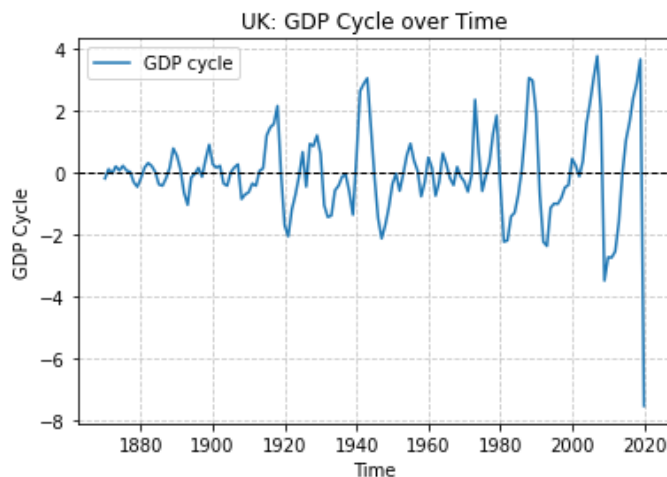
The business cycle is usually defined as the deviations of the aggregate real output from the trend (Lukas, 1977), for that reason in my project I focus on GDP, and then try to compare its movements with other macroeconomic variables.

As I mentioned before, to better describe the business cycles, it is crucial to define the long-run trend of the GDP. In my analysis I used the real GDP (with base year 2005) and by using the Hendrick-Prescott filter (smoothing parameter=100) we can calculate the trend and the cycle of the real GDP.



Over this specific period, it is obvious that the UK's GDP per capita is showing a continuous positive trend, with minor downfalls that can be explained with the general economic environment and geopolitical conditions. For example, a small slump in GDP per capita in 1974, when the great oil crisis occurred, Oil prices quadrupled, leading to a sharp increase in the cost of energy and fuel in the UK. This contributed to inflation and economic stagnation.

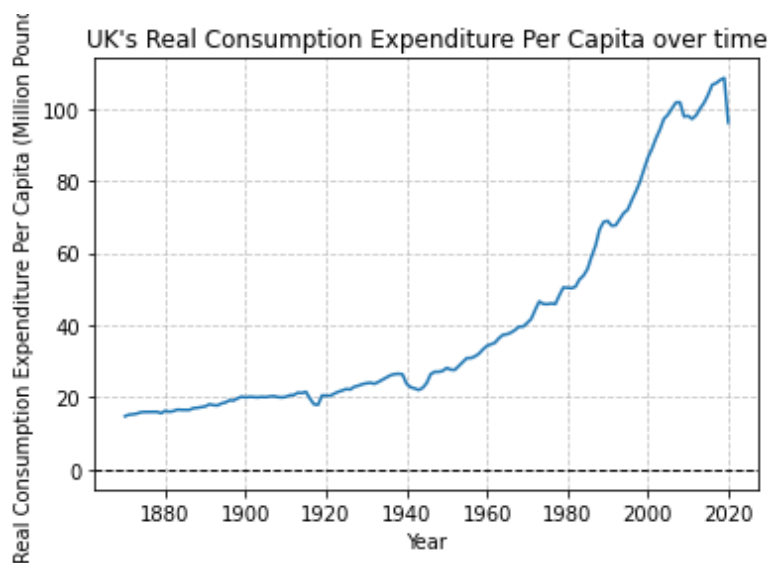
The country's performance was deeply affected by the world financial crisis in 2008, as a leading financial centre, triggering the economy. Finally, after a quick recovery until 2019, in 2020, affected by the Covid-19 pandemic and the UK leaving EU, which led to several economic and political changes. The immediate impacts have been disruptive, particularly in trade, investment, and labour markets.



In this plot, it is shown that the GDP's cycle tends to grow as we get through the years, with the most volatile periods being the world wars, the energy crisis (1974), the great recession of 2007-9 and obviously the COVID-19 pandemic.

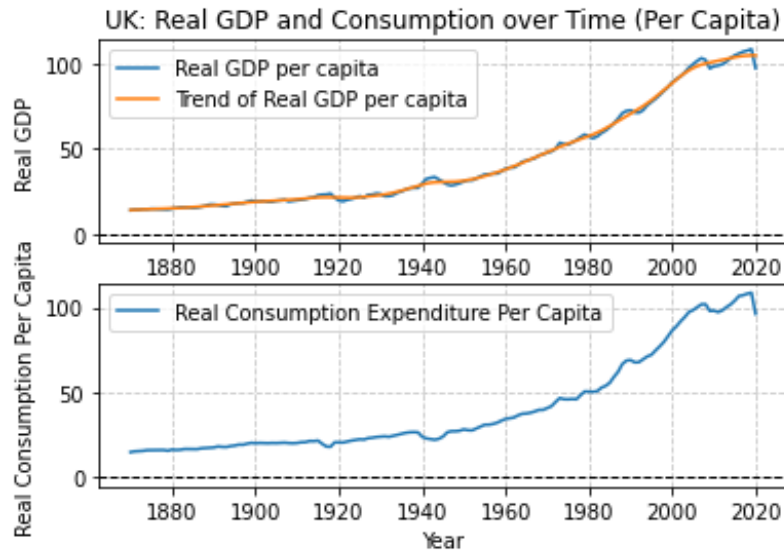
Consumption:

This index refers to the value of goods and services purchased by the UK citizens over a specific period. The economic theory states that the consumption, is a **procyclical** variable, which means that it moves in the same direction of the GDP.



It is obvious, that the long-term trend of the consumption expenditure is also positive, with small fluctuations at periods, of high economic uncertainty.

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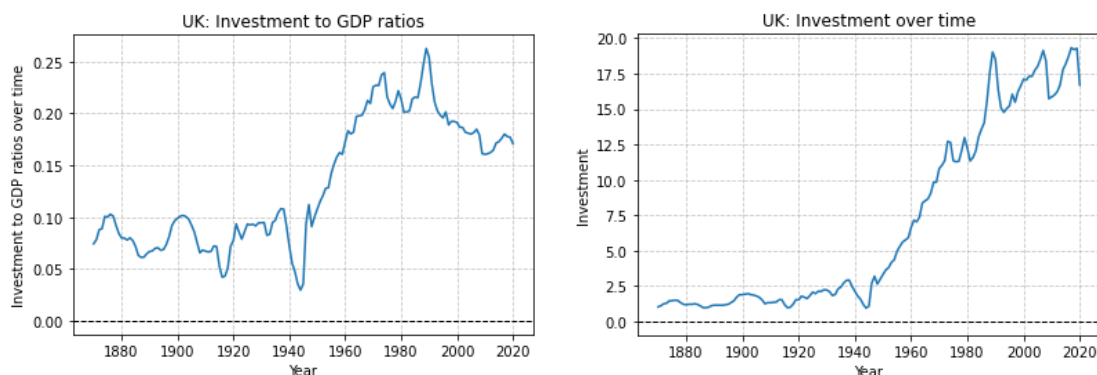


In comparison with the real GDP, we can see that the cycles of the two variables tend to match. This observation is clear, especially if we take a closer look at after the 2008 financial crisis period. For example, when both the GDP and the real consumption expenditure presented a huge dive.

It is interesting to point out, that this relation is not visible, when looking at the 1940's when the British economy had been heavily geared towards war production (constituting 55% of GDP in 1944) resulting in a spike of the real GDP per Capita, but the real consumption expenditure moved in the opposite direction. This means, that while GDP and Consumption tend to move alike, there are times when the economic environment “pushes” consumption in the other direction.

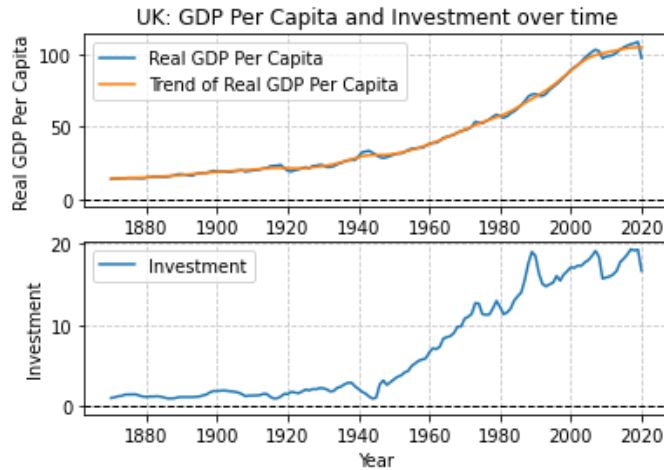
Investment to GDP

Investment, and investment to GDP are two very important macroeconomic indices. Generally, they also present a positive trend over the years.



Investments are a component of aggregate demand, thus changes in investments can shift the GDP. Investments to GDP present great fluctuations over time. A great decrease in investments (both in absolute values and as % of GDP) can be seen in the 1940's at the WW2, which can be explained due to the economic uncertainty at that time. After the war, UK saw substantial increase in investments and capital accumulation as the economy shifted from war related production to rebuilding and growth-focused activities. until the 1970's, when the first oil crisis occurred. Taking

into consideration the role of oil industry in the British economy, an increase in the energy cost, it is obvious that this crisis would influence the investments of the country.



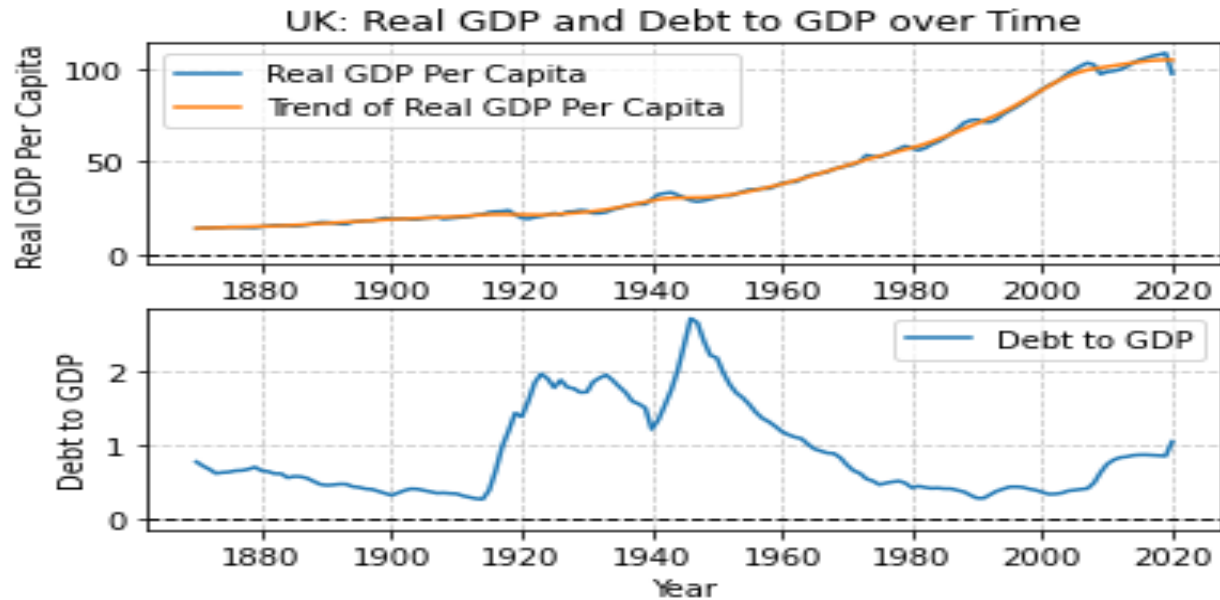
It is obvious, that investment, is a procyclical variable. However, the investments tend to show greater volatility than the real GDP, as they are highly sensitive to changes in economic conditions.

Public Debt (% of GDP)



Debt to GDP ratios, from 1870 to 1920 generally presented a downward trend, which is a signal of economic growth and sustainability. After the 1914 and the 1940 war outbreaks, there is a significant increase in the debt to GDP ratio, which can be explained, because a typical increase in the country's debt (during war periods), was paired with a slump of the real GDP.

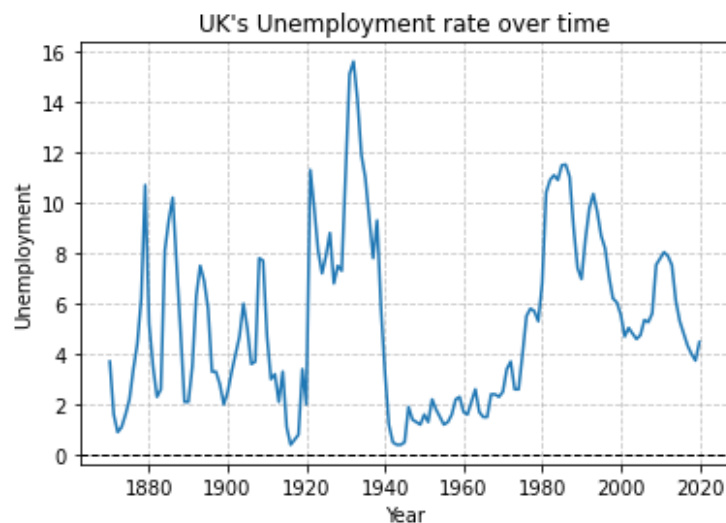
After the end of WW2, a constant decrease in debt to GDP ratios, can be observed, with minor increases at times of economic uncertainty, (i.e. 1974 energy crisis).



To Conclude, the UK's debt-to-GDP ratio has fluctuated significantly between 1870 and 2020. In the late 19th century, it was relatively stable and low, below 50%, due to fiscal prudence and economic growth. However, both World Wars caused dramatic spikes; after WWI, debt-to-GDP surged to around 180%, and following WWII, it peaked near 250%. Post-WWII, the ratio gradually decreased due to sustained economic growth and inflation, falling to around 30% by the 1990s.

In the 2000s, the ratio began climbing again, especially after the 2008 financial crisis, reaching over 80%. From 2010 onwards, austerity measures and moderate growth helped stabilize the ratio, but with COVID-19-related spending in 2020, the debt-to-GDP ratio jumped above 100%, a level not seen since the 1960s.

Unemployment



Looking at the data for the United Kingdom, unemployment rate displays high volatility. When studying unemployment, we come across Okun's law, an economic theory, which links unemployment rate with the real output of an economy. In simple terms, a 1% increase in unemployment a country's GDP will be an additional 2% lower than its potential GDP (natural output-the highest level of output, sustainable over the long term).



While Okun's law is generally accepted by economists worldwide, empirical evidence sometimes shows a different relation between the GDP and employment- unemployment.

B. Monetary Cycles

When focusing on monetary cycles analysis, it is very important to address the measures we will be looking at. It is mandatory to clarify what each of these measures represent:

The Bank of England defines the basic monetary aggregates as follows:

- **MB (Monetary Base):** This includes currency in circulation (banknotes and coins) outside the central bank, along with reserves held by commercial banks at the central bank. These reserves consist of banks' cash deposits at the Bank of England, representing the most liquid form of money in the economy.
- **M1:** M1 is a narrow measure of the money supply, including:
 - o Currency in circulation (banknotes and coins).
 - o Demand deposits (such as checking accounts) that are easily accessible for spending. M1 excludes long-term savings deposits and large money market balances. It represents liquid money readily available for transactions.
- **M3:** M3 is a broader measure of the money supply, encompassing:
 - o All components of M1.
 - o Time deposits and other quasi-money (longer-term deposits and financial assets that are less liquid but still hold value).
 - o Certain types of money market instruments.
 - o M3 provides a more comprehensive view of the total money in the economy, including both highly liquid forms and those that are less immediately accessible.

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The UK was not member of any monetary system, because of this decision, the Bank of England (Central Bank of the UK), is able to use the interest rates to conduct monetary policy.

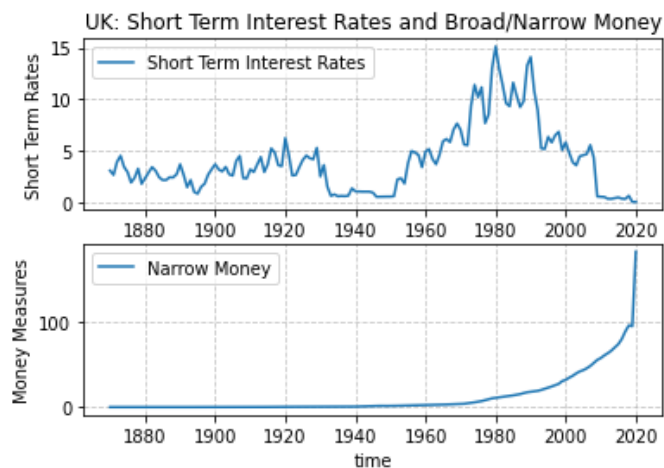
For my analysis, I used data about the short-term and the long-term interest rates.

Instead of using all the monetary variables I presented before, I focused on narrow and broad money, which can be calculated as follows:

$$\text{Narrow Money} = MB + \text{demand deposits} = M1$$

$$\text{Broad Money} = \text{Narrow Money} + \text{Time Deposits} + \text{Other Quasi Money} = M3$$

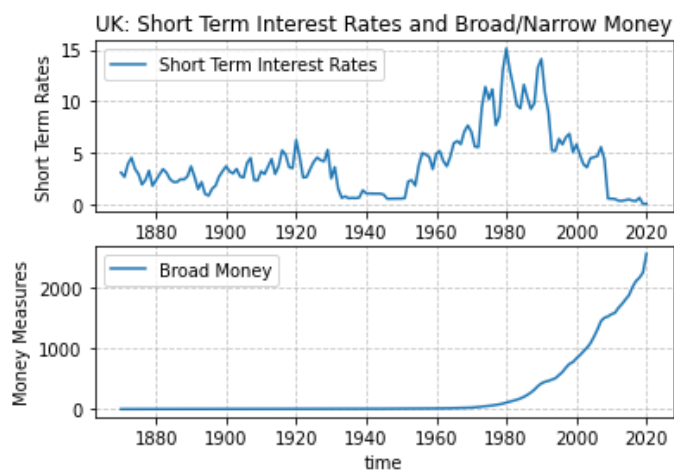
Short term interest rates and Narrow Money:



Looking at the plots, we cannot easily identify the ways in which Narrow and broad money were affected by the interest rates. Before the 1960's the money measures remained relatively balanced, with no substantial movement.

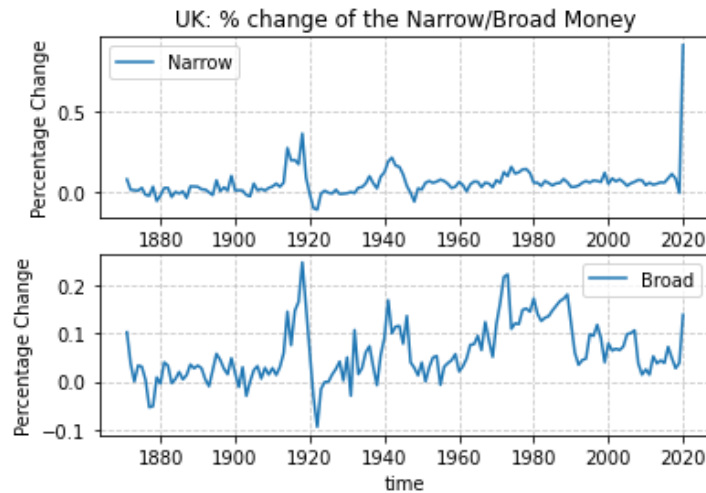
After the 1960's, a continuous upward trend is visible with minor exceptions. In this period, interest rates were declining (while increasing only at times of high inflation).

Short term interest rates and Broad Money:

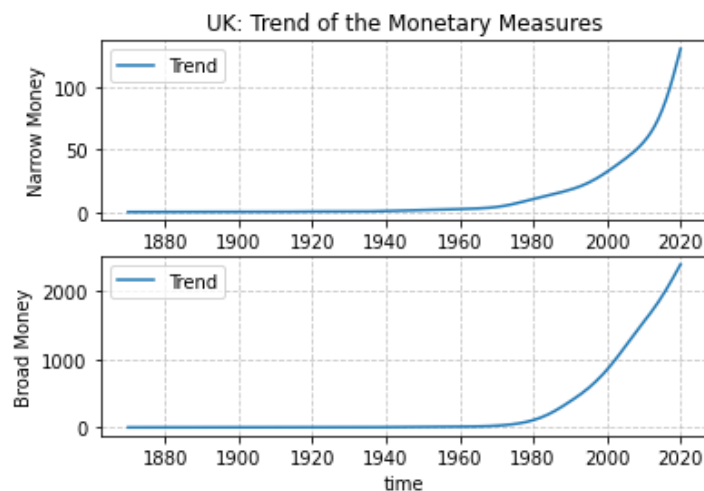


We conclude that lower interest rates, can cause an increase of both narrow and broad money.

Looking at the percentage changes of these measures in the long term, we can identify patterns of the movement for both the narrow and broad money.



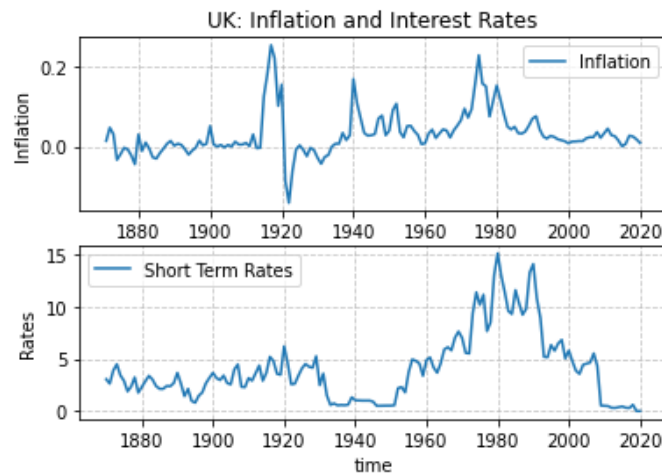
From 1870 to 2020, the UK's narrow and broad money supply evolved significantly in response to economic shifts, financial innovation, and policy changes. During the late 19th century under the gold standard, both aggregates grew slowly, with the money supply tightly regulated. Post-WWI, economic instability and departure from the gold standard in 1931 allowed for more expansion, with both narrow and broad money increasing as authorities sought economic stability. After WWII, welfare policies and reconstruction fueled steady money growth, which accelerated in the 1970s due to inflationary pressures and the collapse of Bretton Woods. Financial deregulation in the 1980s and 1990s further expanded broad money, especially through credit growth, while narrow money grew more moderately. The 2008 financial crisis marked a shift toward aggressive monetary interventions, including quantitative easing (QE), which spiked both narrow and broad money through central bank liquidity measures. By 2020, QE and emergency pandemic responses led to unprecedented expansion in both money supplies, reflecting the UK's adaptive monetary approach over time.



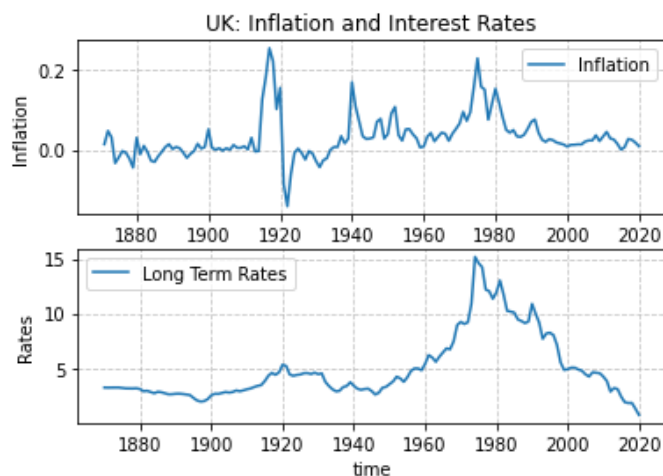
When calculating the trend of this measures, again by using the HP-filter ($\lambda=100$, for annual data), we find a clear positive trend, with a huge spike after the 1980's.

Inflation and Interest Rates

A problem most modern economies face is inflation. As we all know inflation is the constant increase in the prices of goods and services over time.



Governments that can use interest rates as monetary policy tool, tend to increase the interest rates, at times of high inflation. The higher interest rates increase the cost of borrowing money, which means fewer investments are made and economic activity slows down, as well as inflationary pressures (i.e. 1920, 1974 and 2008).



On the other hand, when inflation is under the 2% target point, is a signal of slow economic growth, and the central bank decreases the interest rates giving the incentive to borrow money and invest.

When comparing the effect of long-term and short-term interest rates on inflation, we conclude that:

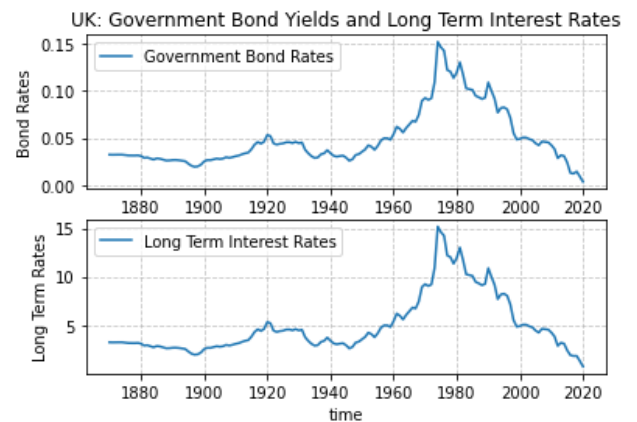
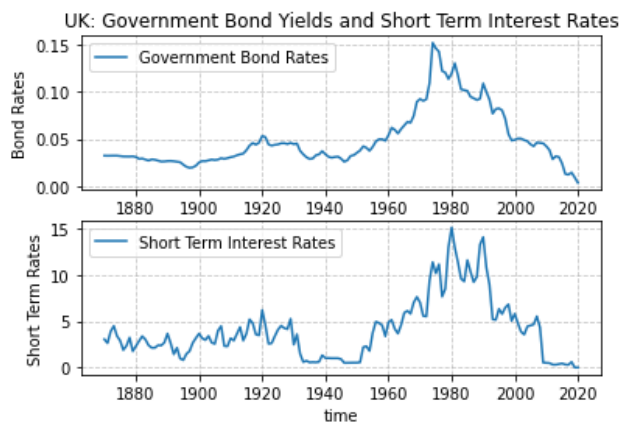
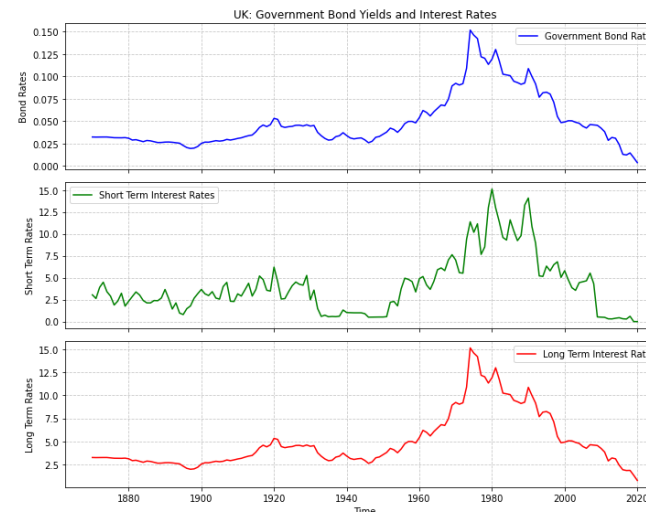
- Short-term interest rates display higher volatility than the long-term interest
- Both are used in the same way to fight back inflation. For example, if we take a closer look at the major economic crises of our observation period, we can see both types of interest rates fall during periods of conflict (World Wars) and reach their peak at times of high cost and inflation (1974 oil crisis), when inflation passing the 20% mark in 1975 with both long-term and short-term interest rates passing 15%.
On the other hand, during the 2008's financial crisis, interest rates came close to 0%, to fight off recession and boost economic activity.

Government Bond Yields

Government bond yields generally have an inverse relationship with bond prices, not directly with interest rates, though interest rates strongly influence bond prices. When interest rates fall, bond prices typically rise, which results in a decrease in bond yields, not an increase. This inverse relationship occurs because the fixed coupon payments of the bond become more attractive when interest rates are lower, driving up the bond price and lowering the yield.

Generally, when short-term interest rates are high, government bond yields tend to rise, reflecting the need to compensate investors for higher borrowing costs and inflation expectations. However, long-term yields, like the 10-year government bond, also respond to broader expectations of economic growth and inflation stability.

From 1870 until World War I, UK bond yields were stable and low, reflecting confidence in the British economy and low inflation. However, during both World Wars, yields rose due to economic uncertainty and increased government borrowing. The post-war period saw varying yields in response to changing interest rates and inflation expectations, peaking in the 1970s and 1980s amid high inflation and restrictive monetary policy. From the 1990s onward, UK yields began to decline, with a trend toward lower interest rates as inflation was kept in check. By 2020, amid ultra-low interest rates following the 2008 financial crisis and COVID-19 pandemic, UK 10-year yields hit historic lows, underscoring the bond market's sensitivity to prolonged periods of low interest rates. This period reflects how both short- and long-term rates shape bond yields, often moving together but diverging when economic uncertainty or inflationary pressures shift expectations.



C. Fiscal Sustainability Analysis

Debt to GDP

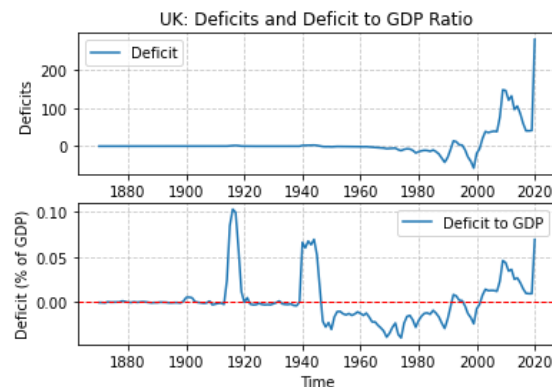


When studying debt sustainability, we typically measure the Debt to GDP ratios, which gives us a better understanding of the country's obligations, in relation to its total output. Except for this, it is a great way to compare the debt between multiple countries.

For the UK, up until the 1920's, there was a clear downwards trend. During the first world war, there was a spike from under 50% to almost 200% later in the 1930's when there was a small dump until the 1940's. When the second world war occurred, debt o GDP ratios reached all time high for the United Kingdom, surpassing the 250% barrier in 1945. Since then, debt to GDP ratios have declined, with only increases in the 2008 financial crisis and the 2020 pandemic. In 2020 the public debt sits at 100.44% of the GDP.

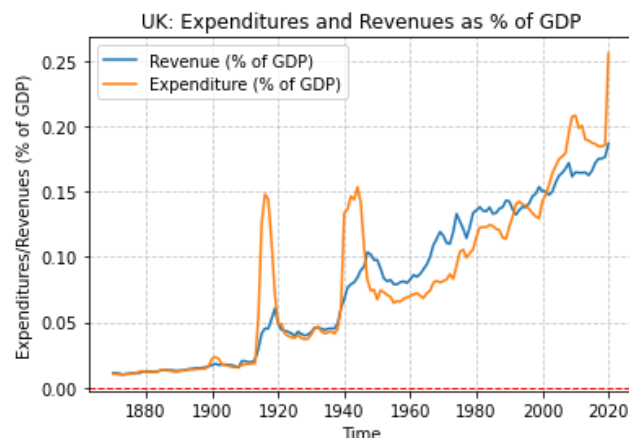
Deficits and Deficits to GDP

To calculate UK's deficit over the years, I used the Expenditures and Receipts. For better accuracy I divided the Deficit with the nominal GDP, to calculate the Deficit to GDP ratio. The latter one, gives us the opportunity to compare the deficit over the years.



Government Expenditures/Receipts

It is obvious that government expenditures and revenue shape the country's deficit/surplus and therefore on the public debt.



Government expenditures tend to increase at times of high geopolitical risks and uncertainty, for example the two world wars in 1920 and 1940, the global financial crisis in 2008 and finally the 2020 pandemic.

As for the government receipts, a general positive trend is obvious, with small fluctuations. We can tell, that during economic crises, the government revenues follow the same direction as the expenditures, but in smaller proportions.

Sustainability of Public Debt:

According to the Governments' Intertemporal Budget Constraint theory the debt-to-GDP ratio of the present can be calculated as the following equation suggests:

$$b_t = \frac{(1+r)}{(1+\pi)(1+\gamma)} b_{t-1} + d_t$$

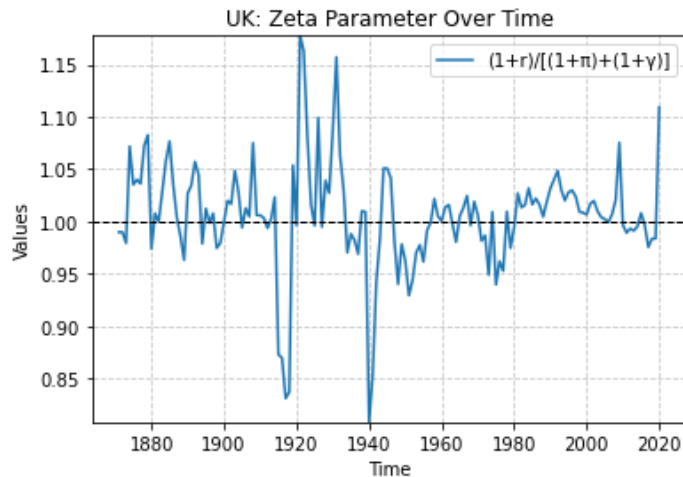
we denote $1+z = \frac{1+r}{(1+\pi)(1+\gamma)}$, the equilibrium outcome of our economy.

If $1+z$ is greater than one, the interest payments growth rates are growing faster than the nominal GDP and is a signal that the economy's debt is not sustainable!

In our model, the $1+z$ variable is dynamically changing, according to the

1. 10-year Government Bond Yields, $(1+r)$
2. Gross Inflation rate $(1+\pi)$
3. Gross Real GDP growth rate $(1+\gamma)$

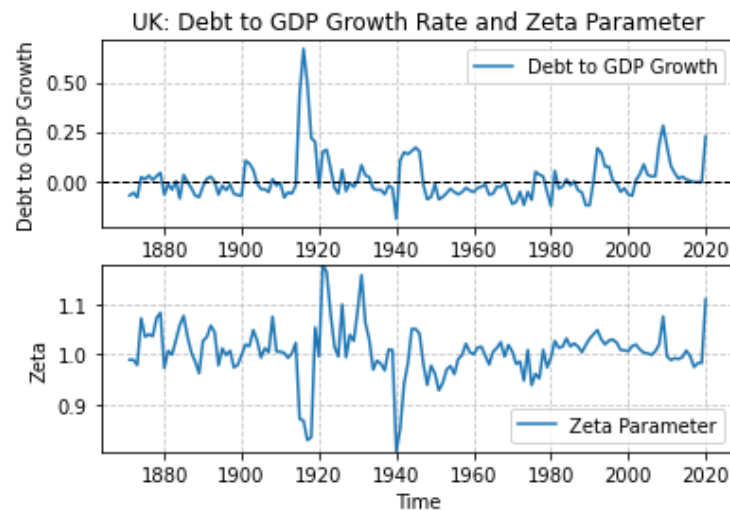
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When the zeta parameter displays higher values, for example over 0.25, public debt (as a share of country's GDP) also spikes. For example, in 1920, zeta parameter was 0.274623, and the debt to GDP increased substantially from 137% in 1919 to 158% in one year.

The all-time highest Debt to GDP was recorded in 1946 (296.8%) when the zeta parameter displayed high values (over 0.25) for 8 consecutive years.

We conclude that when the interest payments grow faster than the nominal GDP for a continuous period, debt to GDP tends to accumulate and reach high points. This is also visible when looking at the debt to GDP growth rates in comparison with the zeta parameter.



Finally, it is obvious that UK's debt in absolute values, shows a continuous positive trend over the years. However, the zeta parameter shows that there are times when the Debt to GDP grew at a not sustainable pace. For example, during the second world war, the zeta parameter was greater than one, which means that the interest payments on the existing debt grew at a faster pace than the country's nominal GDP, this obviously had an effect on the Debt to GDP levels and its growth rate.

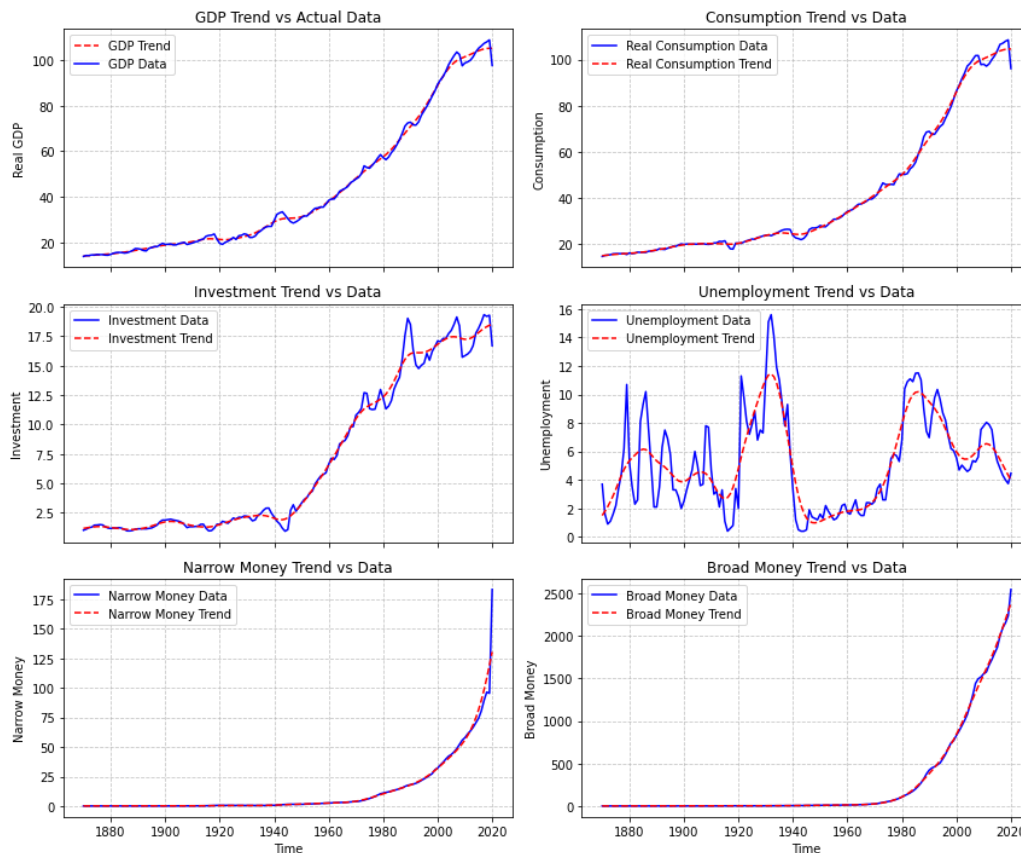
D. A General analysis of the UK economy.

At this point we are going to summarize the key macroeconomic variables and try to explain their movements over time. In the following part let's concentrate on the following variables:

1. Real Gross Domestic Product (Per capita)
2. Real consumption expenditure (Per capita)
3. Investment in million pounds
4. Unemployment rate
5. Narrow Money
6. Broad Money

As I mentioned before, there are 2 main categories of variables when we study business cycles.

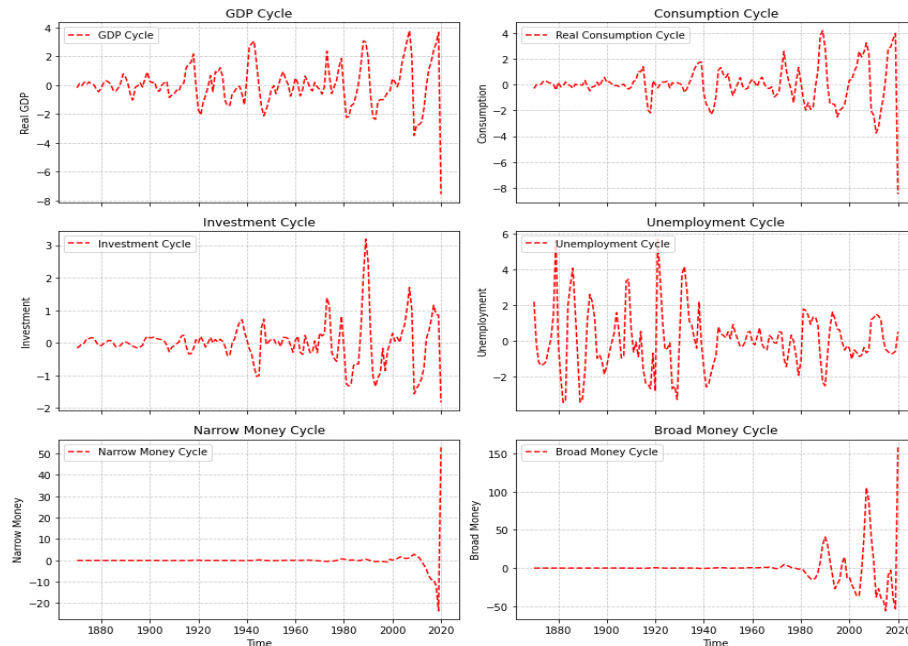
Pro cyclical and counter cyclical variables.



The data show us a continuous positive trend for the GDP and its main components (final consumption expenditure and investments). When it comes to the unemployment rate, using the hp filter we understand that there is no such thing as a long-term trend. Unemployment rate is a counter cyclical variable (just as the economic theory suggests), which means it grows at times of lower output and economic stagnation.

Finally, when looking at the narrow and broad money, they both display a positive term in the long run. The cyclical part of the money measures is minor, to the point that it's not even visible when looking at these plots.

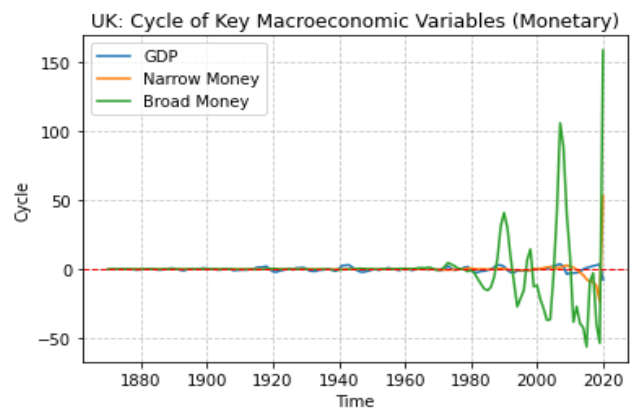
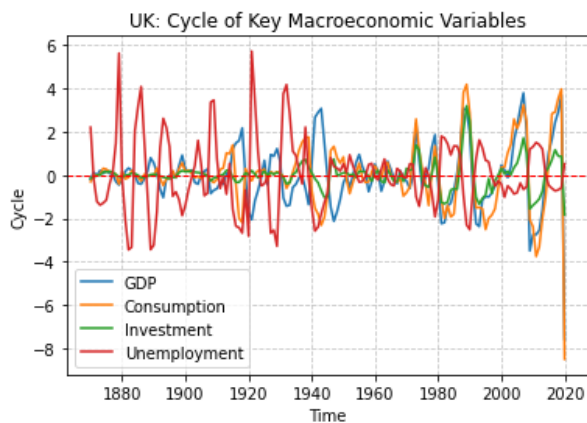
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We can see that; the cycle of Real GDP shows great volatility especially after the 1970s. Consumption seems to strictly follow the GDP's movements, but it is relatively less volatile. On the other hand, investment's cycle is generally greater than the GDP and the consumption. The unemployment rate is no subject to such analysis, as it's movement over the

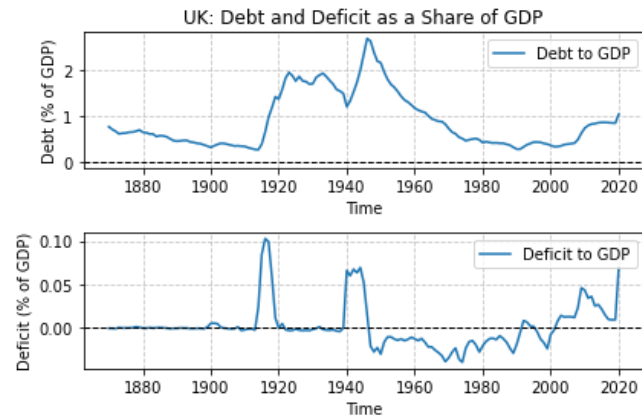
years is so chaotic and cannot be studied in such way.

As mentioned before, the cycle of narrow and broad money remains close to zero until the early 2000s, particularly around the 2008 financial crisis, where both measures start to diverge sharply from prior stability. This increase in money supply, likely a response to the financial turmoil, reflects extensive monetary interventions by central banks aimed at economic stabilization. Following the crisis, both narrow and broad money indicators exhibit increased volatility, with periods of rapid growth and contraction aligning closely with ongoing economic uncertainties and policy shifts. This heightened sensitivity to economic shocks was further evident in 2020, when the COVID-19 pandemic led to a significant surge in narrow money in England. In response to economic slowdowns and lockdowns, the Bank of England implemented aggressive measures, including low interest rates and quantitative easing, to inject liquidity into the system. Consequently, narrow money expanded as households and businesses held onto more liquid assets, reflecting both a shift in policy and heightened demand for liquidity amid widespread uncertainty.



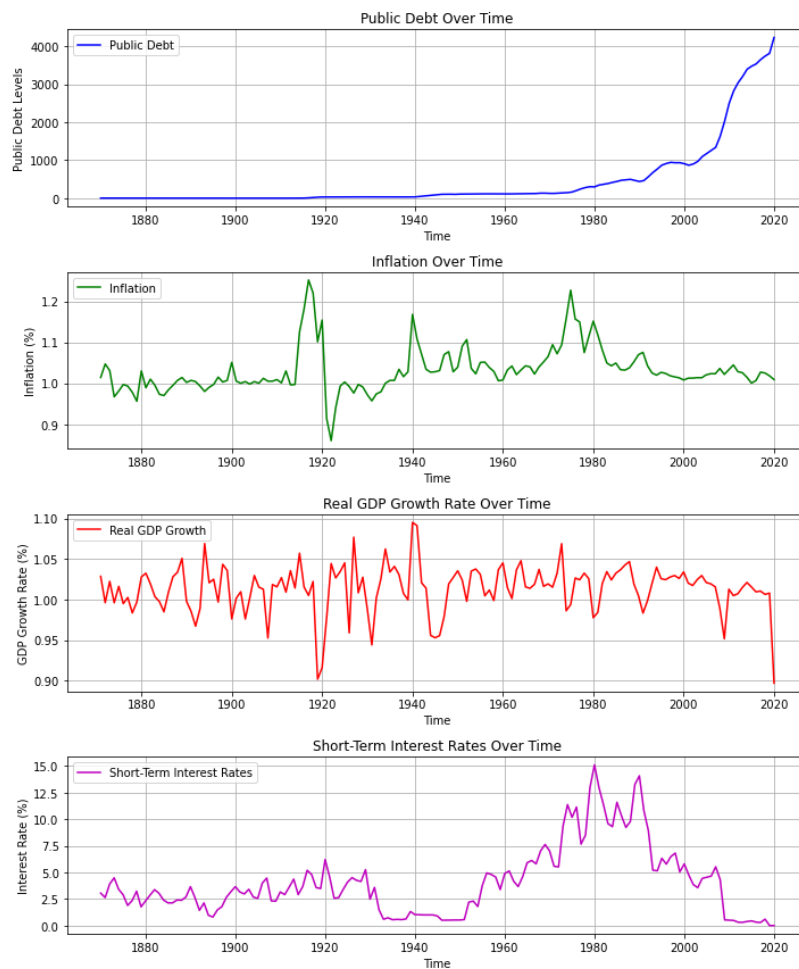
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Now let's examine the Debt and the Deficit of the UK



As we expected, debt as a share of GDP increased after the 2 world wars, the financial crisis in 2008 and slightly at 2020 pandemic.

Deficit to GDP also shows the same movement, increasing in 1920, 1940 and in the financial crisis.

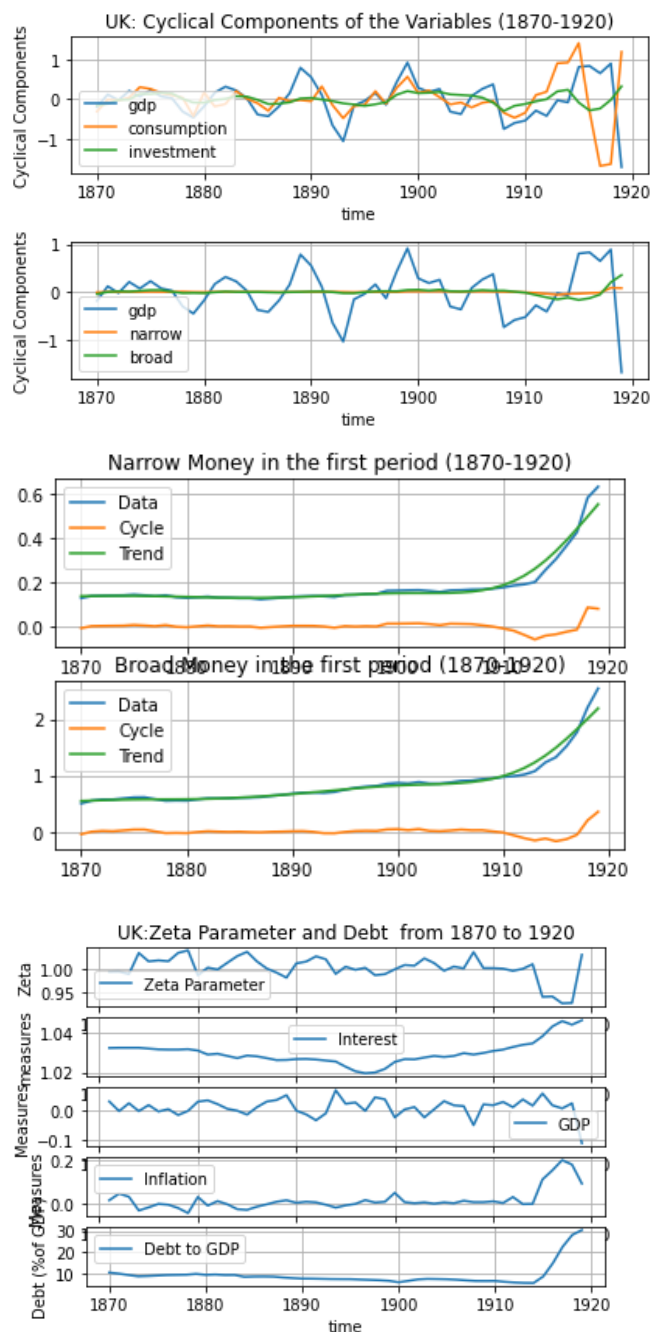


Public debt has fluctuated, peaking during World Wars and following major economic crises, with debt levels reaching new highs in the 21st century after the 2008 financial crisis and COVID-19 pandemic. Inflation remained relatively low until the 1970s, when it surged due to oil shocks and economic stagnation, leading to a period of high inflation and volatile prices. Real GDP growth has seen both stable periods, as in the post-WWII boom, and contractions during recessions, with notable declines in 2008 and 2020. Short-term interest rates have varied widely, peaking in response to inflation in the 1970s and 1980s, then declining as central banks adopted low-rate policies in the 2000s, culminating in near-zero rates after 2008 to stimulate growth.

E. Subsample analysis

In this project we collected data and analyzed key macroeconomic variables of the United Kingdom. We examined 150 years of economic crises, geopolitical and political uncertainty and much more. Thus, it is important that we emphasize in specific time periods, three time periods of 50 years, to examine each case.

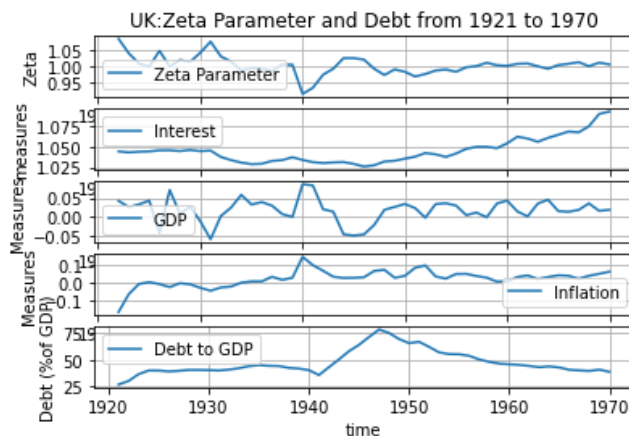
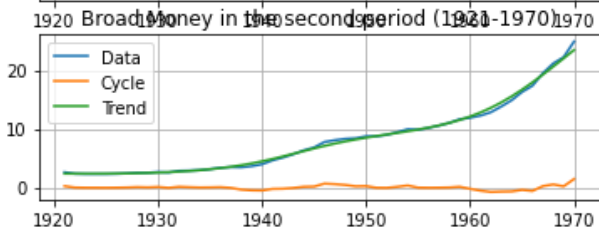
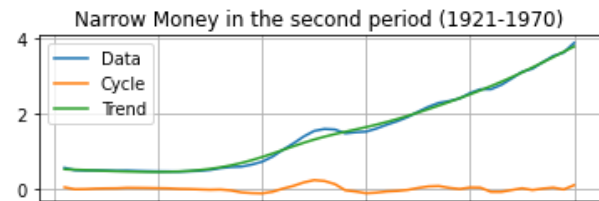
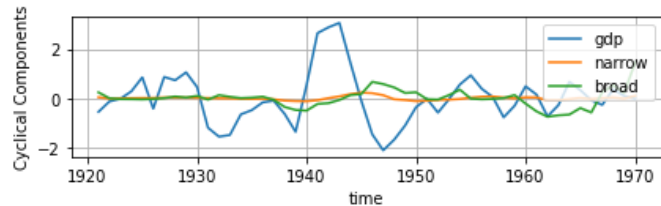
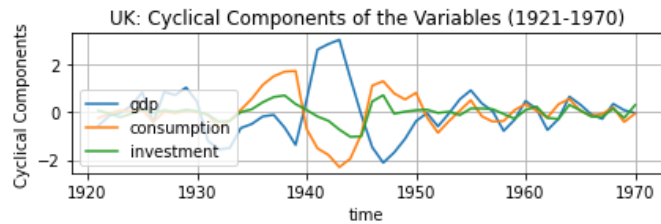
First period (1870-1920):



Between 1870 and 1920, the UK economy saw steady Real GDP growth, although it slowed by the 1890s as global competition increased. World War I, however, caused a sharp decline in economic activity, redirecting resources to the war effort and reducing productivity. Consumption followed GDP trends, expanding until the war, when rationing and inflation affected civilian spending. Investment was high in the late 19th century, particularly in infrastructure and industry, but fell as military demands crowded out private investment during WWI.

Both narrow and broad money supplies expanded steadily, with a spike during the war as the government financed military expenses, contributing to significant inflation and currency devaluation. Government bond yields were stable until wartime borrowing drove them up to attract investors. The debt-to-GDP ratio, low before the war, surged due to heavy wartime borrowing, leading to fiscal pressures and economic constraints in the post-war period. These developments reshaped the UK economy, setting the stage for the fiscal challenges of the interwar years.

Second period (1921-1970)

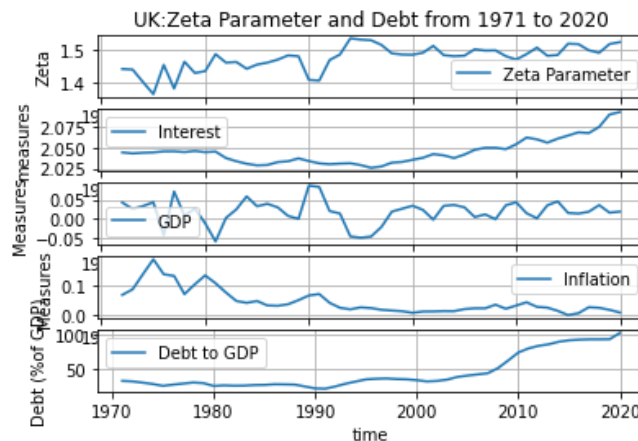
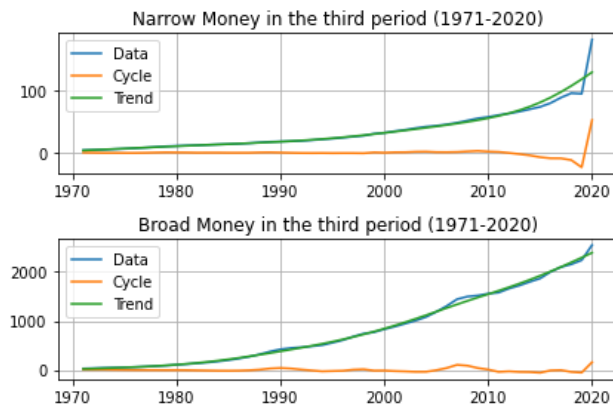
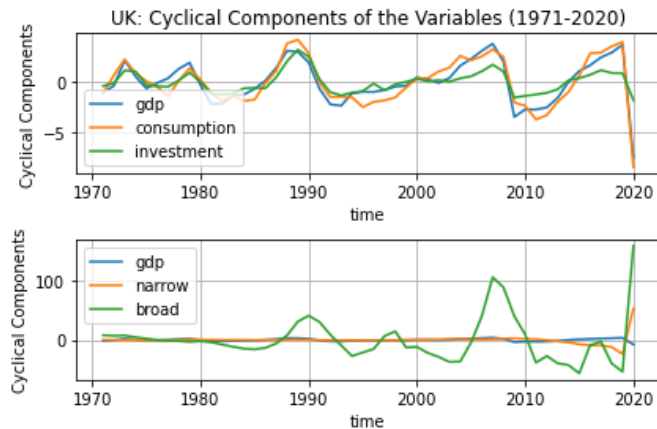


Between 1921 and 1970, the UK economy experienced major shifts influenced by post-WWI recovery, the Great Depression, WWII, and post-war reconstruction. Real GDP grew slowly in the 1920s, with high unemployment and global instability, then contracted during the Great Depression. WWII redirected resources to military production, spurring output, and post-war reconstruction led to rapid GDP growth as the government invested in infrastructure and welfare.

Consumption remained low through the 1920s and 1930s but increased significantly after WWII with rising living standards and greater access to consumer goods. Investment was volatile, limited by economic uncertainty in the interwar years, but surged after WWII with public spending driving industrial growth.

The money supply expanded steadily, especially after WWII, as government spending rose. Inflation was a recurring issue, spiking after WWII due to demand and shortages. Government bond yields fluctuated, peaking during wartime borrowing but stabilizing post-war. The debt-to-GDP ratio surged after WWII, then gradually declined with post-war growth, shaping a modern, mixed economy with rising prosperity and expanded social services.

Third period (1971-2020):



Between 1971 and 2020, the UK economy faced significant changes shaped by oil crises, shifts in industrial policy, globalization, and major financial upheavals. Real GDP growth fluctuated through the 1970s due to the oil shocks, leading to high inflation and stagnation, a period often called “stagflation.” Growth rebounded in the 1980s with market-oriented reforms, deregulation, and privatization, but deindustrialization impacted traditional sectors. The 1990s saw steady growth, fueled by globalization and financial expansion.

Consumption grew steadily, supported by rising household incomes and increased credit availability, though consumer debt also rose. Investment was uneven, slowing during the crises of the 1970s and 2008-2009, but generally rising with technological and financial sector growth.