Macroeconomics

1. Focus

- The performance, structure, behaviour of an economy as a whole
- rather than of individuals, firms and individual markets

2. Topics

- aggregate output, aggregate unemployment, aggregate price level, aggregate consumption, aggregate investment, aggregate saving, international trade

3. Measures

- GDP, unemployment rate, CPI and GDP deflator, inflation rate, etc

GDP

a) Total market value of all final goods and services produced in an economy over a given period

b) The total income earned by factors of production in an economy over a given period

c) The total expenditure on final goods and services in the economy during a given period

GDP concepts

- Length of a period and units of measurement
- GDP vs GDP per capita
- Nominal vs real GDP
- GDP vs GDP growth rate
- GDP and components of expenditure

GDP:

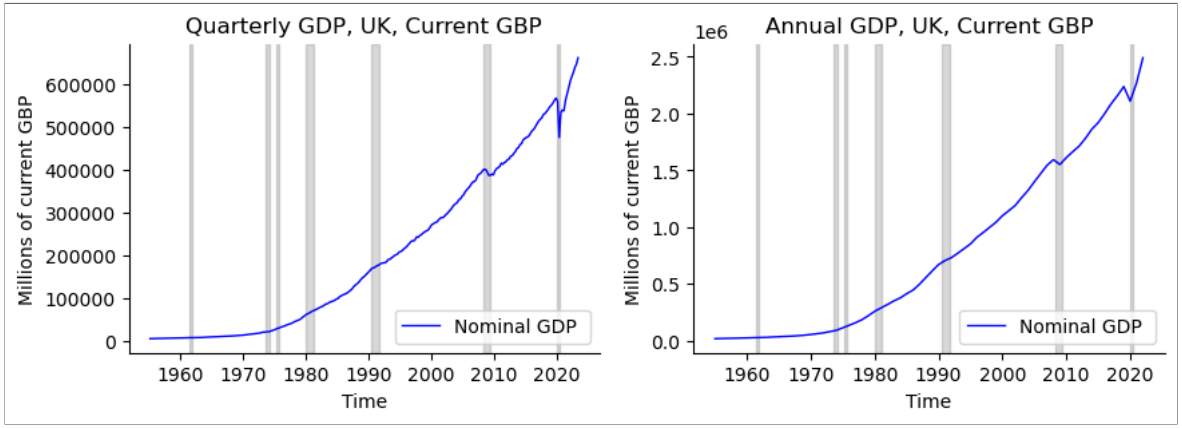
- length of a period and units of measurement

In [35]:

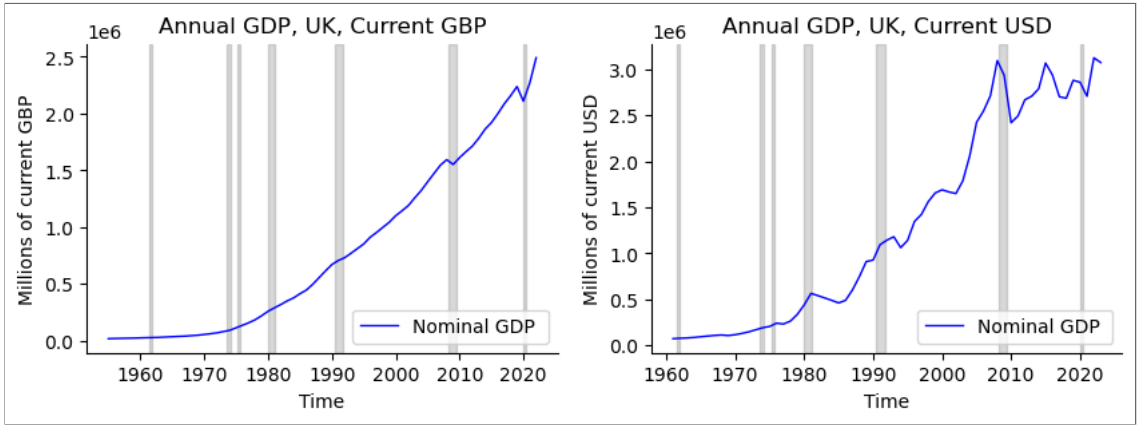
```
dat = hcat(ons_yr[end-10:end],ons_yr_gdp_current[end-10:end])
header = (["Year","Nominal GDP, millions of £"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.0f"))
```

Year	Nominal GDP, millions of £
2012-01-01	1713241
2013-01-01	1782296
2014-01-01	1862827
2015-01-01	1920998
2016-01-01	1999461
2017-01-01	2085008
2018-01-01	2157410
2019-01-01	2238348
2020-01-01	2109594
2021-01-01	2270246
2022-01-01	2491238

In [37]:
```
p1()
```


Quarterly GDP, UK, Current GBP
Millions of current GBP
600000
500000
400000
300000
200000
100000
0
1960
1970
1980
1990
2000
2010
2020
Time
Nominal GDP
Annual GDP, UK, Current GBP
1e6
2.5
2.0
1.5
1.0
0.5
0.0
Millions of current GBP
1960
1970
1980
1990
2000
2010
2020
Time
Nominal GDP

In [41]:
```
p2()
```


Annual GDP, UK, Current GBP
1e6
Millions of current GBP
Nominal GDP
Time
Annual GDP, UK, Current USD
1e6
Millions of current USD
Nominal GDP
Time

GDP and GDP per capita

$$GDPpercapita_t = \frac{GDP_t}{Population_t}$$

In [44]:

```
dat = hcat(ons_yr[end-10:end],ons_yr_gdp_current[end-10:end],ons_yr_pop[end-10:end]./1000000, [ons_yr_gdppc_current[end-10:end-1];"?"])
header = (["Year","Nominal GDP, millions of £", "Population, millions", "Nominal GDP per capita,£"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

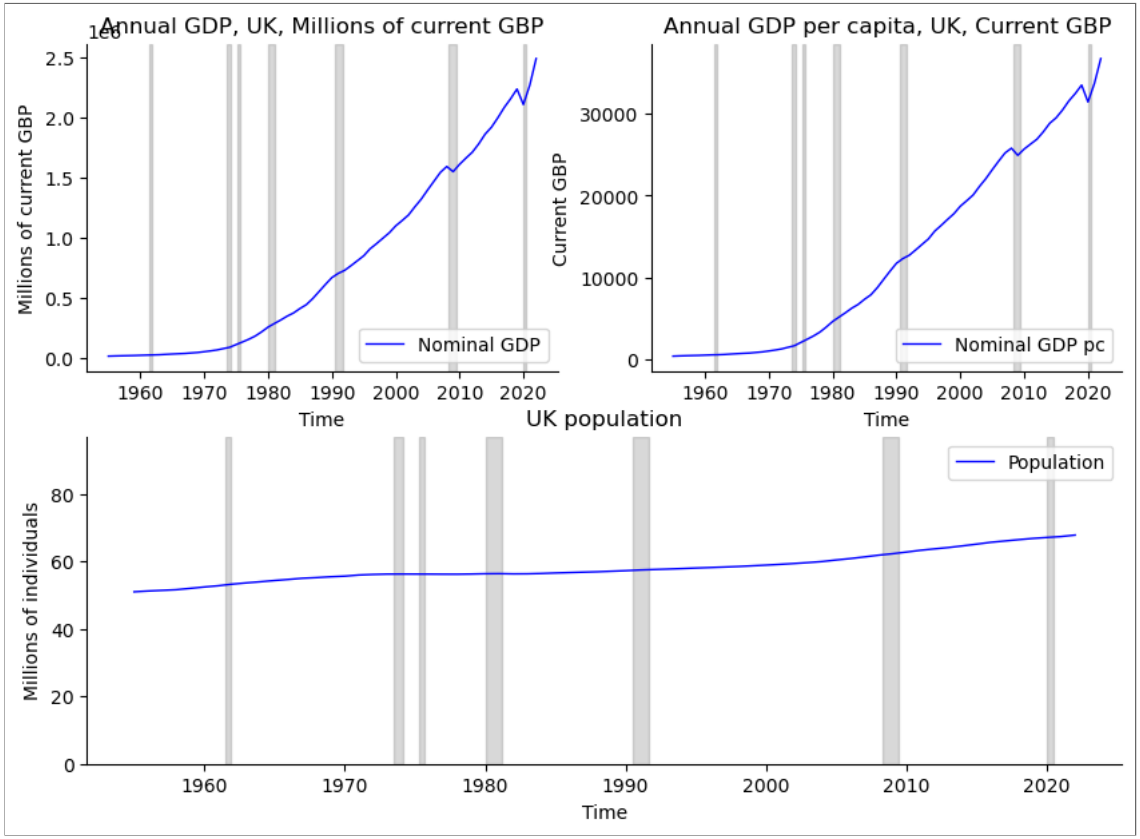
Year	Nominal GDP, millions of £	Population, millions	Nominal GDP per capita,£
2012-01-01	1713241.000	63.706	26893.000
2013-01-01	1782296.000	64.107	27802.000
2014-01-01	1862827.000	64.596	28838.000
2015-01-01	1920998.000	65.110	29504.000
2016-01-01	1999461.000	65.649	30457.000
2017-01-01	2085008.000	66.040	31572.000
2018-01-01	2157410.000	66.435	32474.000
2019-01-01	2238348.000	66.796	33510.000
2020-01-01	2109594.000	67.082	31448.000
2021-01-01	2270246.000	67.350	33708.000
2022-01-01	2491238.000	67.791	?

In [45]:

```
dat = hcat(ons_yr[end-10:end],ons_yr_gdp_current[end-10:end]./1000000,ons_yr_pop[end-10:end]./1000000, ons_yr_gdppc_current[end-10:end])
header = (["Year","Nominal GDP, Trillions of £", "Population, millions", "Nominal GDP per capita,£"])
pretty_table(dat; backend = Val(:html), header = header)
```

Year	Nominal GDP, Trillions of £	Population, millions	Nominal GDP per capita,£
2012-01-01	1.71324	63.7058	26893.0
2013-01-01	1.7823	64.1068	27802.0
2014-01-01	1.86283	64.5963	28838.0
2015-01-01	1.921	65.1097	29504.0
2016-01-01	1.99946	65.6487	30457.0
2017-01-01	2.08501	66.0398	31572.0
2018-01-01	2.15741	66.435	32474.0
2019-01-01	2.23835	66.7964	33510.0
2020-01-01	2.10959	67.082	31448.0
2021-01-01	2.27025	67.3504	33708.0
2022-01-01	2.49124	67.7906	36749.0

In [46]:
```
p3()
```


Annual GDP, UK, Millions of current GBP
1e6
Millions of current GBP
Nominal GDP
Time
Annual GDP per capita, UK, Current GBP
Current GBP
Nominal GDP pc
Time
UK population
Millions of individuals
Population
Time

Nominal vs real GDP

A REAL QUANTITY OS OBTAINED FROM NOMINAL BY DIVIDING THE NOMINAL BY A MEASURE OF THE PRICE LEVEL

$$\text{Real GDP}_t = \frac{\text{Nominal GDP}_t}{\text{GDP deflator}_t}$$

$$\text{Real GDP per capita}_t = \frac{\text{Nominal GDP per capita}_t}{\text{GDP deflator}_t}$$

In [48]:

```
dat = hcat(ons_yr[end-10:end],ons_yr_gdppc_current[end-10:end], ons_yr_gdpdef[end-10:end],[ons_yr_gdppc_constant[end-10:end-1];"?"])
header = (["Year","Nominal GDP per capita,£", "GDP deflator","Real GDP per capita,£"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

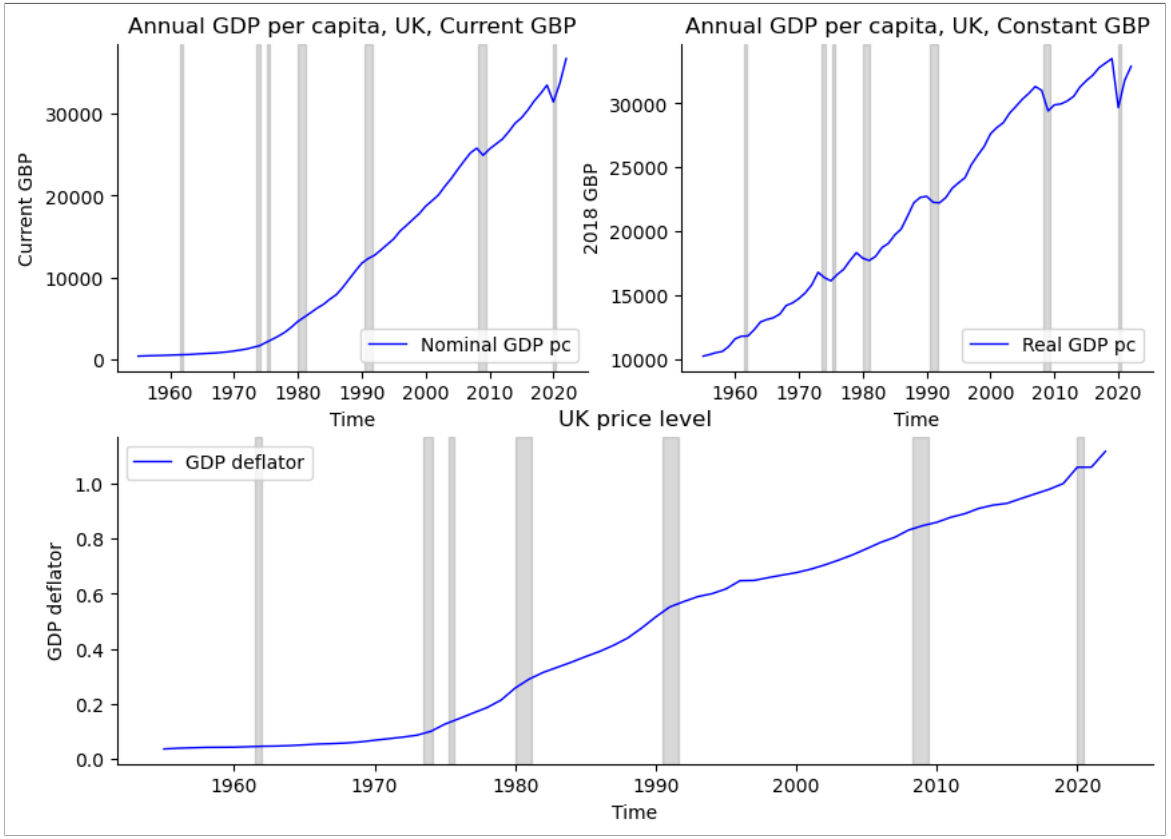
Year	Nominal GDP per capita,£	GDP deflator	Real GDP per capita,£
2012-01-01	26893.000	0.891	30195.000
2013-01-01	27802.000	0.910	30552.000
2014-01-01	28838.000	0.922	31290.000
2015-01-01	29504.000	0.928	31786.000
2016-01-01	30457.000	0.946	32208.000
2017-01-01	31572.000	0.963	32799.000
2018-01-01	32474.000	0.979	33160.000
2019-01-01	33510.000	1.000	33510.000
2020-01-01	31448.000	1.059	29687.000
2021-01-01	33708.000	1.060	31814.000
2022-01-01	36749.000	1.117	?

In [49]:

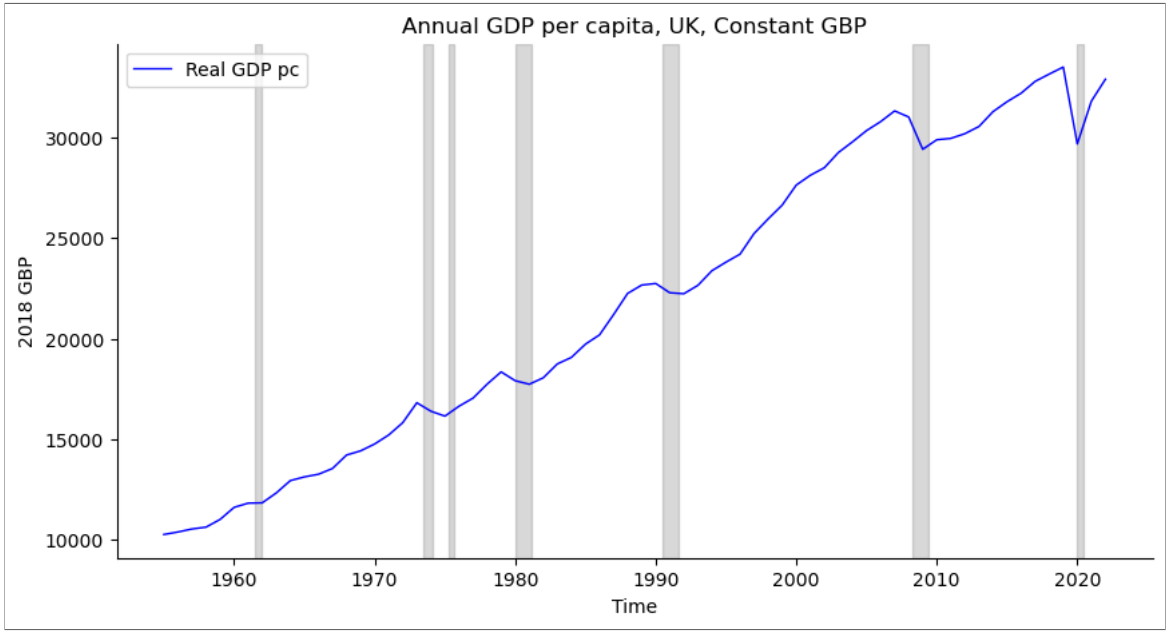
```
dat = hcat(ons_yr[end-10:end],ons_yr_gdppc_current[end-10:end], ons_yr_gdpdef[end-10:end],ons_yr_gdppc_constant[end-10:end])
header = (["Year","Nominal GDP per capita,£", "GDP deflator","Real GDP per capita,£"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

Year	Nominal GDP per capita,£	GDP deflator	Real GDP per capita,£
2012-01-01	26893.000	0.891	30195.000
2013-01-01	27802.000	0.910	30552.000
2014-01-01	28838.000	0.922	31290.000
2015-01-01	29504.000	0.928	31786.000
2016-01-01	30457.000	0.946	32208.000
2017-01-01	31572.000	0.963	32799.000
2018-01-01	32474.000	0.979	33160.000
2019-01-01	33510.000	1.000	33510.000
2020-01-01	31448.000	1.059	29687.000
2021-01-01	33708.000	1.060	31814.000
2022-01-01	36749.000	1.117	32904.000

In [50]:
```
p4()
```


Annual GDP per capita, UK, Current GBP
Current GBP
Nominal GDP pc
Time
Annual GDP per capita, UK, Constant GBP
2018 GBP
Real GDP pc
Time
UK price level
GDP deflator
GDP deflator
Time

In [52]:
```
p5()
```


Annual GDP per capita, UK, Constant GBP
Real GDP pc
2018 GBP
30000
25000
20000
15000
10000
1960
1970
1980
1990
2000
2010
2020
Time

Growth rates

Given a sequence, y_T, that changes over time, T, its per-period growth rate is

$$g_t^y = \frac{y_{t+1} - y_t}{y_t}$$

- For example, if GDP_t is GDP in year t then

$$\frac{GDP_{t+1} - GDP_t}{GDP_t} = \frac{\Delta GDP_t}{GDP_t}$$

is the annual GDP growth rate over year t

- if $GDPpc_t$ is per-capita GDP in quarter t then

$$\frac{GDPpc_{t+1} - GDPpc_t}{GDPpc_t} = \frac{\Delta GDPpc_t}{GDPpc_t}$$

is the quarterly GDP per capita growth rate over year t

- if P_t is the price level at year t then

$$\pi_t = \frac{P_{t+1} - P_t}{P_t} = \frac{\Delta P_t}{P_t}$$

is the annual growth rate of the price level over year t (the inflation rate)

In [54]:

```
dat = hcat(ons_yr[end-10:end],ons_yr_gdppc_constant[end-10:end],[(ons_yr_gdppc_constant[end-9:end-1]-ons_yr_gdppc_constant[end-10:end-2])./ons_yr_gdppc_constant[end-10:end-2];"?";"."])
header = (["Year","Real GDP per capita,£","Real GDP per capita, Growth rate"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

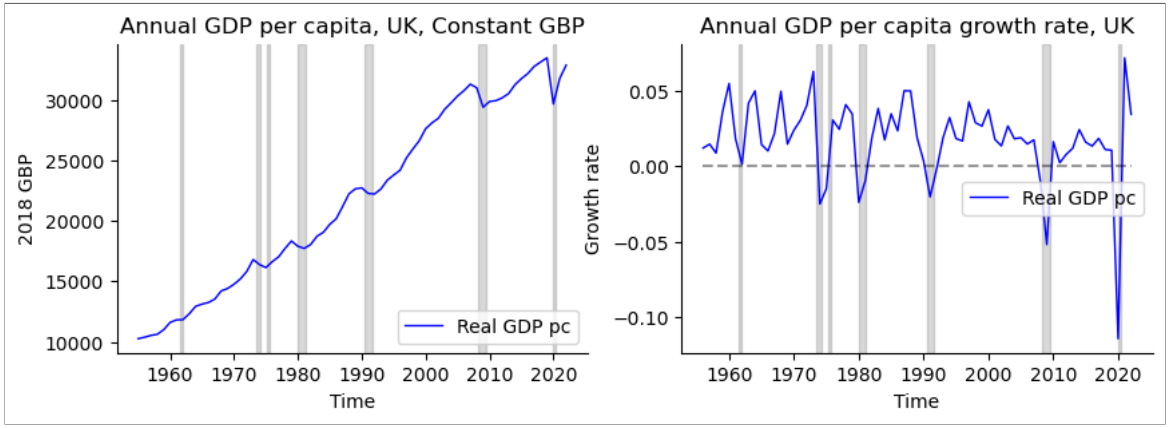
Year	Real GDP per capita,£	Real GDP per capita, Growth rate
2012-01-01	30195.000	0.012
2013-01-01	30552.000	0.024
2014-01-01	31290.000	0.016
2015-01-01	31786.000	0.013
2016-01-01	32208.000	0.018
2017-01-01	32799.000	0.011
2018-01-01	33160.000	0.011
2019-01-01	33510.000	-0.114
2020-01-01	29687.000	0.072
2021-01-01	31814.000	?
2022-01-01	32904.000	.

In [55]:

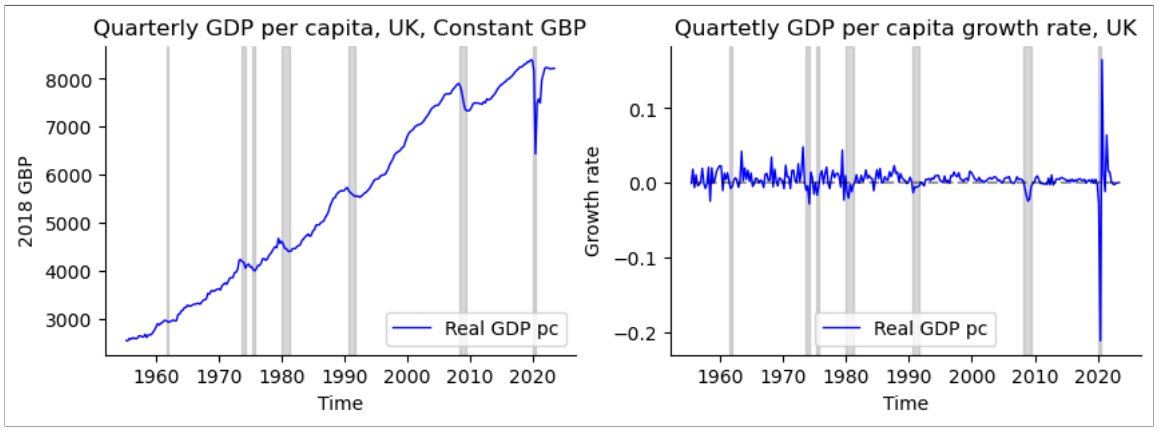
```
dat = hcat(ons_yr[end-10:end],ons_yr_gdppc_constant[end-10:end],[(ons_yr_gdppc_constant[end-9:end]-ons_yr_gdppc_constant[end-10:end-1])./ons_yr_gdppc_constant[end-10:end-1];"."])
header = (["Year","Real GDP per capita,£","Real GDP per capita, Growth rate"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

Year	Real GDP per capita,£	Real GDP per capita, Growth rate
2012-01-01	30195.000	0.012
2013-01-01	30552.000	0.024
2014-01-01	31290.000	0.016
2015-01-01	31786.000	0.013
2016-01-01	32208.000	0.018
2017-01-01	32799.000	0.011
2018-01-01	33160.000	0.011
2019-01-01	33510.000	-0.114
2020-01-01	29687.000	0.072
2021-01-01	31814.000	0.034
2022-01-01	32904.000	.

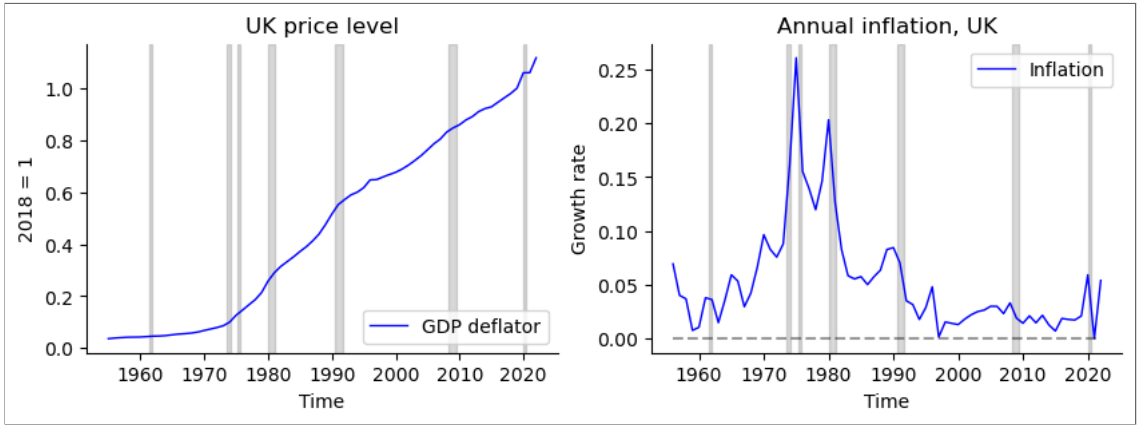
In [56]:
```
p6()
```


Annual GDP per capita, UK, Constant GBP
2018 GBP
30000
25000
20000
15000
10000
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP pc
Annual GDP per capita growth rate, UK
Growth rate
0.05
0.00
−0.05
−0.10
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP pc

In [63]:
```
p7()
```


Quarterly GDP per capita, UK, Constant GBP
2018 GBP
8000
7000
6000
5000
4000
3000
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP pc
Quartetly GDP per capita growth rate, UK
Growth rate
0.1
0.0
−0.1
−0.2
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP pc

In [65]:
```
p8()
```


UK price level
2018 = 1
1.0
0.8
0.6
0.4
0.2
0.0
1960
1970
1980
1990
2000
2010
2020
Time
GDP deflator
Annual inflation, UK
Growth rate
0.25
0.20
0.15
0.10
0.05
0.00
1960
1970
1980
1990
2000
2010
2020
Time
Inflation

In [66]:

```
dat = hcat(ons_yr[end-10:end],[(ons_yr_gdppc_constant[end-9:end]-ons_yr_gdppc_constant[end-10:end-1])./ons_yr_gdppc_constant[end-10:end-1];"."],[(ons_yr_gdp_current[end-9:end]-ons_yr_gdp_current[end-10:end-1])./ons_yr_gdp_current[end-10:end-1];"."],[(ons_yr
header = (["Year","Real GDP per capita, Growth rate", "Nominal GDP, Growth rate", "Population, Growth rate", "GDP deflator, Growth rate"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

Year	Real GDP per capita, Growth rate	Nominal GDP, Growth rate	Population, Growth rate	GDP deflator, Growth rate
2012-01-01	0.012	0.040	0.006	0.022
2013-01-01	0.024	0.045	0.008	0.013
2014-01-01	0.016	0.031	0.008	0.007
2015-01-01	0.013	0.041	0.008	0.019
2016-01-01	0.018	0.043	0.006	0.018
2017-01-01	0.011	0.035	0.006	0.017
2018-01-01	0.011	0.038	0.005	0.021
2019-01-01	-0.114	-0.058	0.004	0.059
2020-01-01	0.072	0.076	0.004	0.000
2021-01-01	0.034	0.097	0.007	0.054
2022-01-01	.	.	.	.

Question 1

GDP and components of expenditure

Recall that GDP equals the total expenditure (on domestically produced goods and services)

$$GDP_t = C_t + I_t + G_t + NX_t$$

$$NX_t = Ex_t - Im_t$$

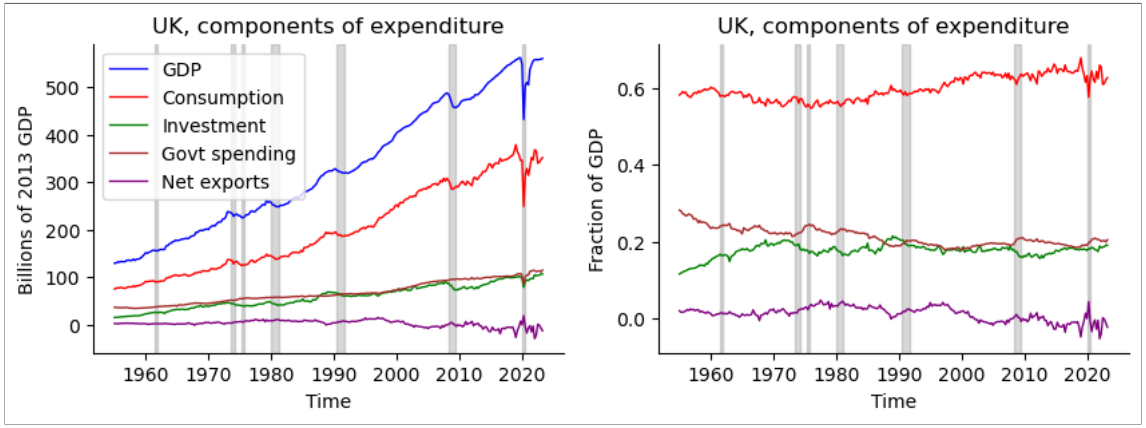
In [69]:

```
dat = hcat(oecd_qr[end-12:end],oecd_gdp[end-12:end],oecd_c[end-12:end],oecd_inv[end-12:end],oecd_g[end-12:end],oecd_nx[end-12:end],oecd_ex[end-12:end],oecd_im[end-12:end])
header = (["Billions of 2013 pounds", "", "","" ,"" ,"" ,"","",""],["Quarter","GDP", "Consumption", "Investment", "Government spending", "Net exports", "Exports","Imports"])
pretty_table(dat; backend = Val(:html), header = header)
```

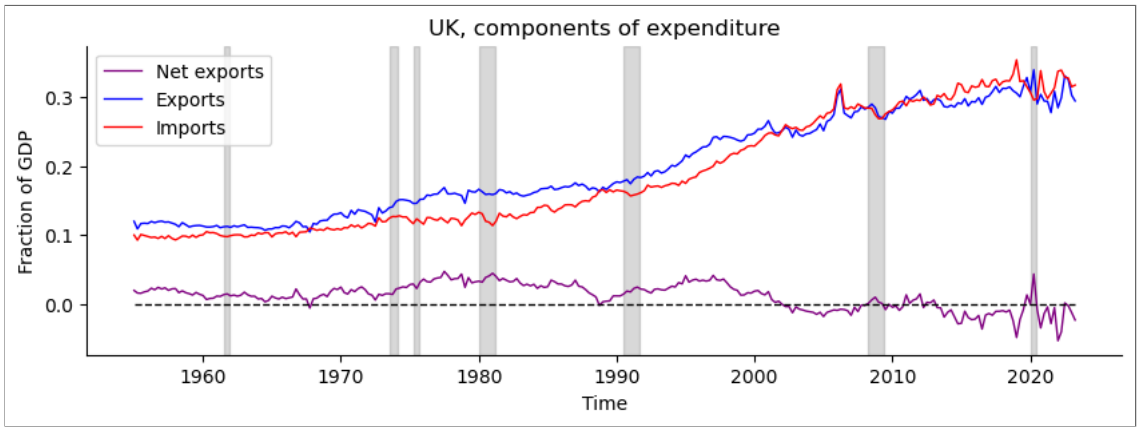
Billions of 2013 pounds

Quarter	GDP	Consumption	Investment	Government spending	Net exports	Exports	Imports
2020-04-01	431.79	248.96	78.81	85.18	18.84	146.53	127.69
2020-07-01	503.51	315.52	91.21	100.66	-3.88	146.05	149.93
2020-10-01	509.62	328.45	94.16	104.53	-17.52	154.88	172.4
2021-01-01	504.26	314.13	92.6	104.38	-6.85	148.36	155.21
2021-04-01	537.17	330.55	96.35	112.39	-2.12	157.84	159.96
2021-07-01	546.49	351.76	97.22	112.85	-15.34	151.64	166.98
2021-10-01	554.82	346.46	96.82	114.28	-2.74	171.08	173.82
2022-01-01	557.52	368.0	105.12	113.88	-29.48	158.6	188.08
2022-04-01	557.81	365.48	102.73	111.95	-22.35	166.71	189.06
2022-07-01	557.29	339.65	103.86	112.79	0.99	184.18	183.19
2022-10-01	558.0	341.68	104.13	113.38	-1.19	181.64	182.83
2023-01-01	558.81	347.7	106.66	111.32	-6.87	169.05	175.92
2023-04-01	559.96	351.33	106.65	114.83	-12.85	164.87	177.72

In [71]:
```
p9()
```


UK, components of expenditure
GDP
Consumption
Investment
Govt spending
Net exports
Billions of 2013 GDP
500
400
300
200
100
0
1960
1970
1980
1990
2000
2010
2020
Time
UK, components of expenditure
Fraction of GDP
0.6
0.4
0.2
0.0
1960
1970
1980
1990
2000
2010
2020
Time

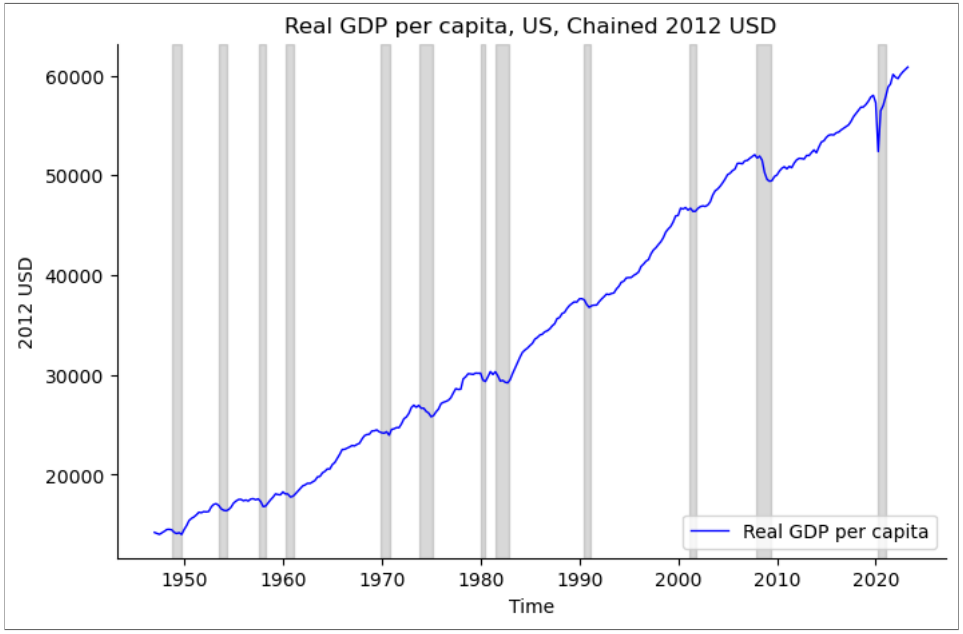
In [73]:
```
p10()
```


UK, components of expenditure
Net exports
Exports
Imports
Fraction of GDP
0.3
0.2
0.1
0.0
1960
1970
1980
1990
2000
2010
2020
Time

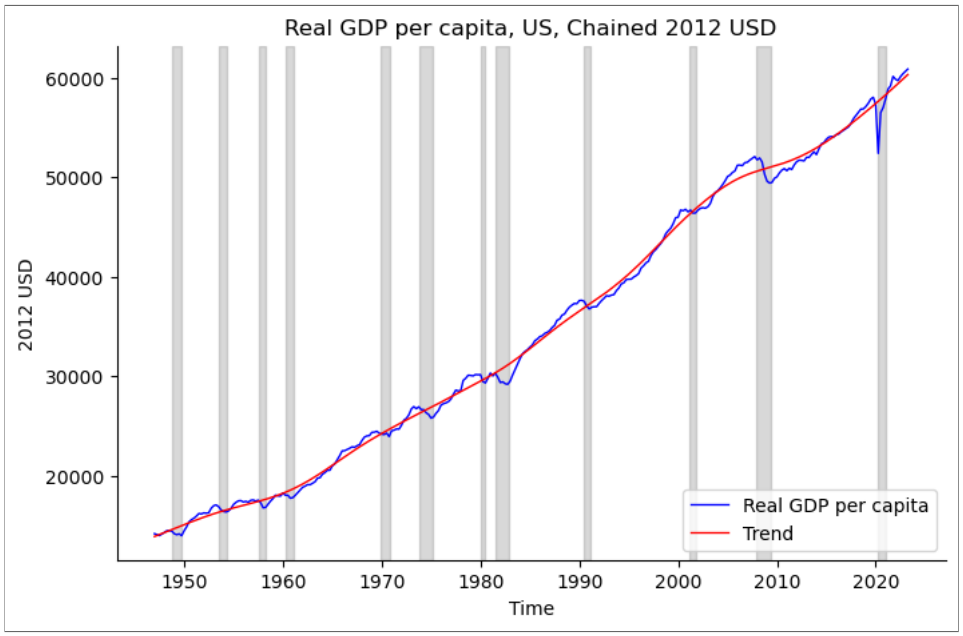
Question 7

Growth and business cycles

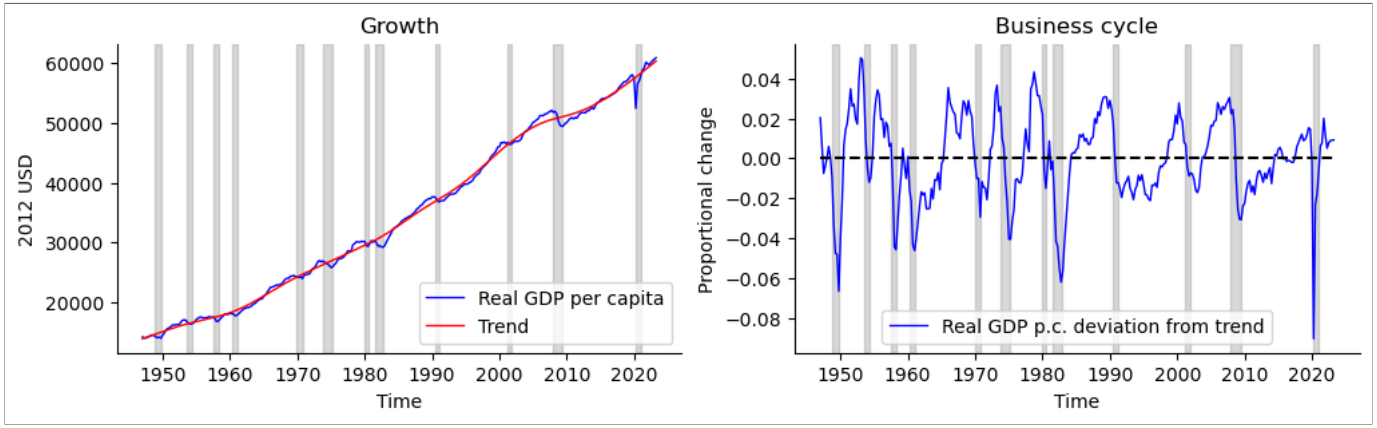
In [79]:
```
p11()
```


Real GDP per capita, US, Chained 2012 USD
60000
50000
40000
30000
20000
2012 USD
1950
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP per capita

In [81]:
```
p12()
```

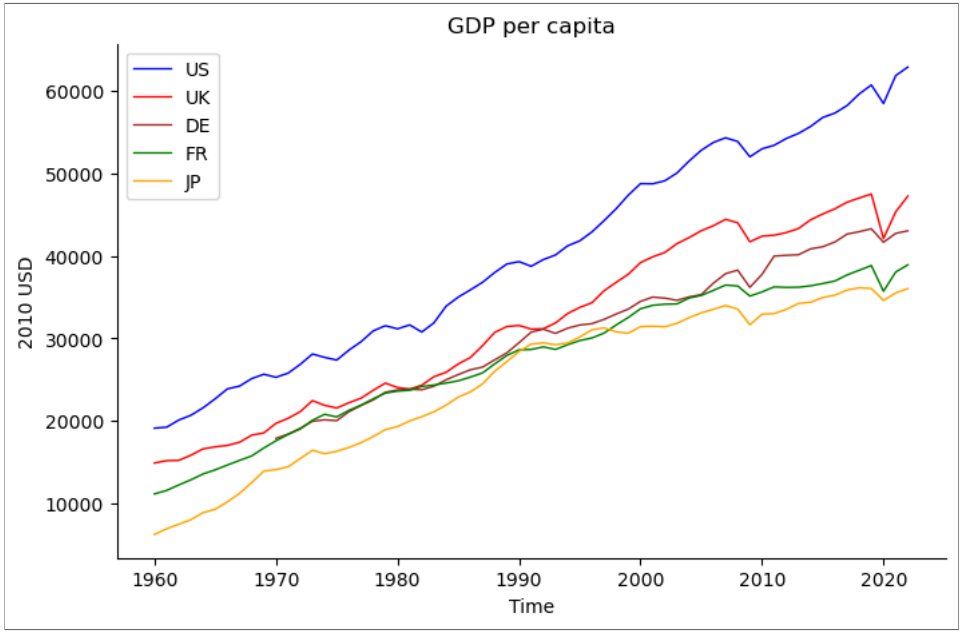

Real GDP per capita, US, Chained 2012 USD
2012 USD
60000
50000
40000
30000
20000
1950
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP per capita
Trend

In [83]:
```
p13()
```


Growth
2012 USD
60000
50000
40000
30000
20000
1950
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP per capita
Trend
Business cycle
Proportional change
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
Real GDP p.c. deviation from trend

Growth

In [87]:
```
p14()
```


GDP per capita
US
UK
DE
FR
JP
2010 USD
60000
50000
40000
30000
20000
10000
1960
1970
1980
1990
2000
2010
2020
Time

Growth formulas

E.g. US real GDP per capita was about 20000 USD in 1960, and grew to 60000 USD in 2020. What is the average growth rate of GDP per capita in US over this period?

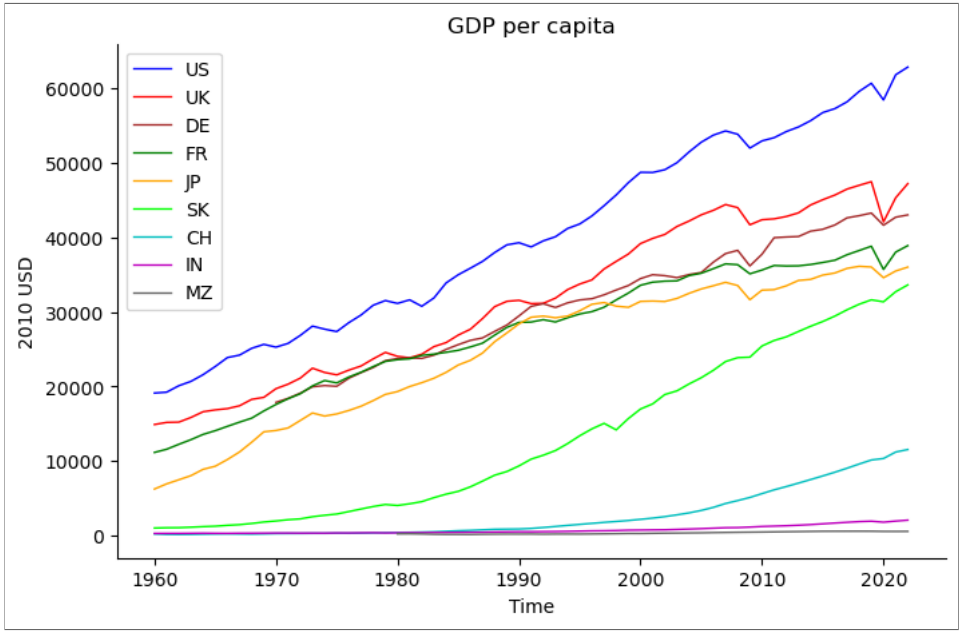
In [88]:

```
3^(1/60)-1
```

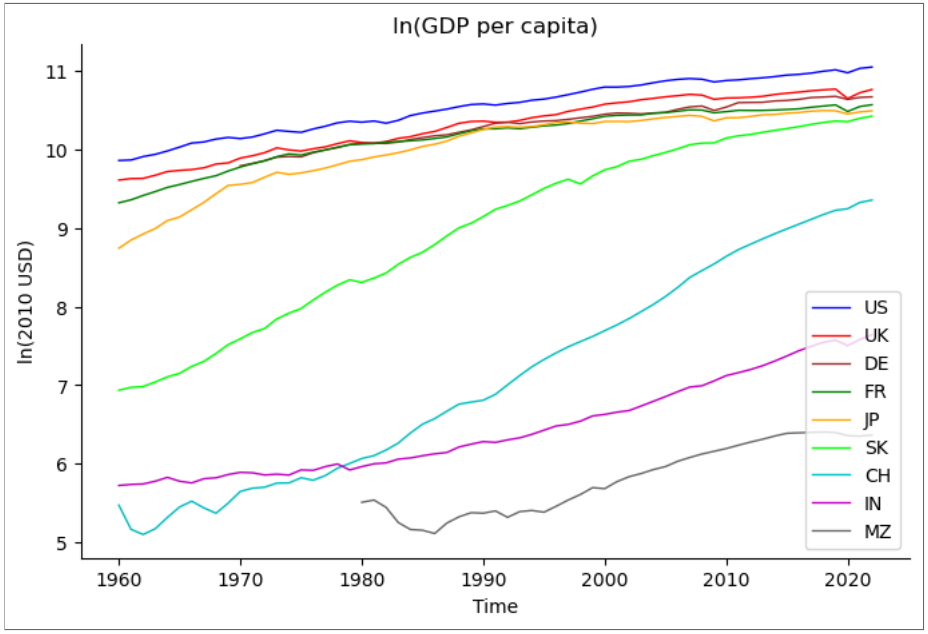
Out[88]:

```
0.01847886443605229
```

In [90]:
```
p15()
```

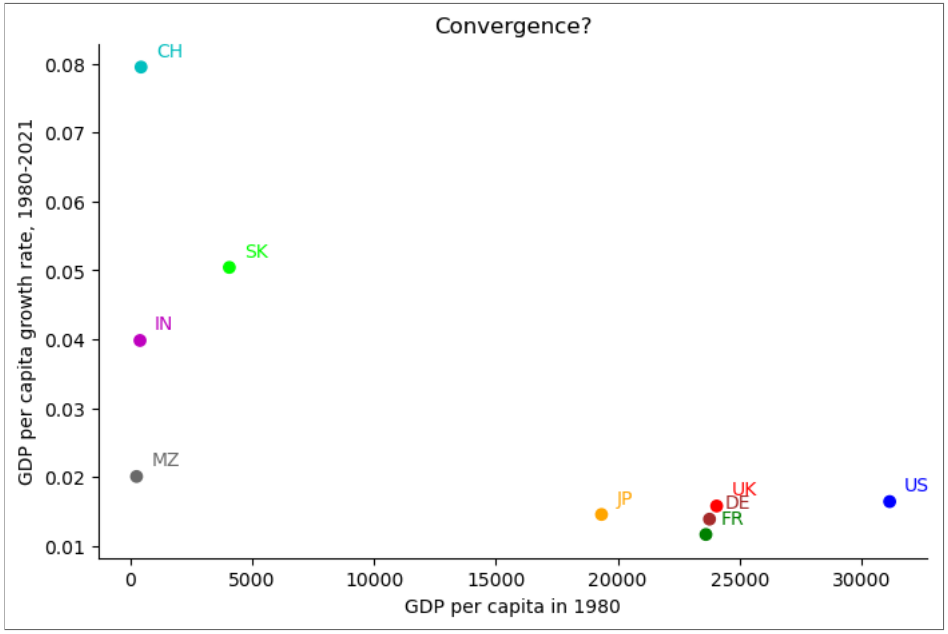

GDP per capita
US
UK
DE
FR
JP
SK
CH
IN
MZ
2010 USD
60000
50000
40000
30000
20000
10000
0
1960
1970
1980
1990
2000
2010
2020
Time

In [92]:
```
p16()
```


ln(GDP per capita)
ln(2010 USD)
Time
11
10
9
8
7
6
5
1960
1970
1980
1990
2000
2010
2020
US
UK
DE
FR
JP
SK
CH
IN
MZ

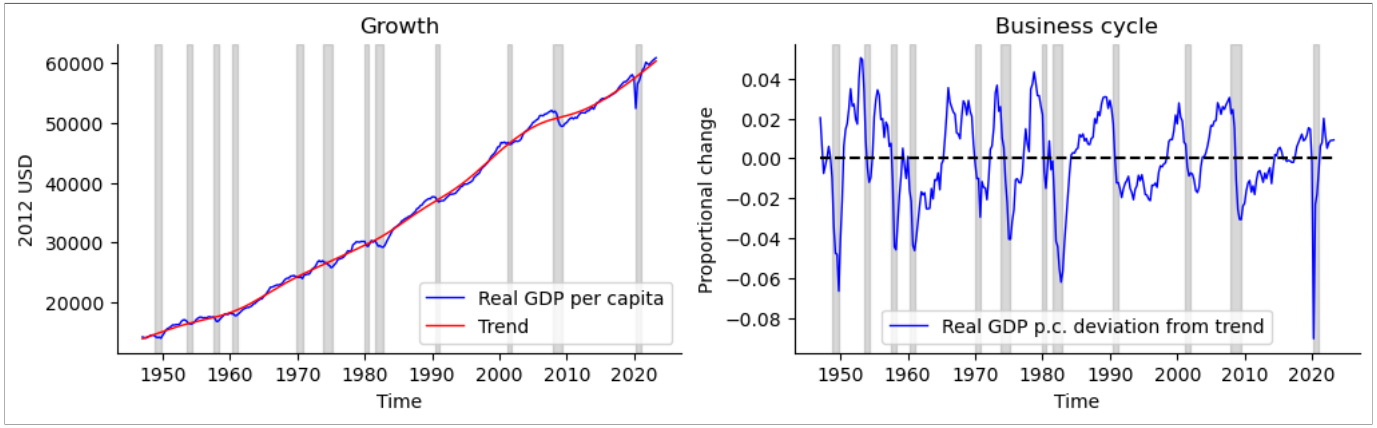
In [95]:

```
p17()
```

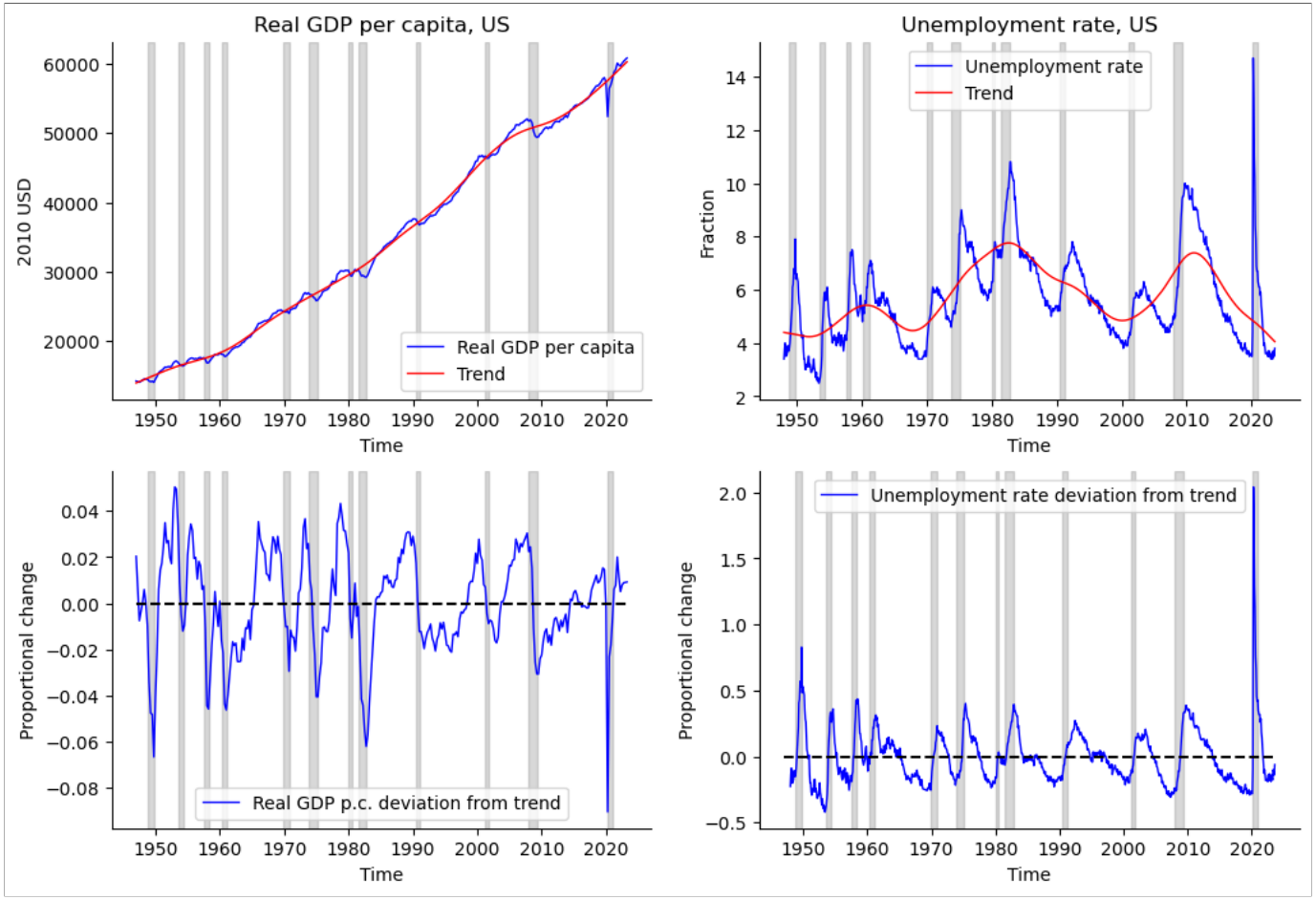

Convergence?
CH
SK
IN
MZ
JP
UK
DE
FR
US
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
GDP per capita growth rate, 1980-2021
0
5000
10000
15000
20000
25000
30000
GDP per capita in 1980

Business cycles

In [96]:
```
p13()
```


Growth
2012 USD
60000
50000
40000
30000
20000
1950
1960
1970
1980
1990
2000
2010
2020
Time
Real GDP per capita
Trend
Business cycle
Proportional change
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
Real GDP p.c. deviation from trend

In [98]:
```
p18()
```


Real GDP per capita, US
2010 USD
Time
Real GDP per capita
Trend
Unemployment rate, US
Fraction
Time
Unemployment rate
Trend
Proportional change
Time
Real GDP p.c. deviation from trend
Proportional change
Time
Unemployment rate deviation from trend

Question 3

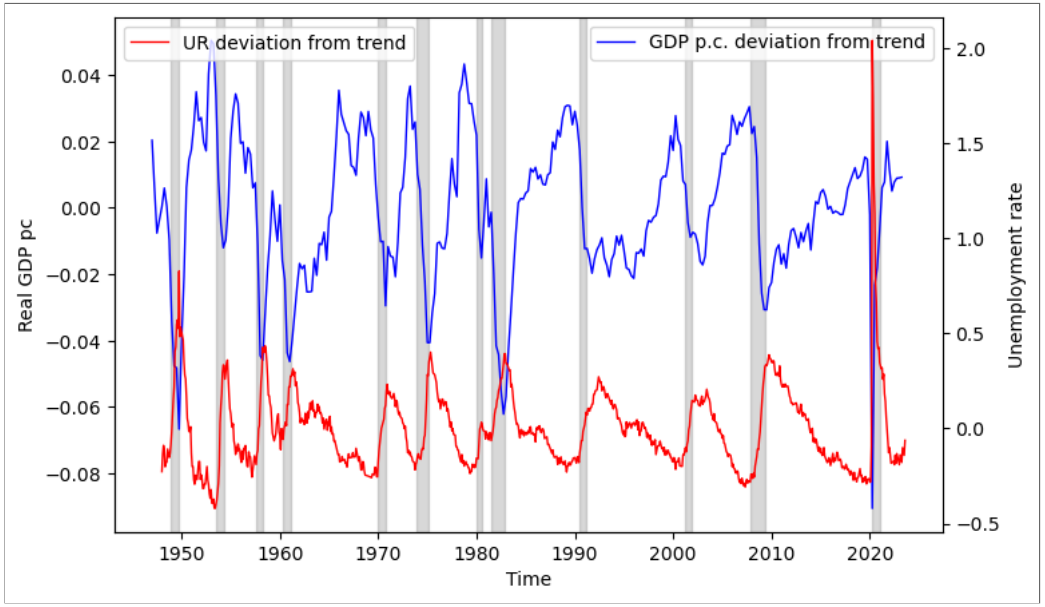
In [99]:

```
year = [2018,2019,2020,2021,2022]
y = [18.00,18.20,18.50,19.50,20.00]

yp=[]
push!(yp,y[1]);
for j = 2:length(year)
    push!(yp,yp[j-1]*1.025)
end
yp

x = (y-yp)./yp

gy = similar(y)
for j = 2:length(year)
    gy[j]=(y[j]-y[j-1])/y[j-1]
end
gy[1]=NaN

dat = hcat(year, y, yp, x,gy)
header = (["Year","GDP","GDP potential", "Output gap", "GDP growth rate"])
pretty_table(dat; backend = Val(:html), header = header,formatters = ft_printf("%5.3f"))
```

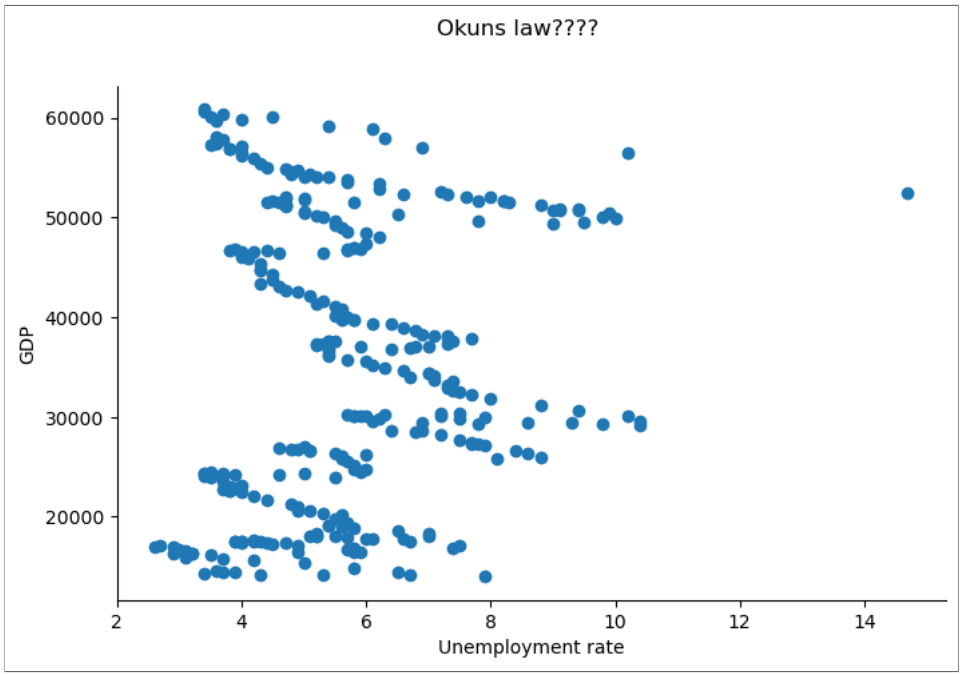
Year	GDP	GDP potential	Output gap	GDP growth rate
2018.000	18.000	18.000	0.000	NaN
2019.000	18.200	18.450	-0.014	0.011
2020.000	18.500	18.911	-0.022	0.016
2021.000	19.500	19.384	0.006	0.054
2022.000	20.000	19.869	0.007	0.026

Question 2

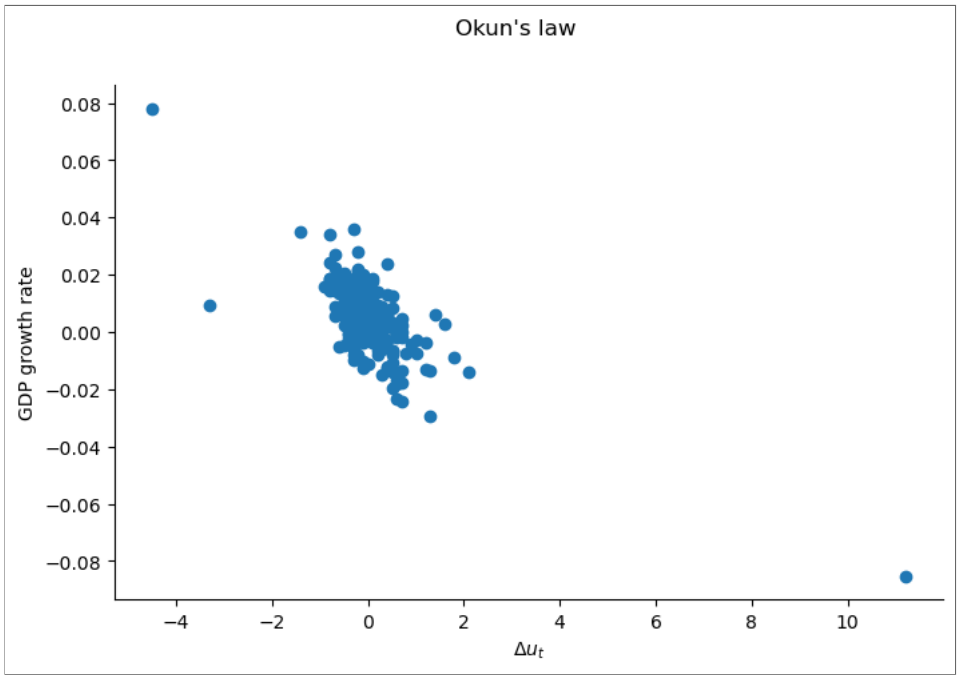
In [101]:
```
p19()
```


UR deviation from trend
GDP p.c. deviation from trend
Real GDP pc
Unemployment rate
Time
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
2.0
1.5
1.0
0.5
0.0
−0.5
1950
1960
1970
1980
1990
2000
2010
2020

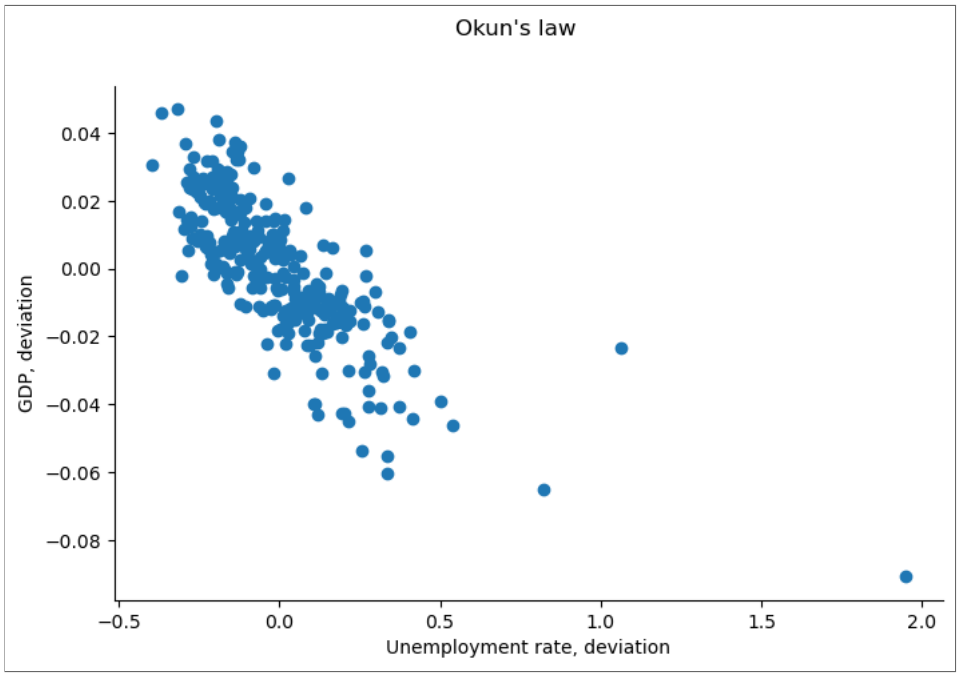
In [104]:
```
pp20()
```


Okuns law????
GDP
60000
50000
40000
30000
20000
2
4
6
8
10
12
14
Unemployment rate

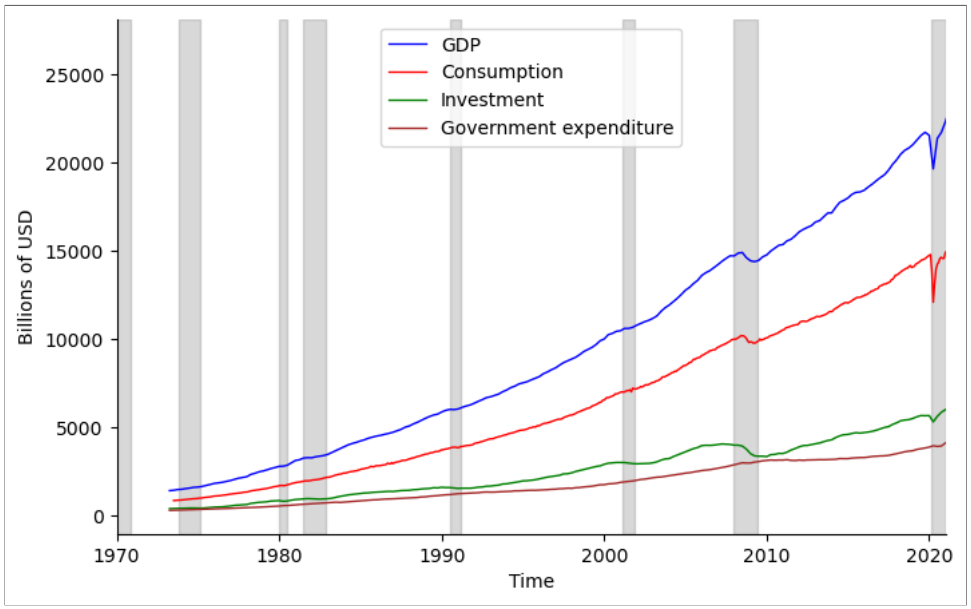
In [106]:
```
ppp20()
```


Okun's law
GDP growth rate
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
−4
−2
0
2
4
6
8
10
Δu_t

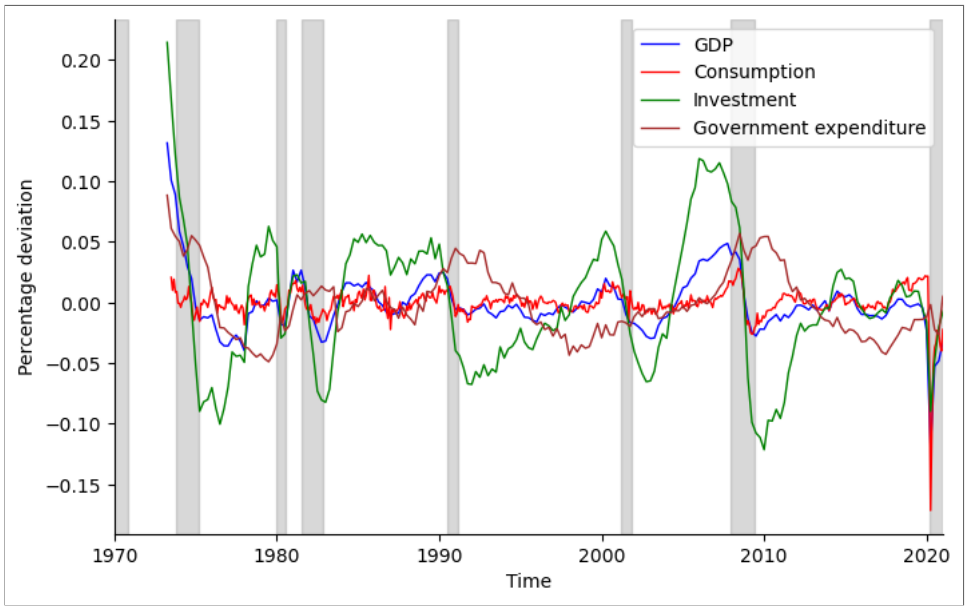
In [108]:
```
p20()
```


Okun's law
GDP, deviation
Unemployment rate, deviation
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
−0.5
0.0
0.5
1.0
1.5
2.0

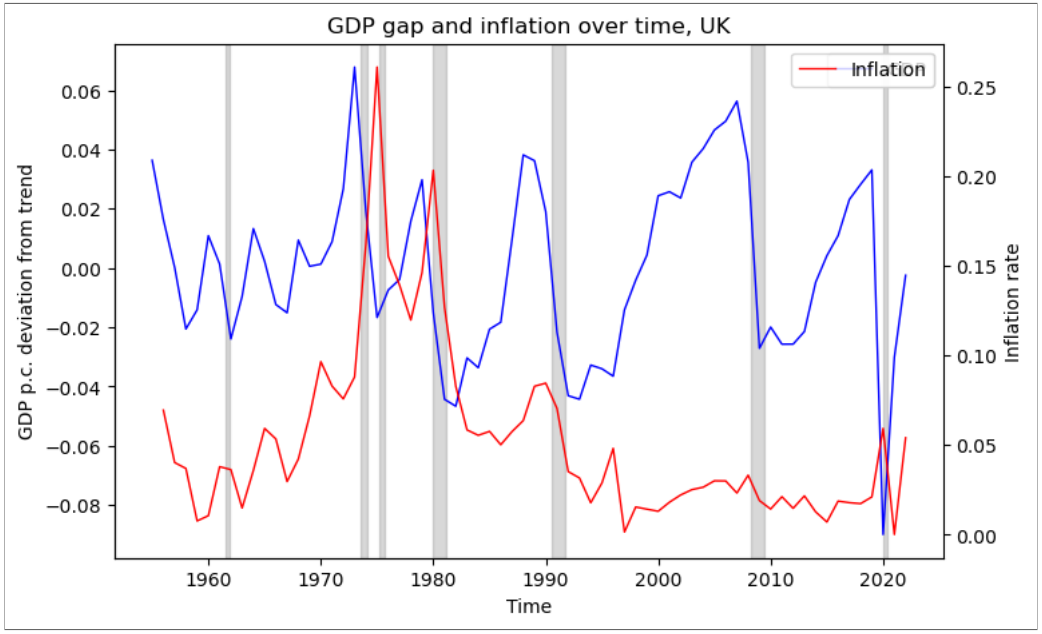
In [114]:
```
p21()
```


GDP
Consumption
Investment
Government expenditure
Billions of USD
25000
20000
15000
10000
5000
0
1970
1980
1990
2000
2010
2020
Time

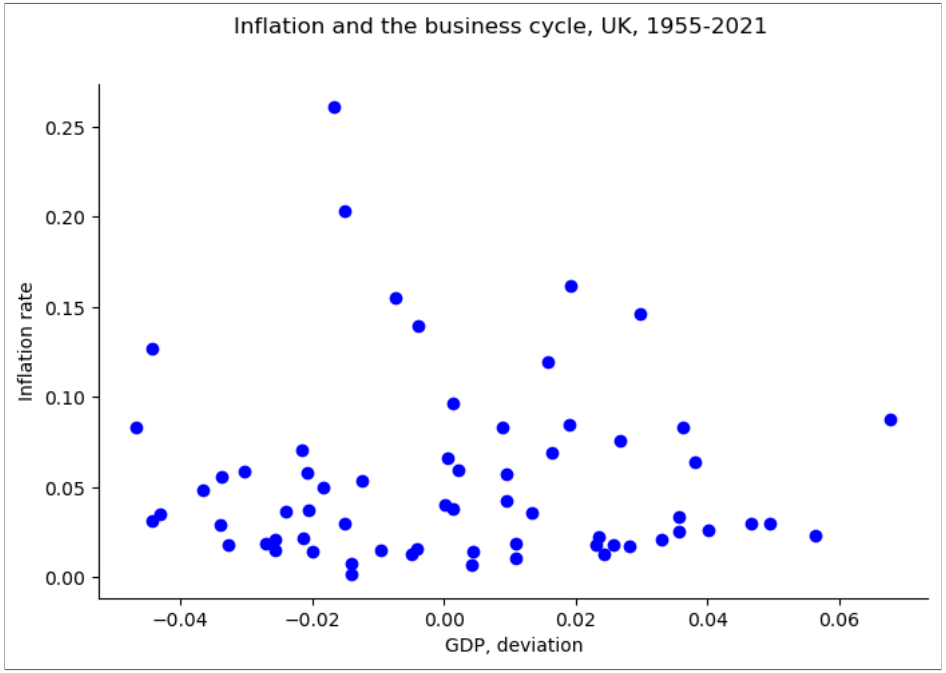
In [116]:
```
p22()
```


GDP
Consumption
Investment
Government expenditure
Percentage deviation
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
1970
1980
1990
2000
2010
2020
Time

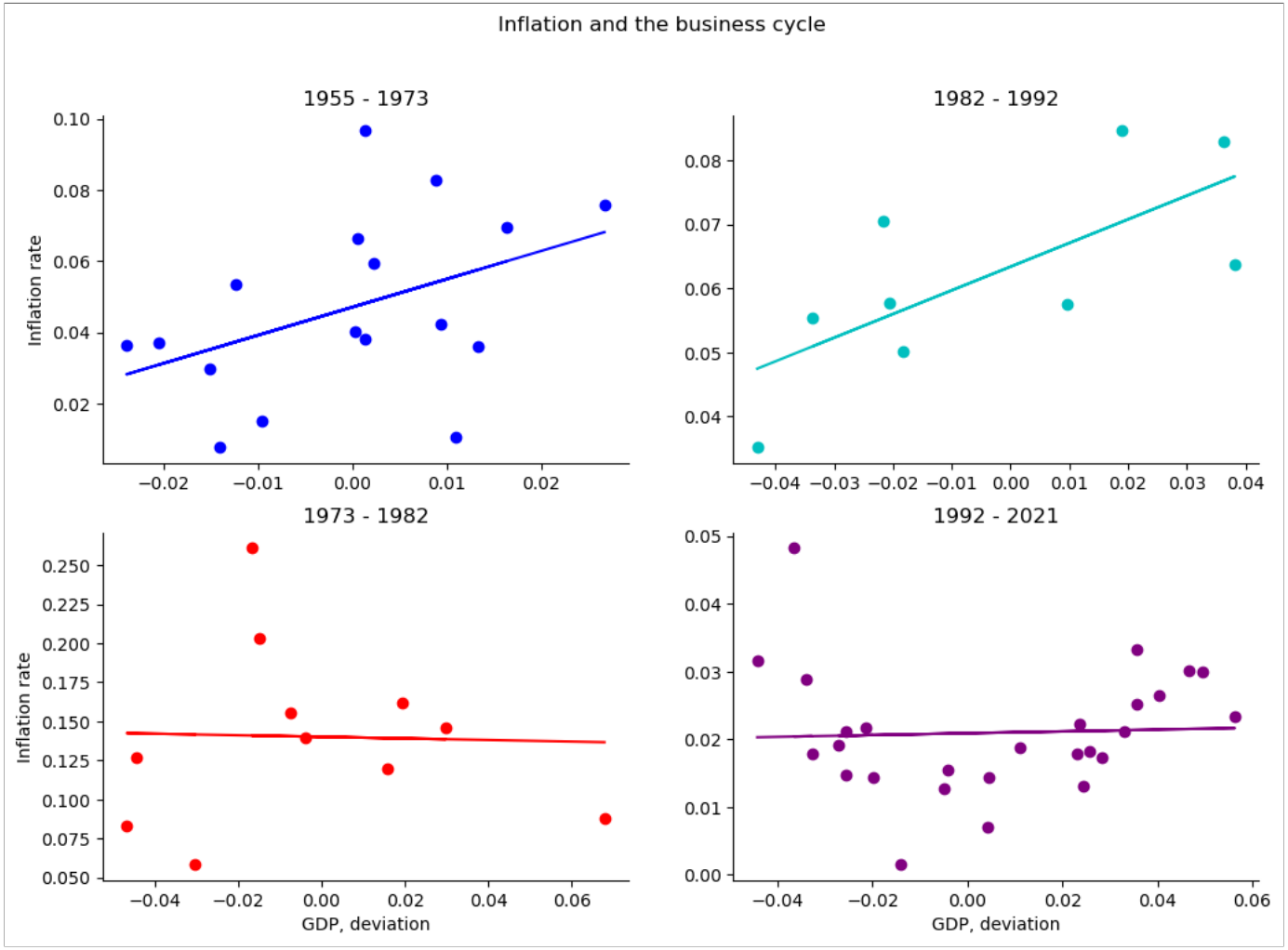
In [121]:
```
p24()
```


GDP gap and inflation over time, UK
Inflation
GDP p.c. deviation from trend
Inflation rate
Time
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
−0.08
0.25
0.20
0.15
0.10
0.05
0.00
1960
1970
1980
1990
2000
2010
2020

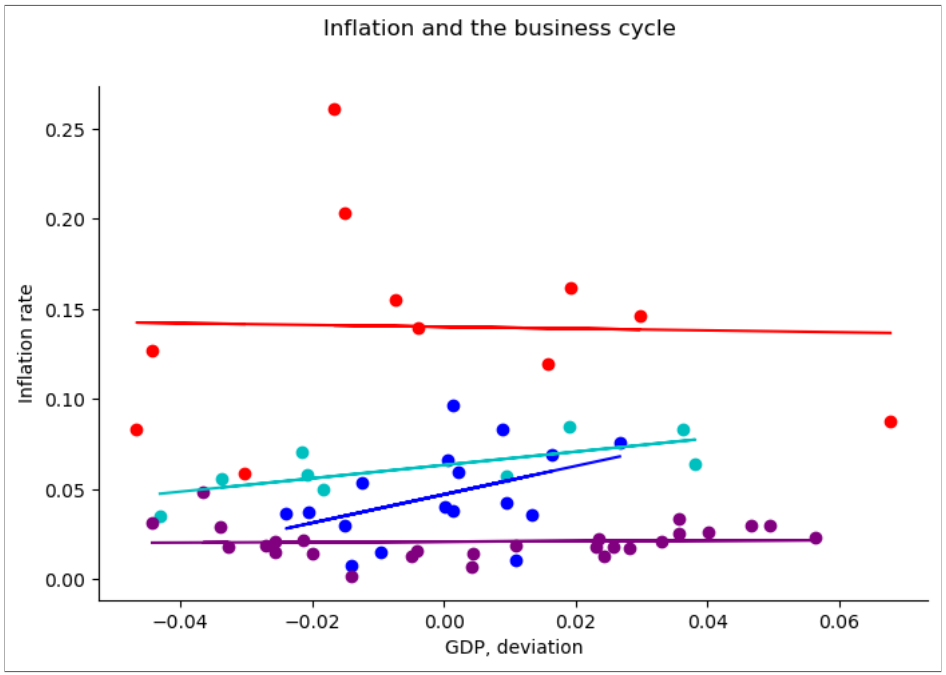
In [125]:
```
p25()
```


Inflation and the business cycle, UK, 1955-2021
Inflation rate
0.25
0.20
0.15
0.10
0.05
0.00
−0.04
−0.02
0.00
0.02
0.04
0.06
GDP, deviation

In [127]:
```
p26()
```


Inflation and the business cycle
1955 - 1973
1982 - 1992
1973 - 1982
1992 - 2021
Inflation rate
GDP, deviation

In [129]:
```
p27()
```


Inflation and the business cycle
Inflation rate
0.25
0.20
0.15
0.10
0.05
0.00
−0.04
−0.02
0.00
0.02
0.04
0.06
GDP, deviation

Question 8