EC640 Assignment 1

Zhu Ziqiu (205199990)

September 2019

Question 1

Part A

	Mean (%)	$\frac{\sigma_X}{\sigma_Y}$	Correlation -4	-3	-2	-1	0	1	2	3	4
GDP	2.39	1.00	0.14	0.40*	0.66*	0.88*	1.00	0.88*	0.66*	0.40*	0.14
Consumption	2.68	0.77	0.12	0.39*	0.60*	0.74*	**0.78***	0.65*	0.49*	0.31*	0.14
Investment	3.25	5.03	0.07	0.30*	0.55*	0.76*	**0.81***	0.70*	0.43*	0.12	(0.12)
Government	1.84	0.87	(**0.23***)	(0.17)	(0.12)	(0.07)	(0.01)	0.03	0.05	0.09	0.12
Exports	4.15	2.79	0.25*	0.34*	0.49*	0.60*	**0.67***	0.57*	0.39*	0.20	(0.02)
Imports	4.68	3.37	0.14	0.33*	0.57*	0.73*	**0.76***	0.63*	0.35*	0.05	(0.19)
Headline CPI	2.98	1.16	(0.32)	(**0.34**)	(0.30)	(0.22)	(0.15)	(0.10)	(0.04)	0.01	0.07
Core CPI	2.19	0.51	(0.09)	(0.09)	(0.09)	(0.07)	(0.02)	0.05	0.11	0.19	**0.26***
Hours Worked	1.22	1.16	0.08	0.30*	0.54*	0.74*	**0.85***	0.80*	0.63*	0.41*	0.22*
Labor Productivity	1.22	0.72	0.33*	0.43*	0.48*	0.49*	**0.50***	0.34*	0.20	0.06	(0.09)
Hourly Compensation	3.56	1.06	(0.12)	(0.19)	(0.20)	(0.18)	(0.11)	0.02	0.16	0.27*	**0.29***

Notes: Summary statistics for year-over-year growth rates using seasonally adjusted quarterly real data from 1981Q1 to 2019Q2. Headline CPI was seasonally adjusted using the X-11 procedure and core CPI data is extracted from 1984Q1 to 2019Q2. Includes mean, relative standard deviation to real GDP, and pairwise serial correlation coefficients to real GDP. Source: Statistics Canada tables: 36-10-0104-01, 36-10-0206-01.36-10-0206-01, 18-10-0006-01 and 18-10-0256-01. * indicates significance at the 0.01 percent level

i.

Variables investment, imports, exports, headline CPI, average hours worked, and total compensation per hour worked are more volatile, with higher standard deviations than GDP.

ii.

Consumption, investments, exports and imports and labor productivity have their highest serial correlation coefficients to GDP in the same time period, however their correlations in forecasting periods are higher than their correlations at later periods to GDP, implying they lead GDP.

Government spending and headline CPI also have significant forecasting correlations, although relatively smaller in comparison to other variables, therefore classified as leading variables.

Hours worked, core CPI and total compensation per hour worked are lagging variables.

Part B

Table 1: Y-o-Y Stylized Facts of the Canadian Economy 1996Q1-2019Q2

	Mean	$\frac{\sigma_X}{\sigma_Y}$	Correlation								
	(%)		-4	-3	-2	-1	0	1	2	3	4
GDP	2.40	1.00	0.18	0.39*	0.65	0.88*	1.00	0.88*	0.65*	0.38*	0.16
Consumption	2.99	0.69	0.00	0.28*	0.53*	**0.69***	0.68*	0.56*	0.36*	0.14	0.00
Investment	3.53	5.31	0.05	0.25	0.47*	0.65*	**0.72***	0.63*	0.37*	0.07	(0.15)
Government	1.91	1.12	(**0.15**)	(0.14)	(0.11)	(0.10)	(0.09)	(0.07)	(0.05)	(0.01)	0.04
Exports	2.81	3.17	0.24	0.42*	0.62*	0.77*	**0.82***	0.65*	0.44*	0.26	0.10
Imports	4.00	3.51	0.12	0.36*	0.60*	0.76*	**0.76***	0.57*	0.28*	0.00	(0.19)
Headline CPI	1.85	0.46	(0.35)	(0.27)	(0.05)	0.22	0.41	**0.47**	0.43	0.33	0.22
Core CPI	1.73	0.23	(0.09)	(0.09)	(0.09)	(0.07)	(0.20)	0.05	0.11	0.19	**0.26***
Hours Worked	1.30	1.01	0.08	0.30*	0.54*	0.74*	**0.85***	0.80*	0.63*	0.41*	0.22*
Labor Productivity	1.17	0.91	0.33*	0.44*	0.48*	0.49*	**0.50***	0.34*	0.20	0.06	(0.09)
Hourly Compensation	2.95	1.00	(0.12)	(0.19)	(0.20)	(0.18)	(0.11)	0.20	0.17	0.27*	**0.29***

Notes: Summary statistics for year-over-year growth rates using seasonally adjusted quarterly real data from 1996Q1 to 2019Q2. Headline CPI was seasonally adjusted using the X-11 procedure. Includes mean growth rates, relative standard deviation to real GDP, and pairwise serial correlation coefficients to real GDP. Source: Statistics Canada tables: 36-10-0104-01, 36-10-0206-01.36-10-0206-01, 18-10-0006-01 and 18-10-0256-01. * indicates significance at the 0.01 percent level

i.

Yes.

In the summary statistics for 1981Q1 to 2019Q2, the ordering from highest volatility to lowest, relative to GDP is: investment (5.03), imports (3.37), exports (2.79), hours worked (1.16), headline CPI (1.16), hourly compensation (1.06), government spending (0.87), consumption (0.77), labor productivity (0.72), and core CPI (0.51).

Meanwhile, the ordering for 1996Q1 to 2019Q2 is: investment (5.31), imports (3.51), exports (3.17), government spending (1.12), hours worked (1.01), hourly compensation (1.01), labor productivity (0.91), consumption (0.69), headline CPI (0.46), and core CPI (0.23) .

ii.

No.

By a symmetric rationale behind the answer for question A part ii, all leading variables continue to be.

Hourly compensation, hours worked, and headline CPI remain to be lagging variables.

iii.

Comparing Table 1 and Table 2, the variables that had their means decline are: exports, imports, headline CPI, core CPI, labor productivity, and hourly compensation.

iv.

Consumption, headline CPI, core CPI, hours worked, and hourly compensation had their relative volatility decline.

Part C

Table 2: Q-o-Q Stylized Facts of the Canadian Economy 1981Q1-2019Q2

	Mean	$\frac{\sigma_X}{\sigma_Y}$	Correlation								
	(%)		-4	-3	-2	-1	0	1	2	3	4
GDP	0.59	1.00	0.02	0.13	0.24*	0.51*	1.00	0.51*	0.26*	0.16	0.02
Consumption	0.66	0.84	(0.05)	0.23*	0.33*	0.44*	**0.57***	0.26*	0.24*	0.15	(0.01)
Investment	0.74	6.05	(0.02)	0.07	0.20	0.46*	**0.55***	0.48*	0.15	(0.05)	(0.11)
Government	0.45	1.06	(0.10)	(0.02)	(0.03)	**(0.13)**	0.05	0.06	0.02	(0.01)	0.06
Exports	1.01	3.40	0.09	(0.02)	0.20	0.29	**0.56***	0.24*	0.06	0.10	(0.05)
Imports	1.11	3.65	0.01	0.02	0.34*	0.48*	**0.52***	0.45*	0.11	(0.02)	(0.18)
Headline CPI	0.71	0.90	(0.24)	(**0.27**)	(0.27)	(0.15)	(0.10)	(0.07)	(0.06)	(0.01)	0.14
Core CPI	0.55	0.42	(0.07)	(0.04)	(0.06)	(0.09)	(0.06)	(0.04)	(0.01)	0.06	**0.12**
Hours Worked	0.30	1.20	(0.11)	(0.04)	0.09	0.28*	0.51*	0.68	**0.71**	0.60	0.37*
Labor Productivity	0.30	1.10	0.16	0.23*	0.27*	0.28*	**0.47**	0.38*	0.33*	0.28*	0.00
Hourly Compensation	0.90	1.13	0.03	(0.07)	(0.13)	(0.15)	(0.17)	(0.13)	(0.08)	0.04	**0.22***

Notes: Summary statistics for quarter-over-quarter growth rates using seasonally adjusted quarterly real data from 1981Q1 to 2019Q2. Headline CPI was seasonally adjusted using the X-11 procedure and core CPI data is extracted from 1984Q1 to 2019Q2. Includes mean growth rates, relative standard deviation to real GDP, and pairwise serial correlation coefficients to real GDP. Source: Statistics Canada tables: 36-10-0104-01, 36-10-0206-01.36-10-0206-01, 18-10-0006-01 and 18-10-0256-01. * indicates significance at the 0.01 percent level

i.

Yes.

In the summary statistics for 1981Q1 to 2019Q2, the ordering from highest volatility to lowest, relative to GDP is: investment (5.03), imports (3.37), exports (2.79), hours worked (1.16), headline CPI (1.16), hourly compensation (1.06), government spending (0.87), consumption (0.77), labor productivity (0.72), and core CPI (0.51).

In table 3, the ordering from highest volatility to least relative to GDP is: investment (6.05), imports (3.65), exports(3.40), hours worked (1.20), hourly compensation (1.13), labor productivity (1.10), government (1.06), headline CPI (0.90), consumption (0.84) and core CPI (0.42).

ii.

Investment changed from a leading variable to a coincident variable, as correlations are showing slight leading and lagging characteristics.

Core CPI now has a weak lagging relationship.

Part D

Table 3: Y-o-Y Stylized Facts of the Canadian Economy 1981Q1-2019Q2

	Mean (%)	$\frac{\sigma_X}{\sigma_Y}$	Correlation -4	-3	-2	-1	0	1	2	3	4
GDP	(0.04)	1.00	0.24*	0.46*	0.68*	0.89*	1.00	0.89*	0.69*	0.46*	0.22*
Consumption	(0.08)	0.44	0.19	0.43*	0.64*	0.67*	**0.81***	0.72*	0.58*	0.40*	0.23*
Investment	(0.22)	3.07	0.23*	0.43*	0.63*	0.80*	**0.84***	0.74*	0.51*	0.25*	0.02*
Government	(0.02)	0.49	(**0.26***)	(0.22)	(0.19)	(0.17)	(0.11)	(0.07)	(0.05)	(0.04)	(0.02)
Exports	(0.17)	1.50	0.35*	0.45*	0.60*	0.71*	**0.75***	0.62*	0.42*	0.23*	0.02
Imports	(0.25)	1.87	0.30*	0.48*	0.68*	**0.80***	0.79*	0.66*	0.40*	0.13	(0.11)
Headline CPI	(0.01)	0.81	(0.57)	(**0.61**)	(0.59)	(0.52)	(0.42)	(0.31)	(0.19)	(0.06)	0.06
Core CPI	(0.00)	0.28	(0.26*)	(0.26*)	(**0.27***)	(0.25*)	(0.19)	(0.12)	(0.04)	0.05	0.12
Hours Worked	(0.01)	1.23	0.06	0.28*	0.51*	0.72*	**0.84***	0.83*	0.71*	0.54*	0.36*
Labor Productivity	(0.00)	0.72	0.31*	0.39*	0.44*	**0.46***	0.46*	0.27*	0.10	(0.03)	(0.17)
Hourly Compensation	(0.01)	0.92	(0.26*)	(**0.29***)	(0.27*)	(0.23*)	(0.16)	(0.02)	0.13	0.24*	0.28*

Notes: Summary statistics for percentage deviations from trend, applying a Hodrick–Prescott filter on seasonally adjusted quarterly real data from 1981Q1 to 2019Q2. Headline CPI was seasonally adjusted using the X-11 procedure and core CPI data is extracted from 1984Q1 to 2019Q2. Includes mean percentage deviations, relative standard deviation to real GDP, and pairwise serial correlation coefficients to real GDP. Source: Statistics Canada tables: 36-10-0104-01, 36-10-0206-01.36-10-0206-01, 18-10-0006-01 and 18-10-0256-01. * indicates significance at the 0.01 percent level

i.

Yes.

In the summary statistics for 1981Q1 to 2019Q2, the ordering from highest volatility to lowest, relative to GDP is: investment (5.03), imports (3.37), exports (2.79), hours worked (1.16), headline CPI (1.16), hourly compensation (1.06), government spending (0.87), consumption (0.77), labor productivity (0.72), and core CPI (0.51).

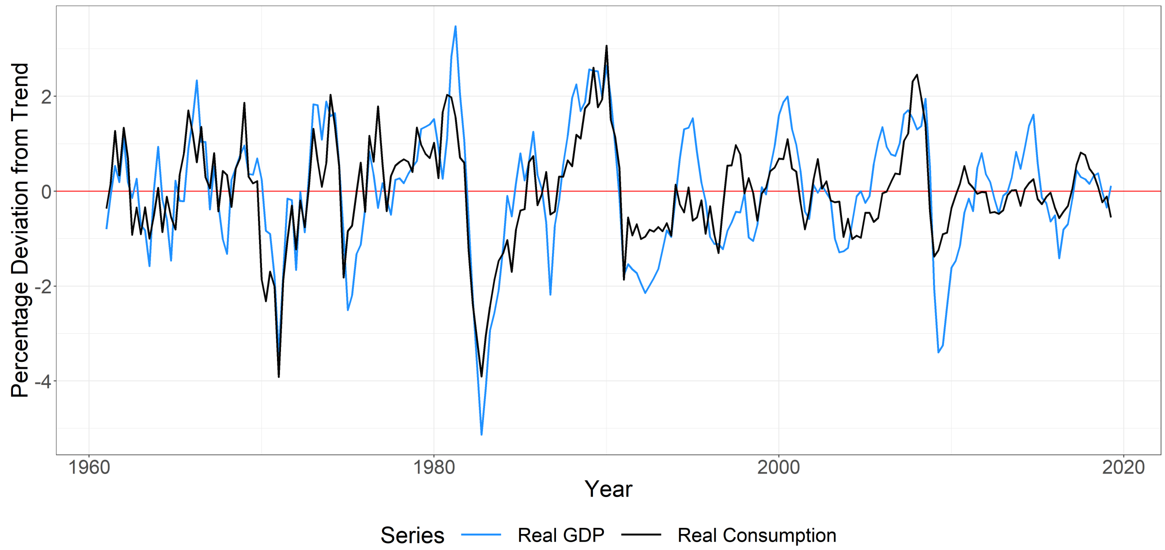
In table 4, the ordering from highest volatility to least relative to GDP is: investment (3.07), imports (1.87), exports (1.50), hours worked (1.23), hourly compensation (0.92), headline CPI (0.81), labor productivity (0.72), government (0.49), consumption (0.44) and core CPI (0.28).

ii.

All variables are now leading.

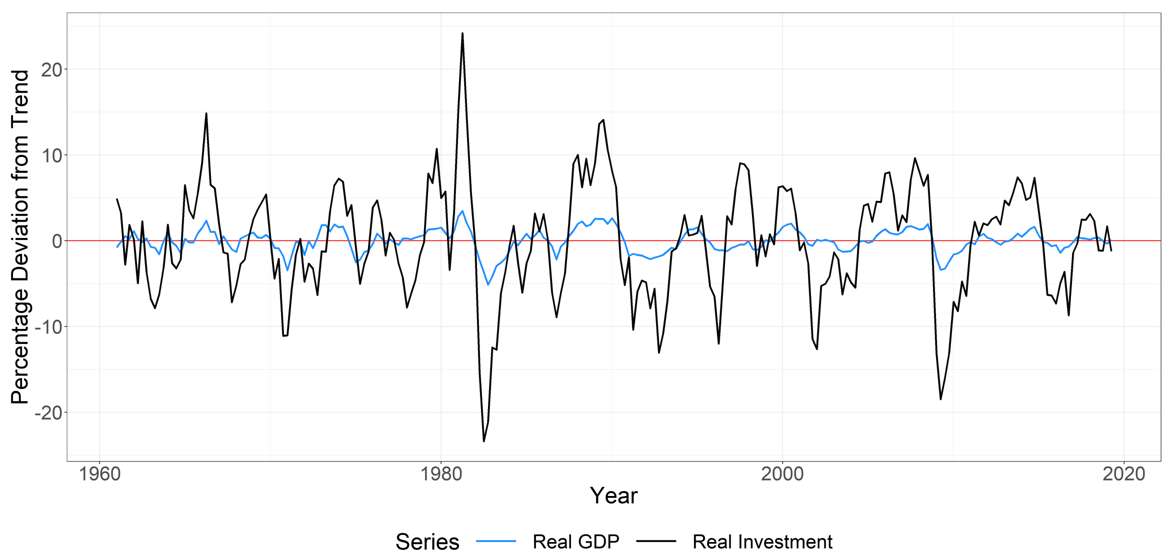
Question 2

Figure 1: Percentage Deviation in Trend in Real Consumption and GDP of Canada 1961Q1 - 2019Q2



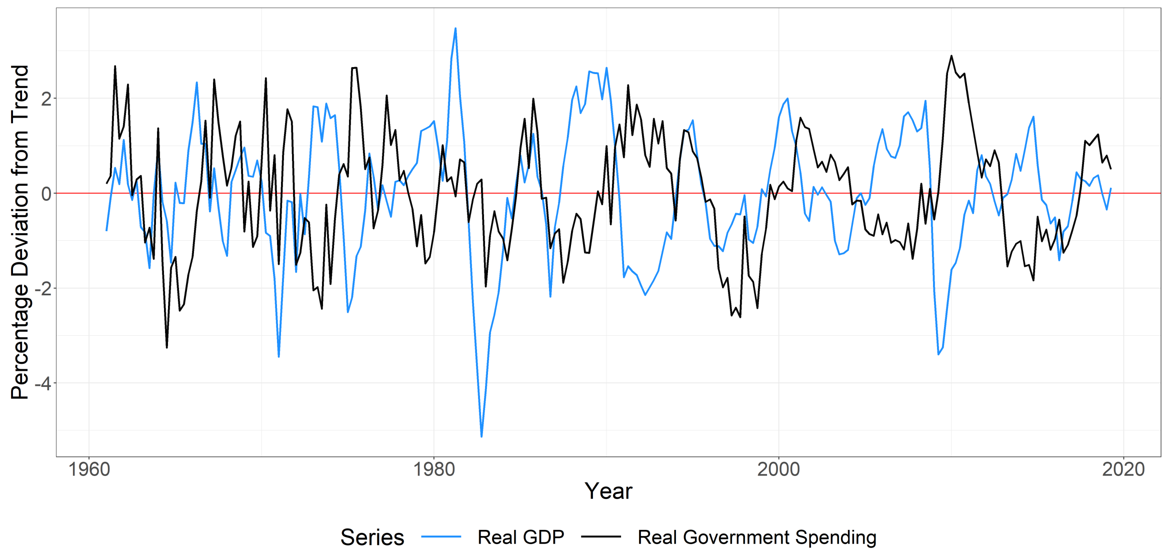
Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to real seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 2: Percentage Deviation in Trend in Real Investment and GDP of Canada 1961Q1 - 2019Q2



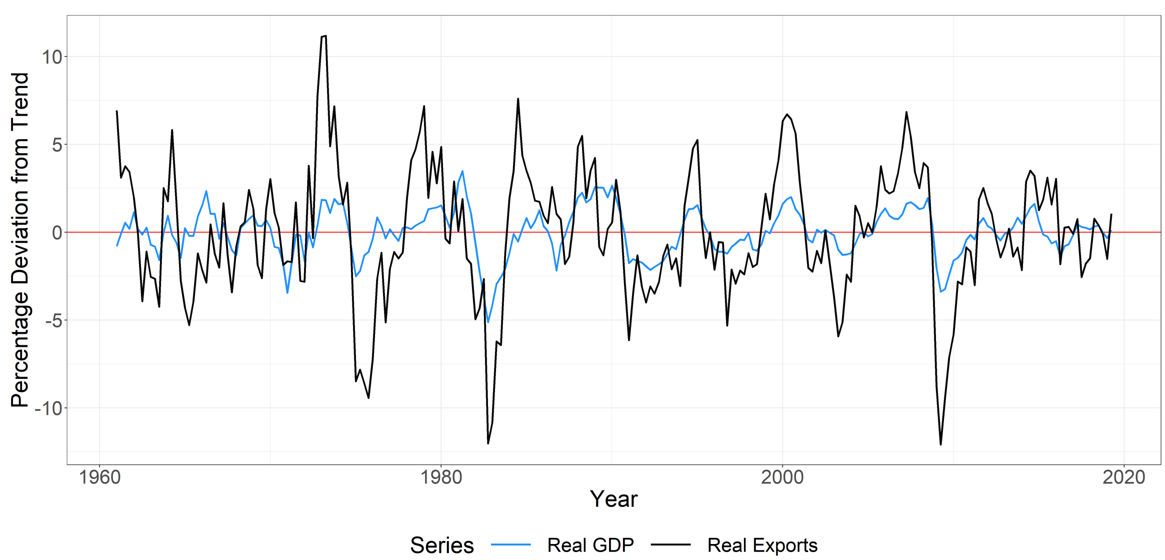
Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to real seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 3: Percentage Deviation in Trend in Real Government Spending and GDP of Canada 1961Q1 - 2019Q2



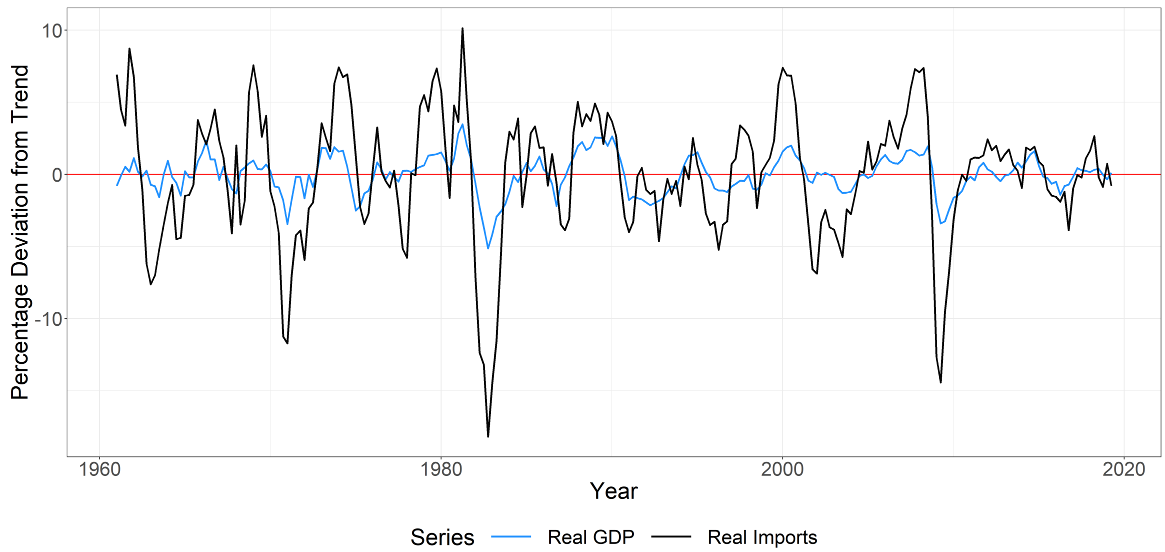
Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to real seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 4: Percentage Deviation in Trend in Real Exports and GDP of Canada 1961Q1 - 2019Q2



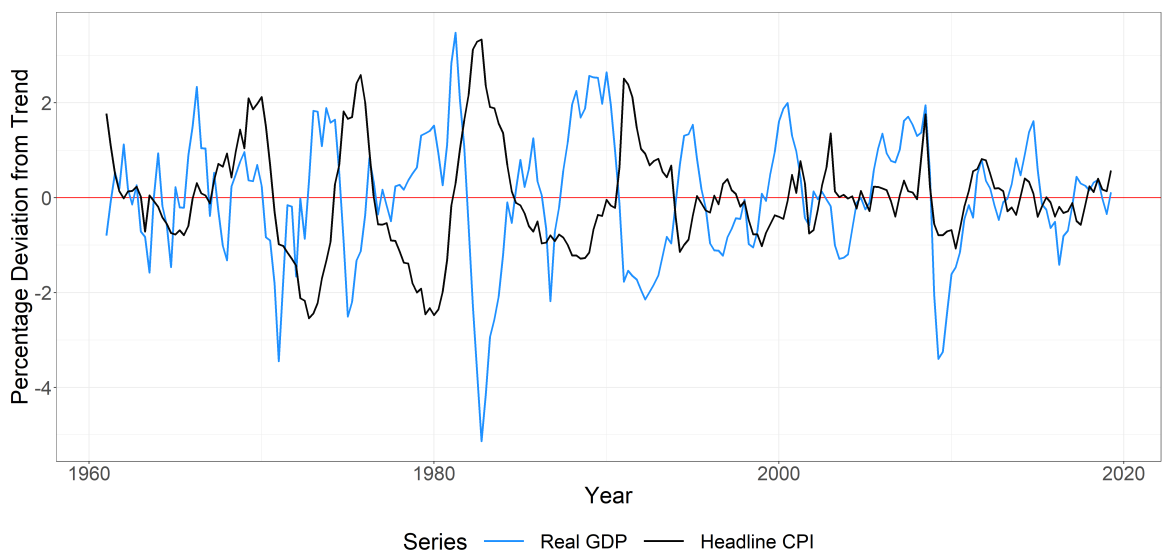
Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (2012 chained prices), while applying a Hodrick–Prescott filter to real seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 5: Percentage Deviation in Trend in Real Imports and GDP of Canada
1961Q1 - 2019Q2



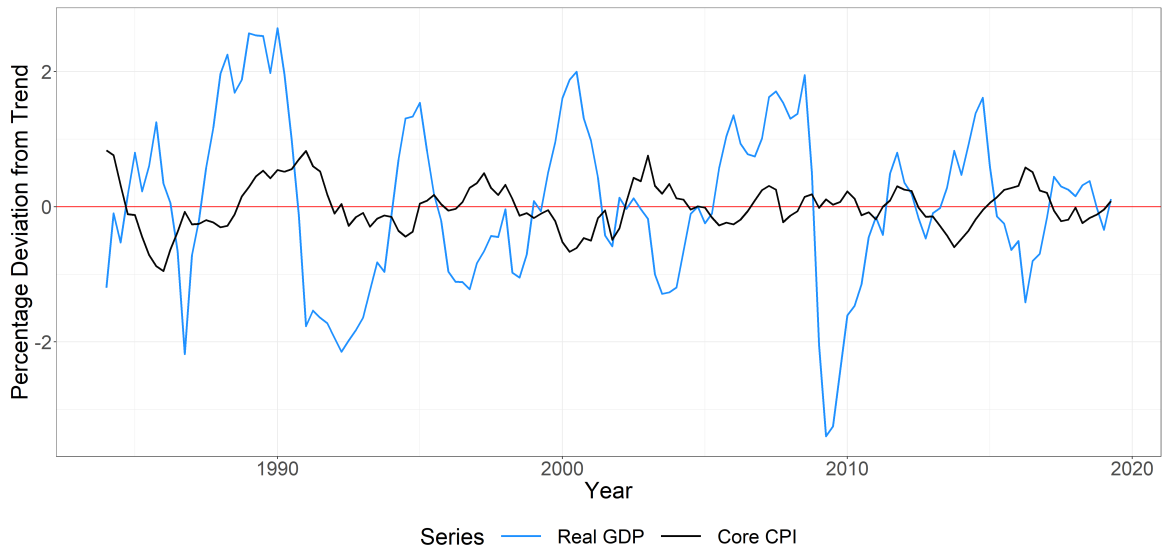
Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to real seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 6: Percentage Deviation in Trend in Headline CPI and Real GDP of Canada 1961Q1 - 2019Q2



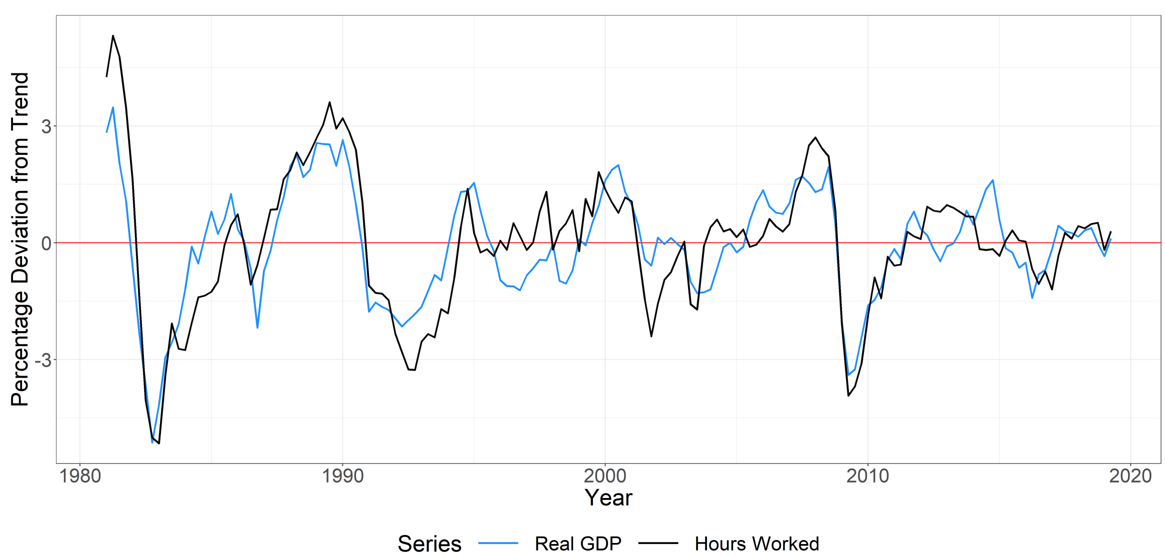
Source: CPI (2002 base) and real GDP are adapted from the Statistics Canada Tables: 18-10-0006-01 and 36-10-0104-01 (2012 chained prices) respectively, after applying a Hodrick–Prescott filter to seasonally adjusted quarterly data from 1961Q1-2019Q2.

Figure 7: Percentage Deviation in Trend in Core CPI Inflation and Real GDP of Canada 1984Q1 - 2019Q2



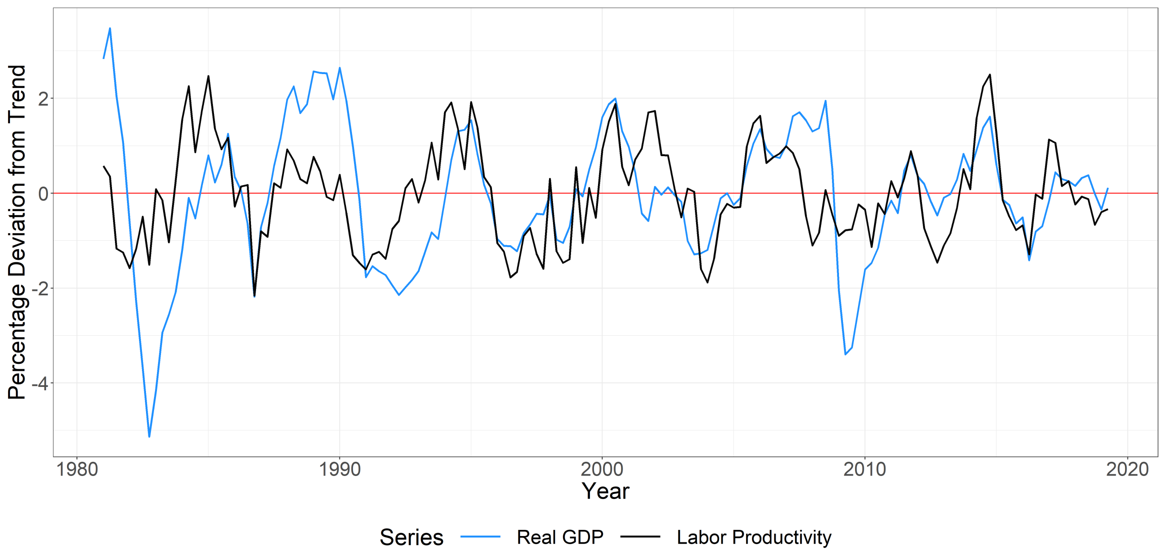
Source: Core CPI (2002 base) and real GDP are adapted from the Statistics Canada Tables: 18-10-0256-01 and 36-10-0104-01 (2012 chained prices) respectively, after applying a Hodrick–Prescott filter to seasonally adjusted quarterly data from 1984Q1-2019Q2. Defined by the Bank of Canada, core CPI inflation is "*the year-over-year rate of change of the consumer price index excluding food, energy, and the effects of changes in indirect taxes*".

Figure 8: Percentage Deviation in Trend in Average Hours Worked and Real GDP of Canada 1981Q1 - 2019Q2



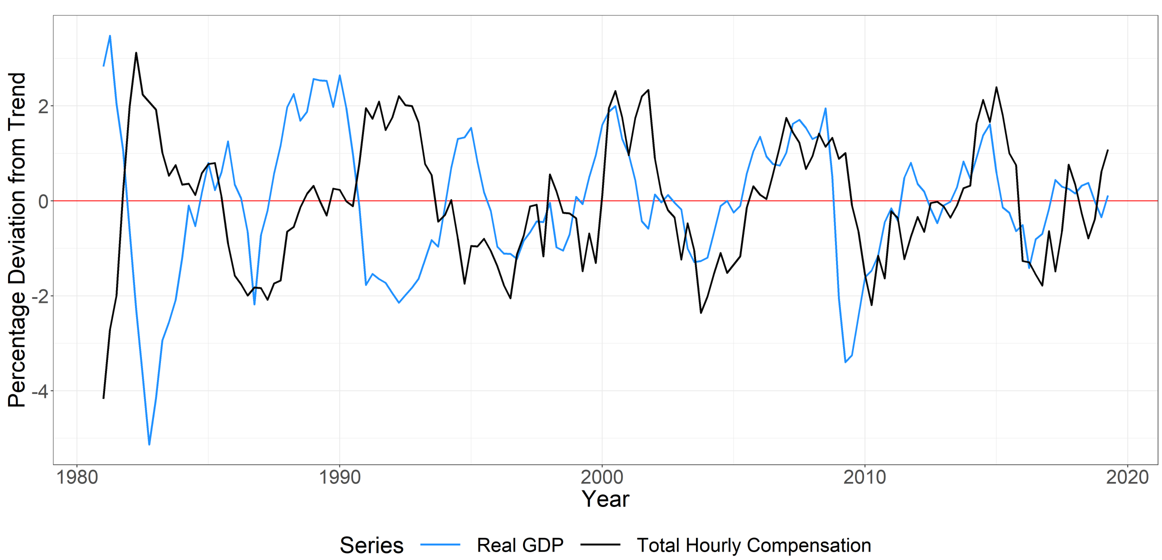
Source: hours worked and real GDP are adapted from the Statistics Canada Tables: 36-10-0206-01 and 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to seasonally adjusted quarterly data from 1981Q1-2019Q2.

Figure 9: Percentage Deviation in Trend in Labor Productivity and Real GDP of Canada 1981Q1 - 2019Q2



Source: labor productivity and real GDP are adapted from the Statistics Canada Tables: 36-10-0206-01 and 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to seasonally adjusted quarterly data from 1981Q1-2019Q2.

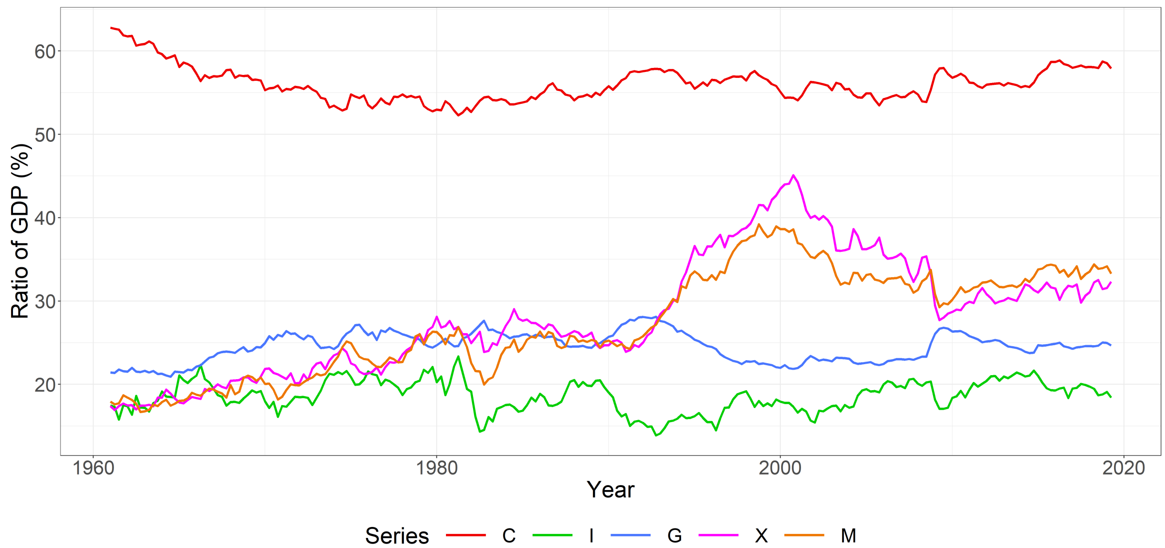
Figure 10: Percentage Deviation in Trend in Total Compensation per Hour Worked and Real GDP of Canada 1981Q1 - 2019Q2



Source: total compensation per hour worked and real GDP are adapted from the Statistics Canada Tables: 36-10-0206-01 and 36-10-0104-01 (2012 chained prices) after applying a Hodrick–Prescott filter to seasonally adjusted quarterly data from 1981Q1-2019Q2.

Question 3

Figure 11: Share of Canadian Nominal GDP per variable 1961Q1 - 2019Q2



Source: Adapted from the Statistics Canada Table: 36-10-0104-01 (current prices) using nominal seasonally adjusted quarterly data for the components of GDP from 1961Q1-2019Q2. The components of GDP are: consumption (C), investment (I), government spending (G), exports (X) less imports (M). Nominal imports (M) is graphed using the absolute value of its ratio to GDP.

i

Consumption represents the largest component, hovering a majority share between 50 to 65% of nominal GDP throughout the time series.

ii

Using the inception of data from 1961 as a base point, all components excluding consumption has increased in their ratio to nominal GDP as depicted on Figure 11. Looking at the most current data in 2019, investment and government spending has increased slightly (less than 5% points) as a ratio of GDP relative to 1961, while exports and imports has seen a much more significant growth in share size (over 10% points) over the same time period.

Question 4

A

Figure 12: Velocity of M1+ and Government of Canada's Marketable Bonds Yields

Source: Velocity of M1+ is calculated as a ratio of nominal GDP to M1+, adapted from the Statistics Canada tables: 36-10-0104-01 (current prices) and 10-10-0116-01 respectively. Government of Canada marketable bond percentage yields with maturities 1-3 years, 3-5 years, 5-10 years, and over 10 years, has been adapted from Statistics Canada table 10-10-0139-01. All data is analyzed quarterly, nominally and not seasonally adjusted for the periods 1991Q1-2019Q2.

A ***cooler*** animated version of the graph can be found at an RPubs here for better visualisation.

B

Throughout the periods 1991Q1 to 2019Q2, the velocity of M1+ has shown strong coincidence to the movement of Government of Canada marketable bonds' yields, resulting in positive correlation values ranging from 0.905 to 0.934. While causality has not yet been tested, a hypothesis to the relationship can be derived from monetarism's quantity theory of money. Particularly in the short term, velocity of money is variable and inversely related to the demand for money; as liquidity preferences increases, propensity to hold onto money reduces the frequency that money is circulated. On the other hand, bond yields represents interest rates or the opportunity cost of money demand, such that as yields decrease, investments become less attractive and thereby increases the demand of money and decreasing the velocity of money. Noticeably then, figure 12 illustrates downwards trending velocity of M1+ and government marketable bond yields, which depicts a growing tendency for liquidity preferences in the economy.

Appendix

```
The stata code was used for Q1, R was used for everything else including the season

clear
log close
import excel "/Users/renmingyan/Desktop/Data for run/A1_Data.xlsx", sheet("Quartly
log using "/Users/renmingyan/Desktop/Data for run/Assignment1.txt",replace

set more off

timer on 1


gen quarter=tq(1961q1)+_n-1

format quarter %tq

tsset quarter


*Annual growth rate for each variable

*GDP
gen growth_Y=((Y[_n]-Y[_n-4])/Y[_n-4])*100

*C
gen growth_C=((C[_n]-C[_n-4])/C[_n-4])*100

*I
gen growth_I=((I[_n]-I[_n-4])/I[_n-4])*100

*G
gen growth_G=((G[_n]-G[_n-4])/G[_n-4])*100

*X
gen growth_X=((X[_n]-X[_n-4])/X[_n-4])*100

*M
gen growth_M=((M[_n]-M[_n-4])/M[_n-4])*100

*CPI
gen growth_CPI=((CPI[_n]-CPI[_n-4])/CPI[_n-4])*100

*pi
gen growth_pi=((pi[_n]-pi[_n-4])/pi[_n-4])*100
```

```
*Hours
gen growth_Hours=((Hours[_n]-Hours[_n-4])/Hours[_n-4])*100

*Labourproductivity
gen growth_Labourproductivity=((Labourproductivity[_n]-Labourproductivity[_n-4])/La

*Wages
gen growth_Wages=((Wages[_n]-Wages[_n-4])/Wages[_n-4])*100


sum growth_Y growth_C growth_I growth_G growth_X growth_M growth_CPI growth_pi grow

*question #1(a)
pwcorr growth_Y L1.growth_Y L2.growth_Y L3.growth_Y L4.growth_Y F1.growth_Y F2.grow
pwcorr growth_Y growth_C L1.growth_C L2.growth_C L3.growth_C L4.growth_C F1.growth_
pwcorr growth_Y growth_I L1.growth_I L2.growth_I L3.growth_I L4.growth_I F1.growth_
pwcorr growth_Y growth_G L1.growth_G L2.growth_G L3.growth_G L4.growth_G F1.growth_
pwcorr growth_Y growth_X L1.growth_X L2.growth_X L3.growth_X L4.growth_X F1.growth_
pwcorr growth_Y growth_M L1.growth_M L2.growth_M L3.growth_M L4.growth_M F1.growth_
pwcorr growth_Y growth_CPI L1.growth_CPI L2.growth_CPI L3.growth_CPI L4.growth_CPI
pwcorr growth_Y growth_pi L1.growth_pi L2.growth_pi L3.growth_pi L4.growth_pi F1.gr
pwcorr growth_Y growth_Hours L1.growth_Hours L2.growth_Hours L3.growth_Hours L4.gro
pwcorr growth_Y growth_Labourproductivity L1.growth_Labourproductivity L2.growth_La
pwcorr growth_Y growth_Wages L1.growth_Wages L2.growth_Wages L3.growth_Wages L4.gro


*question #1(b)
*GDP
gen growth_Y2=((Y[_n]-Y[_n-4])/Y[_n-4])*100

*C
gen growth_C2=((C[_n]-C[_n-4])/C[_n-4])*100

*I
gen growth_I2=((I[_n]-I[_n-4])/I[_n-4])*100

*G
gen growth_G2=((G[_n]-G[_n-4])/G[_n-4])*100

*X
gen growth_X2=((X[_n]-X[_n-4])/X[_n-4])*100

*M
gen growth_M2=((M[_n]-M[_n-4])/M[_n-4])*100

*CPI
gen growth_CPI2=((CPI[_n]-CPI[_n-4])/CPI[_n-4])*100
```

```
*pi
gen growth_pi2=((pi[_n]-pi[_n-4])/pi[_n-4])*100

*Hours
gen growth_Hours2=((Hours[_n]-Hours[_n-4])/Hours[_n-4])*100

*Labourproductivity
gen growth_Labourproductivity2=((Labourproductivity[_n]-Labourproductivity[_n-4])/I

*Wages
gen growth_Wages2=((Wages[_n]-Wages[_n-4])/Wages[_n-4])*100


sum growth_Y2 growth_C2 growth_I2 growth_G2 growth_X2 growth_M2 growth_CPI2 growth_

pwcorr growth_Y2 L1.growth_Y2 L2.growth_Y2 L3.growth_Y2 L4.growth_Y2 F1.growth_Y2 F
pwcorr growth_Y2 growth_C2 L1.growth_C2 L2.growth_C2 L3.growth_C2 L4.growth_C2 F1.g
pwcorr growth_Y2 growth_I2 L1.growth_I2 L2.growth_I2 L3.growth_I2 L4.growth_I2 F1.g
pwcorr growth_Y2 growth_G2 L1.growth_G2 L2.growth_G2 L3.growth_G2 L4.growth_G2 F1.g
pwcorr growth_Y2 growth_X2 L1.growth_X2 L2.growth_X2 L3.growth_X2 L4.growth_X2 F1.g
pwcorr growth_Y2 growth_M2 L1.growth_M2 L2.growth_M2 L3.growth_M2 L4.growth_M2 F1.g
pwcorr growth_Y2 growth_CPI2 L1.growth_CPI2 L2.growth_CPI2 L3.growth_CPI2 L4.growth
pwcorr growth_Y2 growth_pi2 L1.growth_pi2 L2.growth_pi2 L3.growth_pi2 L4.growth_pi2
pwcorr growth_Y2 growth_Hours2 L1.growth_Hours2 L2.growth_Hours2 L3.growth_Hours2 I
pwcorr growth_Y2 growth_Labourproductivity2 L1.growth_Labourproductivity2 L2.growth
pwcorr growth_Y2 growth_Wages2 L1.growth_Wages2 L2.growth_Wages2 L3.growth_Wages2 I


*question #1 (c)

*GDP
gen growth_Y3=((Y[_n]-Y[_n-1])/Y[_n-1])*100

*C
gen growth_C3=((C[_n]-C[_n-1])/C[_n-1])*100

*I
gen growth_I3=((I[_n]-I[_n-1])/I[_n-1])*100

*G
gen growth_G3=((G[_n]-G[_n-1])/G[_n-1])*100

*X
gen growth_X3=((X[_n]-X[_n-1])/X[_n-1])*100

*M
gen growth_M3=((M[_n]-M[_n-1])/M[_n-1])*100
```

```
*CPI
gen growth_CPI3=((CPI[_n]-CPI[_n-4])/CPI[_n-4])*100

*pi
gen growth_pi3=((pi[_n]-pi[_n-4])/pi[_n-4])*100

*Hours
gen growth_Hours3=((Hours[_n]-Hours[_n-4])/Hours[_n-4])*100

*Labourproductivity
gen growth_Labourproductivity3=((Labourproductivity[_n]-Labourproductivity[_n-4])/I

*Wages
gen growth_Wages3=((Wages[_n]-Wages[_n-4])/Wages[_n-4])*100


sum growth_Y3 growth_C3 growth_I3 growth_G3 growth_X3 growth_M3 growth_CPI3 growth_

pwcorr growth_Y3 L1.growth_Y3 L2.growth_Y3 L3.growth_Y3 L4.growth_Y3 F1.growth_Y3 F
pwcorr growth_Y3 growth_C3 L1.growth_C3 L2.growth_C3 L3.growth_C3 L4.growth_C3 F1.g
pwcorr growth_Y3 growth_I3 L1.growth_I3 L2.growth_I3 L3.growth_I3 L4.growth_I3 F1.g
pwcorr growth_Y3 growth_G3 L1.growth_G3 L2.growth_G3 L3.growth_G3 L4.growth_G3 F1.g
pwcorr growth_Y3 growth_X3 L1.growth_X3 L2.growth_X3 L3.growth_X3 L4.growth_X3 F1.g
pwcorr growth_Y3 growth_M3 L1.growth_M3 L2.growth_M3 L3.growth_M3 L4.growth_M3 F1.g
pwcorr growth_Y3 growth_CPI3 L1.growth_CPI3 L2.growth_CPI3 L3.growth_CPI3 L4.growth
pwcorr growth_Y3 growth_pi3 L1.growth_pi3 L2.growth_pi3 L3.growth_pi3 L4.growth_pi3
pwcorr growth_Y3 growth_Hours3 L1.growth_Hours3 L2.growth_Hours3 L3.growth_Hours3 I
pwcorr growth_Y3 growth_Labourproductivity3 L1.growth_Labourproductivity3 L2.growth
pwcorr growth_Y3 growth_Wages3 L1.growth_Wages3 L2.growth_Wages3 L3.growth_Wages3 I


*question #1 (d)

tsfilter hp Y_hp=Y, smooth(1600) trend(trend_Y_hp)
tsfilter hp C_hp=C, smooth(1600) trend(trend_C_hp)
tsfilter hp I_hp=I, smooth(1600) trend(trend_I_hp)
tsfilter hp G_hp=G, smooth(1600) trend(trend_G_hp)
tsfilter hp X_hp=X, smooth(1600) trend(trend_X_hp)
tsfilter hp M_hp=M, smooth(1600) trend(trend_M_hp)
tsfilter hp CPI_hp=CPI, smooth(1600) trend(trend_CPI_hp)
tsfilter hp pi_hp=pi, smooth(1600) trend(trend_pi_hp)
tsfilter hp hours_hp=Hours, smooth(1600) trend(trend_hours_hp)
tsfilter hp Labour_productivity_hp=Labour~y, smooth(1600) trend(trend_Labour_produc
tsfilter hp Wages_hp=Wages, smooth(1600) trend(trend_Wages_hp)
```

```
*Percentage Deviation from Trend
gen pd_Y_hp = 100*Y_hp/trend_Y_hp
gen pd_C_hp = 100*C_hp/trend_C_hp
gen pd_I_hp = 100*I_hp/trend_I_hp
gen pd_G_hp = 100*G_hp/trend_G_hp
gen pd_X_hp = 100*X_hp/trend_X_hp
gen pd_M_hp = 100*M_hp/trend_M_hp
gen pd_CPI_hp = 100*CPI_hp/trend_CPI_hp
gen pd_pi_hp = 100*pi_hp/trend_pi_hp
gen pd_hours_hp = 100*hours_hp/trend_hours_hp
gen pd_Labour_productivity_hp = 100*Labour_productivity_hp/trend_Labour_productivit
gen pd_Wages_hp = 100*Wages_hp/trend_Wages_hp



sum pd_Y_hp pd_C_hp pd_I_hp pd_G_hp pd_X_hp pd_M_hp if quarter>=tq(1981q1) & quarte

pwcorr pd_Y_hp L1.pd_Y_hp L2.pd_Y_hp L3.pd_Y_hp L4.pd_Y_hp F1.pd_Y_hp F2.pd_Y_hp F3
pwcorr pd_Y_hp pd_C_hp L1.pd_C_hp  L2.pd_C_hp L3.pd_C_hp L4.pd_C_hp F1.pd_C_hp F2.p
pwcorr pd_Y_hp pd_I_hp L1.pd_I_hp  L2.pd_I_hp L3.pd_I_hp L4.pd_I_hp F1.pd_I_hp F2.p
pwcorr pd_Y_hp pd_G_hp L1.pd_G_hp  L2.pd_G_hp L3.pd_G_hp L4.pd_G_hp F1.pd_G_hp F2.p
pwcorr pd_Y_hp pd_X_hp L1.pd_X_hp  L2.pd_X_hp L3.pd_X_hp L4.pd_X_hp F1.pd_X_hp F2.p
pwcorr pd_Y_hp pd_M_hp L1.pd_M_hp  L2.pd_M_hp L3.pd_M_hp L4.pd_M_hp F1.pd_M_hp F2.p
pwcorr pd_Y_hp pd_CPI_hp L1.pd_CPI_hp  L2.pd_CPI_hp L3.pd_CPI_hp L4.pd_CPI_hp F1.pd
pwcorr pd_Y_hp pd_pi_hp L1.pd_pi_hp  L2.pd_pi_hp L3.pd_pi_hp L4.pd_pi_hp F1.pd_pi_h
pwcorr pd_Y_hp pd_hours_hp L1.pd_hours_hp  L2.pd_hours_hp L3.pd_hours_hp L4.pd_hour
pwcorr pd_Y_hp pd_Labour_productivity_hp L1.pd_Labour_productivity_hp L2.pd_Labour_
pwcorr pd_Y_hp pd_Wages_hp L1.pd_Wages_hp L2.pd_Wages_hp L3.pd_Wages_hp L4.pd_Wages
### Call Libraries

library(seasonal)
library(dplyr)
library(ggplot2)
library(zoo)
library(mFilter)

# Loading Data Frame ----

df <- read.csv("D:/Users/Ziqiu/OneDrive/Documents/Masters Courses/EC640 Macroeconom
               header = TRUE)
df[,-1] <- as.data.frame(sapply(df[-1], as.numeric))
df[,1] <- as.Date(as.character(df[,1]), format = "%m/%d/%Y")

GDP_y2y <- select(df, Date,C_Y2Y:Y_Y2Y)[-c(1:4),] #remove first 4 rowws

GDP_comp <- select(df, Date:Y)
GDP_comp <- GDP_comp[complete.cases(GDP_comp),]
```

```
consumer_price <- select(df, Date, cpi)
consumer_price[,2] <- ts(consumer_price[,2], start = c(1961, 1), end = c(2019, 2),
                         frequency = 4)



plot(consumer_price[,2])
sa_series <- seas(consumer_price[,2], x11 = "")
lines(final(sa_series), col=2)

c <- as.numeric(final(sa_series))
write.csv(matrix(c, nrow=1), file ="myfile.csv", row.names=FALSE)
### added this as a column in my excel file

#  zoom in

# zoom_cp <- ts(consumer_price[,2][1:25], start = c(1961, 1), end = c(1967, 1),
#               frequency = 4)
# zoom_sas <- ts(final(sa_series)[1:25], start = c(1961,1), end = c(1967,1),
#                frequency = 4)
# plot(zoom_cp)
# lines(zoom_sas, col = 2)

### with GGPLOT instead ### Need to label


# consumer_price <- consumer_price %>%
#         mutate(s_adjusted = as.numeric(final(sa_series)))
#
# ggplot(data = consumer_price, aes(x = Date)) +
#     geom_line(aes(y = as.numeric(cpi))) +
#     geom_line(aes(y = s_adjusted, color = 'red')) #+
#     #coord_cartesian(ylim=c(15,30) , xlim = c(as.Date("1961-01-01"), as.Date("197

### Question 1.a) ----

### mean and variance

### To compare with sample table
GDP_y2y %>%
    select(C_Y2Y:Y_Y2Y) %>%
    summarise_all(funs(mean))
GDP_y2y %>%
    select(C_Y2Y:Y_Y2Y) %>%
    summarise_all(funs(sd))

### mean and SD
```

```
summarise_all(GDP_y2y, funs(mean))
summarise_all(GDP_y2y, funs(sd))
summarise_all(select(GDP_y2y, C_Y2Y:M_Y2Y), funs(sd))/sapply(GDP_y2y['Y_Y2Y'], sd)



#This is a function that creates lags from -4 to 4 of a vector.
create_lags <- function(vctr) {
    zoo_vector <- zoo(vctr)
    lagged_df <- vctr
    #if (GDP_y2y['Y_Y2Y'] == vctr) {
     #   lagged_df <- GDP_y2y['Y_Y2Y']
      #  } else {
       #     lagged_df <- cbind(GDP_y2y['Y_Y2Y'],vctr)
        #}
    for (i in c(-4:-1, 1:4)){
        lags <- stats::lag(zoo_vector, i, na.pad = TRUE)
        lagged_df <- cbind(lagged_df, as.data.frame(lags))
    }
    return(lagged_df[,c(2:5,1,6:9)])
}

### Autocorrelation table

# get the same results as his chart for 1961-2019

#correlates the lags to the vector of GDP to get the first row
#of the correlation table
test_table <- sapply(create_lags(GDP_y2y['Y_Y2Y']), cor, GDP_y2y['Y_Y2Y'],
                     use = 'pairwise.complete.obs')

#loop on the other variables to complete the rest of the correlation table.

for (i in names(GDP_y2y[,c(-1,-7)])) {
    test_table <- rbind(test_table,
                        sapply(create_lags(GDP_y2y[i]), cor, GDP_y2y['Y_Y2Y'],
                               use = 'pairwise.complete.obs'))
}
colnames(test_table) <- c(-4:4)
test_table
# my numbers are off by 0.04 from the numbers posted on the table at consumption

# 1981-2019

Q1A <- df %>%
    select(Date, C_Y2Y:Tcomp_hour_Y2Y) %>%
    filter(Date >= as.Date("1981-01-01"))# %>%
# select(C_Y2Y:Y_Y2Y)
```

```
summarise_all(Q1A, funs(mean), na.rm = TRUE)
summarise_all(Q1A, funs(sd), na.rm = TRUE)
summarise_all(Q1A[,-c(9:12)], funs(sd), na.rm = TRUE)/sapply(Q1A['Y_Y2Y'], sd)
sd(Q1A[,9], na.rm = TRUE)/sapply(Q1A %>%
                                     filter(Date >= as.Date('1985-01-01')) %>%
                                     select(Y_Y2Y), sd)
summarise_all(Q1A[10:12], funs(sd), na.rm = TRUE)/sapply(Q1A %>%
                                                             filter(Date >= as.Date
                                                             select(Y_Y2Y), sd)


cor_table_1a <- sapply(create_lags(Q1A['Y_Y2Y']), cor, Q1A['Y_Y2Y'],
                       use = 'pairwise.complete.obs')
for (i in names(Q1A[,c(2:6,8:12)])) {
    cor_table_1a <- rbind(cor_table_1a,
                          sapply(create_lags(Q1A[i]), cor, Q1A['Y_Y2Y'],
                                 use = 'pairwise.complete.obs'))
}

colnames(cor_table_1a) <- c(-4:4)
cor_table_1a

### Q1b ----


Q1B <- df %>%
    select(Date, C_Y2Y:Tcomp_hour_Y2Y) %>%
    filter(Date >= as.Date("1996-01-01"))

summarise_all(Q1B, funs(mean), na.rm = TRUE)
summarise_all(Q1B, funs(sd), na.rm = TRUE)
summarise_all(Q1B[,-c(9:12)], funs(sd), na.rm = TRUE)/sapply(Q1B['Y_Y2Y'], sd)
sd(Q1B[,9], na.rm = TRUE)/sapply(Q1B %>%
                                     filter(Date >= as.Date('1996-01-01')) %>%
                                     select(Y_Y2Y), sd)
summarise_all(Q1B[10:12], funs(sd), na.rm = TRUE)/sapply(Q1B %>%
                                                             filter(Date >= as.Date
                                                             select(Y_Y2Y), sd)

cor_table_1b <- sapply(create_lags(Q1B['Y_Y2Y']), cor, Q1B['Y_Y2Y'],
                       use = 'pairwise.complete.obs')
for (i in names(Q1B[,c(2:6,8:12)])) {
    cor_table_1b <- rbind(cor_table_1b,
               sapply(create_lags(Q1B[i]), cor, Q1B['Y_Y2Y'],
                      use = 'pairwise.complete.obs'))
}
```

```
colnames(cor_table_1b) <- c(-4:4)
cor_table_1b


### Q1c ----

GDP_q2q <-  select(df, Date, C_Q2Q:Tcomp_hour_Q2Q)
Q1C <- GDP_q2q %>%
    filter(Date >= as.Date("1981-01-01"))

summarise_all(Q1C, funs(mean), na.rm = TRUE)
summarise_all(Q1C, funs(sd), na.rm = TRUE)
summarise_all(Q1C[,-c(9:12)], funs(sd), na.rm = TRUE)/sapply(Q1C['Y_Q2Q'], sd)
sd(Q1C[,9], na.rm = TRUE)/sapply(Q1C %>%
                                     filter(Date >= as.Date('1984-04-01')) %>%
                                     select(Y_Q2Q), sd)
summarise_all(Q1C[10:12], funs(sd), na.rm = TRUE)/sapply(Q1C %>%
                                                             filter(Date >= as.Date
                                                             select(Y_Q2Q), sd)

cor_table_1b <- sapply(create_lags(Q1B['Y_Y2Y']), cor, Q1B['Y_Y2Y'],
                       use = 'pairwise.complete.obs')
for (i in names(Q1B[,c(2:6,8:12)])) {
    cor_table_1b <- rbind(cor_table_1b,
                          sapply(create_lags(Q1B[i]), cor, Q1B['Y_Y2Y'],
                                 use = 'pairwise.complete.obs'))
}

colnames(cor_table_1b) <- c(-4:4)
cor_table_1b

cor_table_1c <- sapply(create_lags(Q1C['Y_Q2Q']), cor, Q1C['Y_Q2Q'],
                       use = 'pairwise.complete.obs')
for (i in names(Q1C[,c(2:6, 8:12)])) {
    cor_table_1c  <- rbind(cor_table_1c ,
               sapply(create_lags(Q1C[i]), cor, Q1C['Y_Q2Q'],use = 'pairwise.comple
}
colnames(cor_table_1c) <- c(-4:4)
cor_table_1c

### Q1d ----

## Converting time series ----
# Convert everything to a time series so I can pass hp filter for Q2
GDP_comp_TS <- GDP_comp[,-1] %>%
    mutate_all(ts, start = c(1961,1), end=c(2019,2), frequency = 4)

cpi <- ts(final(sa_series), start = c(1961,1), end = c(2019,2), frequency = 4)
```

```
cpi8 <- ts(df %>%
               filter(Date >= '1984-01-01') %>%
               select(cpi_8),
           start = c(1984,1), end = c(2019,2), frequency = 4)

labour_var <- ts(df %>%
                     filter(Date >= '1981-01-01') %>%
                     select(Hrs_worked:Tcomp_hour), start = c(1981,1),
                 end = c(2019,2), frequency = 4)


## Creating dataframes after passing HP filters ----

HP_Series <- hpfilter(GDP_comp_TS['Y'], freq = 1600)
HP_Series <- as.data.frame(cbind(GDP_comp['Date'],
                                 100* (HP_Series$x - HP_Series$tre

for (i in c('C', 'I', 'G', 'X', 'M')) {
    HP_i <- hpfilter(GDP_comp_TS[i], freq = 1600)
    HP_Series <- cbind(HP_Series, 100* (HP_i$x - HP_i$trend)/HP_i$trend)
}
names(HP_Series)[2:7] <- c('Y_Dev', 'C_Dev', 'I_Dev', 'G_Dev', 'X_Dev', 'M_Dev')

HP_81 <- filter(HP_Series, Date >= '1981-01-01')

HP_cpi <- hpfilter(cpi, freq = 1600)

HP_cpi_series <- as.data.frame(cbind(HP_Series['Date'], HP_Series['Y_Dev'],
                                     as.numeric(100 * (HP_cpi$x - HP_cpi$trend)/HP_
names(HP_cpi_series)[3] <- 'CPI_Dev'


HP_cpi8 <- hpfilter(cpi8, freq = 1600)
HP_cpi8_series <- as.data.frame(cbind(HP_Series[,1:2] %>%
                                          filter(Date >= '1984-01-01'),
                                      as.numeric(100 * (HP_cpi8$x - HP_cpi8$trend)/
names(HP_cpi8_series)[3] <- 'CPI8_Dev'

HP_hrs_wrk <- hpfilter(labour_var[,1], freq = 1600)
HP_wrk_series <- as.data.frame(cbind(HP_Series[,1:2] %>%
                                         filter(Date >= '1981-01-01'),
                                     as.numeric(100 * (HP_hrs_wrk$x - HP_hrs_wrk$tr
names(HP_wrk_series)[3] <- 'Wrk_Dev'

HP_labor <- hpfilter(labour_var[,2], freq = 1600)
HP_labor_series <- as.data.frame(cbind(HP_Series[,1:2] %>%
                                           filter(Date >= '1981-01-01'),
```

```
                                       as.numeric(100 * (HP_labor$x - HP_labor$tren
names(HP_labor_series)[3] <- 'Labor_Prod'

HP_hrly_comp <- hpfilter(labour_var[,3], freq = 1600)
HP_hrly_series <- as.data.frame(cbind(HP_Series[,1:2] %>%
                                         filter(Date >= '1981-01-01'),
                                      as.numeric(100 * (HP_hrly_comp$x - HP_hrly_co
names(HP_hrly_series)[3] <- 'Hrly_Comp'

# Summary Statistics
summarise_all(HP_81[,-1], funs(mean))
summarise_all(select(HP_81, C_Dev:M_Dev), funs(sd))/sapply(GDP_y2y['Y_Y2Y'], sd)

summarise_all(HP_cpi_series, funs(mean), na.rm =TRUE)
summarise_all(HP_cpi8_series, funs(mean), na.rm =TRUE)
summarise_all(HP_wrk_series, funs(mean), na.rm =TRUE)
summarise_all(HP_labor_series, funs(mean), na.rm =TRUE)
summarise_all(HP_hrly_series, funs(mean), na.rm =TRUE)

sapply(HP_cpi_series['CPI_Dev'],sd)/sapply(HP_Series['Y_Dev'], sd)
sapply(HP_cpi8_series['CPI8_Dev'], sd)/sapply(HP_Series %>%
                                                filter(Date >= '1984-01-01') %>%
                                                select(Y_Dev), sd)
sapply(HP_wrk_series['Wrk_Dev'],sd)/sapply(HP_Series %>%
                                              filter(Date >= '1981-01-01') %>%
                                              select(Y_Dev), sd)
sapply(HP_labor_series['Labor_Prod'],sd)/sapply(HP_Series %>%
                                              filter(Date >= '1981-01-01') %>%
                                              select(Y_Dev), sd)
sapply(HP_hrly_series['Hrly_Comp'],sd)/sapply(HP_Series %>%
                                              filter(Date >= '1981-01-01') %>%
                                              select(Y_Dev), sd)
# Correlation table


cor_table_1d <- sapply(create_lags(HP_81['Y_Dev']), cor, HP_81['Y_Dev'],
                       use = 'pairwise.complete.obs')
for (i in names(HP_Series[,c(-1,-2)])) {
    cor_table_1d <- rbind(cor_table_1d,
               sapply(create_lags(HP_81[i]), cor, HP_81['Y_Dev'],
                      use = 'pairwise.complete.obs'))
}

cor_table_1d <- rbind(cor_table_1d,
                      sapply(create_lags(HP_cpi_series %>%
                                           filter(Date >= '1981-01-01') %>%
                                           select(CPI_Dev)), cor, HP_81['Y_Dev'],
                                       use = "pairwise.complete.obs"))
```

```
cor_table_1d <- rbind(cor_table_1d,
                      sapply(create_lags(HP_cpi8_series['CPI8_Dev']), cor,
                             HP_81 %>%
                                 filter(Date >= '1984-01-01') %>%
                                 select(Y_Dev),
                                         use = "pairwise.complete.obs"))
cor_table_1d <- rbind(cor_table_1d,
                      sapply(create_lags(HP_wrk_series['Wrk_Dev']), cor, HP_81['Y_D
                                         use = 'pairwise.complete.obs'))
cor_table_1d <- rbind(cor_table_1d,
                      sapply(create_lags(HP_labor_series['Labor_Prod']), cor, HP_81
                                         use = 'pairwise.complete.obs'))
cor_table_1d <- rbind(cor_table_1d,
                      sapply(create_lags(HP_hrly_series['Hrly_Comp']), cor, HP_81['
                                         use = 'pairwise.complete.obs'))

colnames(cor_table_1d) <- c(-4,-3,-2,-1,0,1,2,3,4)
cor_table_1d

# Question 2 ----
### deviations for cpi



### Plot of consumption ----

png("CDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_Series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = C_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Real Consumption'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Investment ----
```

```
png("IDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_Series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = I_Dev, color = I('grey2')), size = 1.1) +
    scale_color_manual(labels = c('Real GDP', 'Real Investment'),
                       values = c("dodgerblue1", 'grey2')) +
    theme_bw() +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Government Spending ----

png("GDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_Series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = G_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Real Government Spending'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Exports ----

png("XDev.png", width = 465, height = 225, units='mm', res = 300)
```

```
ggplot(data = HP_Series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = X_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Real Exports'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Imports ----

png("MDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_Series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = M_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Real Imports'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Headline CPI ----

png("CPIDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_cpi_series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
```

```
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = CPI_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Headline CPI'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of CPI excluding the 8 most volatile components ----

png("CPI8Dev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_cpi8_series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = CPI8_Dev, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Core CPI'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Plot of Hours Worked----

png("WorkDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_wrk_series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = Wrk_Dev, color = I('grey2')), size = 1.1) +
```

```
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Hours Worked'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Labour Productivity ----

png("LaborDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_labor_series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1'), size = 1.1) +
    geom_line(aes(y = Labor_Prod, color = I('grey2')), size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Labor Productivity'),
                       values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

### Total hourly compensation ----

png("CompensationDev.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = HP_hrly_series, aes(x = Date)) +
    geom_hline(yintercept = 0, colour = 'red') +
    geom_line(aes(y = Y_Dev, color = 'dodgerblue1') , size = 1.1) +
    geom_line(aes(y = Hrly_Comp, color = I('grey2')) , size = 1.1) +
    theme_bw() +
    scale_color_manual(labels = c('Real GDP', 'Total Hourly Compensation'),
```

```
                        values = c("dodgerblue1", 'grey2')) +
    labs(color = 'Series') +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm")) +
    labs(x = 'Year', y = 'Percentage Deviation from Trend')
dev.off()

# Question 3 Plot ----

png("GDPshare.png", width = 465, height = 225, units='mm', res = 300)
ggplot(data = df, aes(x = Date)) +
    theme_bw() +
    geom_line(aes(y = Q3C, color = 'red2'), size = 1.25) +
    geom_line(aes(y = Q3I, color = 'green3'), size = 1.25) +
    geom_line(aes(y = Q3G, color = 'royalblue1'), size = 1.25) +
    geom_line(aes(y = Q3X, color = 'magenta1'), size = 1.25) +
    geom_line(aes(y = Q3M, color = 'darkorange2'), size = 1.25) +
    labs(color = 'Series',
         y = 'Ratio of GDP (%)',
         x = 'Year') +
    scale_color_identity(guide = 'legend',
                         breaks = c('red2',
                                    'green3',
                                    'royalblue1',
                                    'magenta1',
                                    'darkorange2'),
                         labels = c('C',
                                    'I',
                                    'G',
                                    'X',
                                    'M')) +
    theme(legend.position="bottom",
          legend.text = element_text(size=22),
          axis.text = element_text(size=22),
          axis.title = element_text(size=26),
          plot.title=element_text(size = 26),
          legend.title=element_text(size= 26),
          # Change legend key size and key width
          legend.key.size = unit(1.5, "cm"),
          legend.key.width = unit(2.0,"cm"))
dev.off()
```

```
#Q4 ----

library(gganimate)

q4df <- read.csv("D:/Users/Ziqiu/OneDrive/Documents/Masters Courses/EC640 Macroecon
                 header = TRUE)
q4df[,-1] <- as.data.frame(sapply(q4df[-1], as.numeric))
q4df[,1] <- as.Date(as.character(q4df[,1]), format = "%m/%d/%Y")

q4df_complete <- q4df[complete.cases(q4df),]

#exploratory data analysis of velocity of money y2y growth and inflation

cor(q4df['vM2_1'], q4df['GBond10y'], 'pairwise.complete.obs')
cor(q4df['vM2_11'], q4df['GBond10y'], 'pairwise.complete.obs')
cor(q4df['vM1_1'], q4df['GBond10y'], 'pairwise.complete.obs')
cor(q4df['vM1_11'], q4df['GBond10y'], 'pairwise.complete.obs')

cor(q4df['vM2_1'], q4df['GBond1t3y'], 'pairwise.complete.obs')
cor(q4df['vM2_11'], q4df['GBond1t3y'], 'pairwise.complete.obs')
cor(q4df['vM1_1'], q4df['GBond1t3y'], 'pairwise.complete.obs')
cor(q4df['vM1_11'], q4df['GBond1t3y'], 'pairwise.complete.obs')

cor(q4df['vM2_1'], q4df['GBond3t5y'], 'pairwise.complete.obs')
cor(q4df['vM2_11'], q4df['GBond3t5y'], 'pairwise.complete.obs')
cor(q4df['vM1_1'], q4df['GBond3t5y'], 'pairwise.complete.obs')
cor(q4df['vM1_11'], q4df['GBond3t5y'], 'pairwise.complete.obs')

cor(q4df['vM2_1'], q4df['GBond5t10y'], 'pairwise.complete.obs')
cor(q4df['vM2_11'], q4df['GBond5t10y'], 'pairwise.complete.obs')
cor(q4df['vM1_1'], q4df['GBond5t10y'], 'pairwise.complete.obs')
cor(q4df['vM1_11'], q4df['GBond5t10y'], 'pairwise.complete.obs')

### M1+ has the highest correlation to government bond yields

q4treasury <- q4df %>% filter(Date >= '1991-01-01')

P <- ggplot(data = q4treasury, aes(x = Date)) +
    geom_line(aes(y = vM1_1, color = 'red2')) +
    geom_line(aes(y = GBond10y, color =  'dodgerblue1')) +
    geom_line(aes(y = GBond5t10y, color = 'turquoise2')) +
    geom_line(aes(y = GBond3t5y, color = 'palegreen3')) +
    geom_line(aes(y = GBond1t3y, color = 'green4')) +
    theme_bw() +
    labs(color = 'Series',
         y = 'Yield',
         x = 'Year') +
```

```
    scale_color_identity(guide = 'legend',
                         breaks = c('red2',
                                    'dodgerblue1',
                                    'turquoise2',
                                    'palegreen3',
                                    'green4'),
                         labels = c('M1+ Velocity Ratio',
                                    'Bonds Over 10 years',
                                    'Bonds 5-10 years',
                                    'Bonds 3-5 years',
                                    'Bonds 1-3 years')) +
    scale_y_continuous(name = 'Yield %',
                       sec.axis = sec_axis(~ ., name = 'Ratio')) +
    theme(
        legend.position = c(1,1),
        axis.line.y.right = element_line(color = "red2"),
        axis.ticks.y.right = element_line(color = "red2"),
        axis.text.y.right = element_text(color = "red2"),
        axis.title.y.right = element_text(color = "red2")
    )
png("Q4.png", width = 465, height = 225, units='mm', res = 300)

P + theme(legend.position="bottom",
      legend.text = element_text(size=18),
      axis.text = element_text(size=18),
      axis.title = element_text(size=26),
      plot.title=element_text(size = 26),
      legend.title=element_text(size= 26),
          # Change legend key size and key width
      legend.key.size = unit(1.5, "cm"),
      legend.key.width = unit(2.0,"cm")) +
    guides(color = guide_legend(override.aes = list(size = 1.75)))
dev.off()

#looking at other Money supplies
# P <- ggplot(data = q4treasury, aes(x = Date)) +
#     geom_line(aes(y = vM1_1, color = 'blue')) +
#     geom_line(aes(y = vM1_11, color = 'blue')) +
#     geom_line(aes(y = vM2_1, color = 'blue')) +
#     geom_line(aes(y = vM2_11, color = 'blue')) +
#     geom_line(aes(y = GBond5t10y, color = 'red')) +
#     geom_line(aes(y = GBond1t3y, color = 'purple')) +
#     geom_line(aes(y = GBond3t5y, color = 'orange')) +
#     geom_line(aes(y = GBond10y, color = 'grey'))

###animate into a gif for better readability.
Pgif <- P + transition_reveal(Date) +
    theme(legend.text = element_text(size = 14),
```

```
           axis.text = element_text(size = 14),
           axis.title = element_text(size = 18),
           plot.title = element_text(size = 18),
           legend.title = element_text(size = 18),
           # Change legend key size and key width
           legend.key.size = unit(0.8, "cm"),
           legend.key.width = unit(1.2, "cm"))
anim_save("Q4gif.gif", Pgif, width = 250, height = 120, units='mm', res = 200)
```