Total Expenditure into monthly data and Model Consumption and CPI

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Contents

1 Process

According to your suggestion, I made quarterly into smoothed monthly data. The idea is I give Jan, April, July and Oct 1/3 weight of the previous quarter and 2/3 current quarter, sum up and divided by 2. Feb, May, August, Nov keep their quarter figures and divide by 2. March, June, Sept and Dec have given 1/3 of the previous quarter and 2/3 current quarter, sum up and divided by 2.

```
##
##  Augmented Dickey-Fuller Test
##
## data:  df.ts
## Dickey-Fuller = -3.0187, Lag order = 6, p-value = 0.1469
## alternative hypothesis: stationary
```

2 Augmented Dickey-Fuller Test

One way to test whether a time series is stationary is to perform an augmented Dickey-Fuller test, which uses the following null and alternative hypotheses:

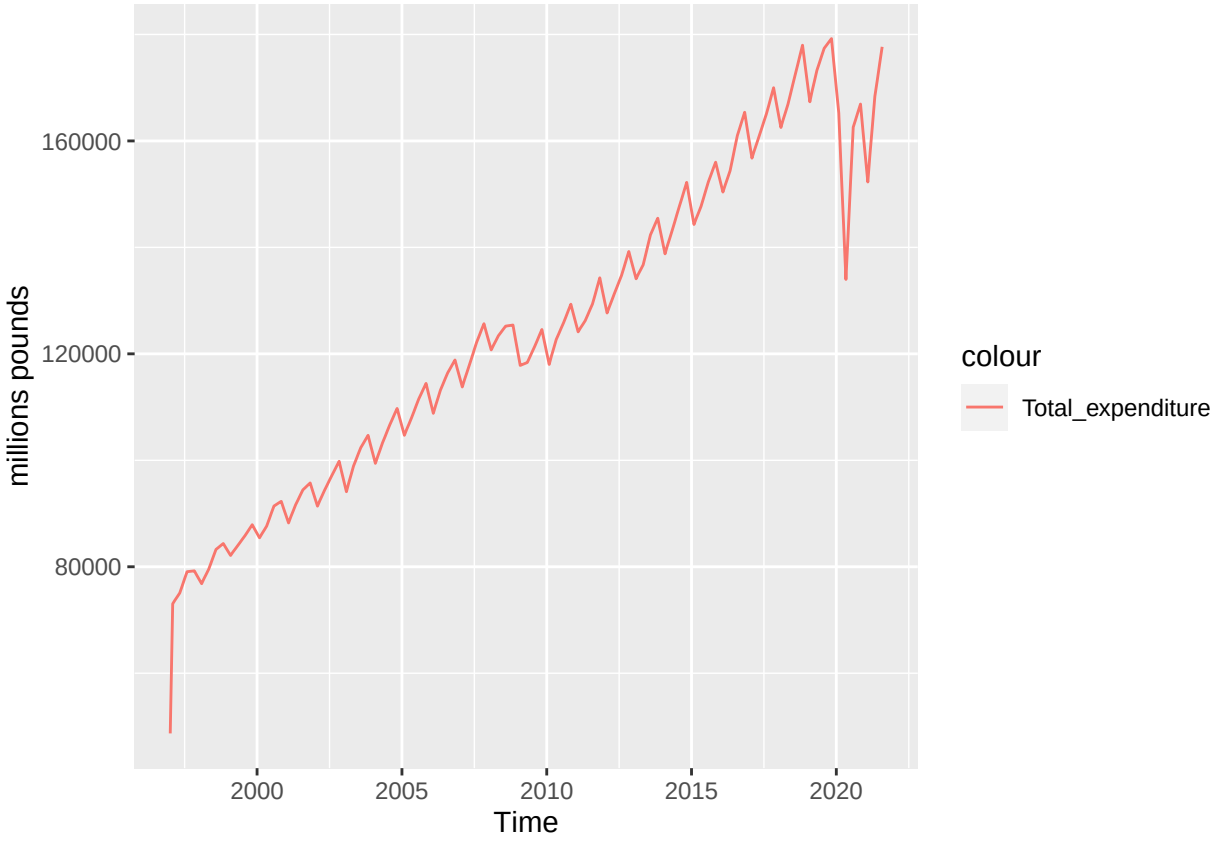

Figure 1: Total expenditure

H0: The time series is non-stationary. In other words, it has some time-dependent structure and does not have constant variance over time.

HA: The time series is stationary.

P-value: 0.1469

Since the p-value is 0.1469 not less than .05, we fail to reject the null hypothesis.

This means the time series is non-stationary. In other words, it has some time-dependent structure and does not have constant variance over time.

3 Growh rate

Since total expenditure monthly data is not stationary, I try to convert to a percentage growth rate.

```
##
##  Augmented Dickey-Fuller Test
##
## data:  df.ts
## Dickey-Fuller = -8.332, Lag order = 6, p-value = 0.01
## alternative hypothesis: stationary
```

We examine the growth rate stationary by applying the ADF test. The p-value is 0.01; we reject the null hypothesis. This means the time series is stationary now.

After we perform an augmented Dickey-Fuller test on the data, we can create a quick plot to visualize the data: There was a very clear fluctuation between March and August 2020.

4 Model and data

4.1 CPI all items level

The data set is monthly CPI all items and total expenditure for the UK from March 1997 to November 2019. We ignore the data after December 2019 since it is impacted by the Covid effect in 2020 Q1.

One of the significant differences between this model and the previous one is that we use total consumption as the demand variable for the overall CPI rate. This model for monthly data not only assumes inflation depends on 12 lagged inflation, dummies variables of each month, three VAT change announcements, and the great $D_{recession}$, but also Consumption C.

$$\begin{aligned} CPI_t = & Constant + \text{ Trend}_t + \beta_1 D_{Jan} + ... + \beta_{11} D_{Dec} + \beta_{12} D_{\text{recesion}} + \\ & \beta_{13} D_{VAT_1} + \beta_{14} D_{VAT_2} + \beta_{15} D_{TAT_3} + \sum_{j=1}^{12} \alpha_j C_{t-j} + \sum_{i=1}^{12} \lambda_i CPI_{t-i} + \sigma_t \end{aligned}$$

Where CPI is the inflation for CPI all itmes, D_{JAN} to D_{Dec} are eleven dummy variables for each month. We define February as the base category against which the others are assessed to avoid the dummy variable trap. $D_{recession}$, the great recession that officially began in April 2008 and ended in June 2009, D_{VAT_1} , D_{VAT_2} and D_{VAT_3} are three Value-add ed tax change in the United Kingdom, which were December 2008, January 2010 and January 2011. $\sum_{j=1}^{12} \alpha_j C_{t-j}$ is the sum of 12 monthly lags consumption growth rate. $\sum_{i=1}^{12} \lambda_i CPI_{t-i}$ represents the sum of twelve months lags of the inflation rate of CPI ALL ITEMS.

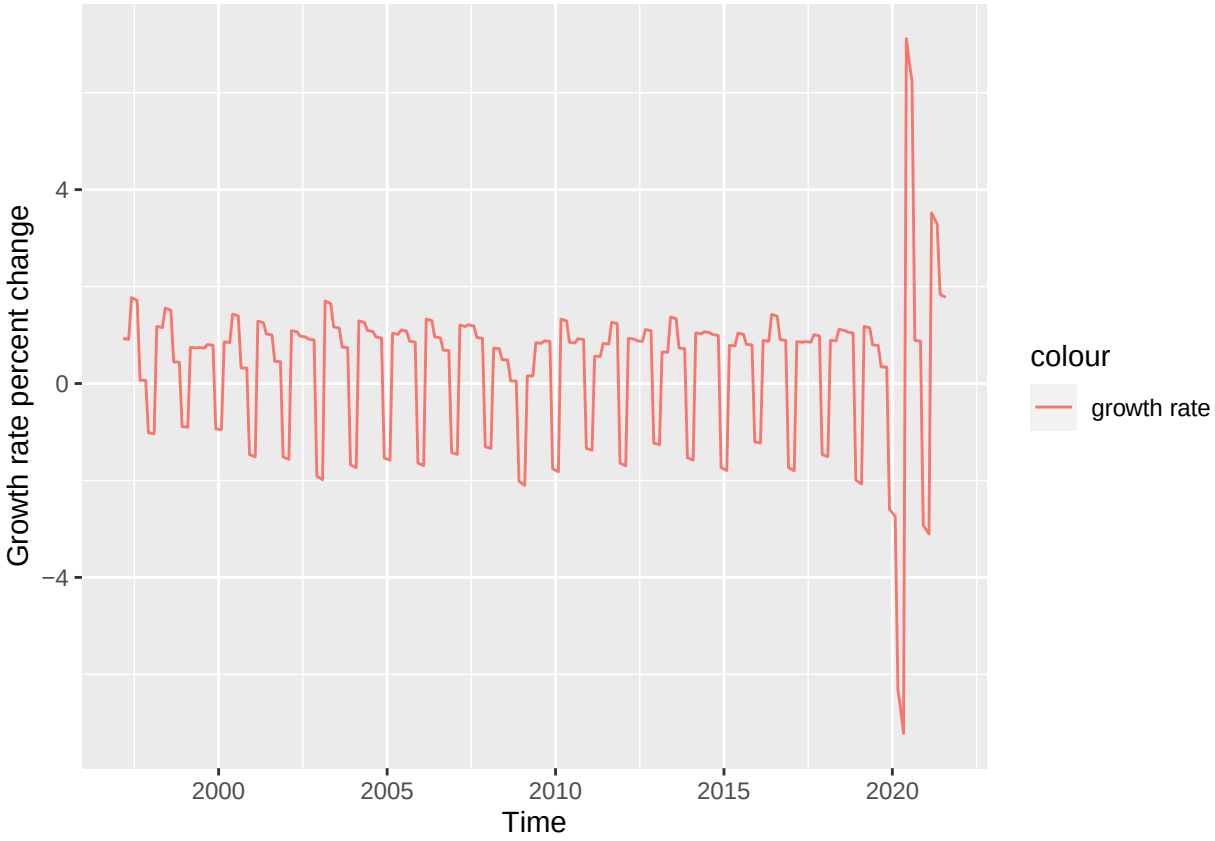

Figure 2: Growth rate

5 Stepwise function

To further discover the independent variables that have a more significant influence on inflation and remove less critical coefficients, we introduce stepwise regression. In our simplified process, we apply backward elimination selection based on P-value criteria. For CPI all items, we go through a systematic procedure to simplify the lag structure: Omit the least significant independent variable and rerun until all variables are significant at 5% or 1%. In this process, we always leave the dummy variables in (VAT, monthly, crisis etc.) in regression, even if insignificant.

5.0.1 Results

5.0.1.1 The original results

```
##
## ================================================
##                          Dependent variable:
##                      ---------------------------
##                              COPY[, 1]
##                            CPI ALL ITEMS
## ------------------------------------------------
## Constant                     0.52**
## lag1                          0.11
## lag2                          -0.01
## lag3                          0.10
## lag4                          0.02
## lag5                          -0.01
## lag6                          0.06
## lag7                          0.04
## lag8                          0.04
## lag9                          0.02
## lag10                        -0.001
## lag11                         0.02
## lag12                        0.17**
## time_Aug                      -0.56
## time_Dec                     -0.61*
## time_Apr                      -0.44
## time_Jan                     -1.07**
## time_Jul                     -0.96**
## time_Jun                     -0.66**
## time_Mar                      -0.37
## time_May                      -0.36
## time_Nov                     -0.65*
## time_Oct                      -0.40
## time_Sep                      -0.31
## VAT1                         -0.94**
## VAT2                          0.51*
## VAT3                          0.48*
## Recession                     0.17*
## Trend                        0.0002
## growth lag1                   0.18*
## growth lag2                   -0.12
## growth lag3                   0.01
## growth lag4                   0.08
```

```
## growth lag5                        -0.01
## growth lag6                        -0.05
## growth lag7                        0.03
## growth lag8                        -0.05
## growth lag9                        0.14
## growth lag10                       0.02
## growth lag11                       -0.14
## growth lag12                       0.06
## ------------------------------------------------
## Observations                        273
## R2                                 0.76
## Adjusted R2                        0.72
## Residual Std. Error                0.19
## F Statistic                       18.37**
## ================================================
## Note:               *p<0.05; **p<0.01; ***p<[0.***]
```

5.0.1.2 The simplified result

```
##
## ================================================
##                          Dependent variable:
##                     ----------------------------
##                              COPY[, 1]
##                            CPI ALL ITEMS
## ------------------------------------------------
## Constant                     0.39**
## lag3                          0.12*
## lag12                        0.19**
## time_Aug                     -0.26*
## time_Dec                     -0.44**
## time_Apr                      -0.15
## time_Jan                     -1.06**
## time_Jul                     -0.75**
## time_Jun                     -0.52**
## time_Mar                     -0.13*
## time_May                     -0.36**
## time_Nov                     -0.39**
## time_Oct                      -0.17
## time_Sep                      -0.11
## VAT1                         -0.92**
## VAT2                         0.57**
## VAT3                         0.56**
## Recession                    0.18**
## Trend                        0.0002
## growth lag2                   0.09*
## growth lag10                 0.11**
## growth lag12                 -0.07*
## ------------------------------------------------
## Observations                  273
## R2                           0.75
## Adjusted R2                  0.73
## Residual Std. Error          0.18
```

```
## F Statistic                        35.24**
## ================================================
## Note:                *p<0.05; **p<0.01; ***p<[0.***]
```

5.0.1.3 Conclusions Comparing the results before and after simplification, we can see that after simplification, 2, 10 and 12 monthly lags consumption growth variables are significant. However, before stepwise, the results show that only one monthly lag consumption out of 12 is significant.

5.1 Divisions level

Besides modelling CPI for all items and Consumption, we also try with the divisions level.

5.1.1 Model

$$\pi_t = \pi + \text{Trend}_t + \beta_1 D_{Jan} + ... + \beta_{11} D_{Dec} + \beta_{12} D_{\text{recesion}} + \beta_{13} D_{VAT_1} + \beta_{14} D_{VAT_2} + \beta_{15} D_{TAT_3} + \sum_{j=1}^{12} \alpha_j \pi_{t-j} + \sum_{i=1}^{12} \lambda_i CPI_{t-i} + \sum_{k=1}^{12} \theta_k C_{t-k} + \sigma_t$$

Where π is the inflation for each divisions, D_{JAN} to D_{Dec} are eleven dummy variables for each month. We define February as the base category against which the others are assessed to avoid the dummy variable trap. $D_{recession}$, the great recession that officially began in April 2008 and ended in June 2009, D_{VAT_1} , D_{VAT_2} and D_{VAT_3} are three Value-add ed tax change in the United Kingdom, which were December 2008, January 2010 and January 2011. $\sum_{k=1}^{12} \theta_k C_{t-k}$ is the sum of 12 monthly lags consumption growth rate. $\sum_{i=1}^{12} \lambda_i CPI_{t-i}$ represents the sum of twelve months lags of the inflation rate of CPI ALL ITEMS and $\sum_{j=1}^{12} \alpha_j \pi_{t-j}$ is the sum of twelve months lagged inflation dependent variables.

5.1.2 Output

5.1.3 Conclusions

From divisions stepwise results, we can see that all consumption lags of output in 01FB, 05FH, 08CM, 09RC and 12MS is insignificant.

	Dependent variable:											
	01FB	02AT	03CF	04HW	05FH	06HL	07TR	08CM	09RC	10ED	11RH	12MS
lag1	0.15*	-0.19**	-0.22**	0.23**	-0.25**	-0.32**			-0.18**		-0.23**	-0.13*
lag7				0.14*		-0.18**						
CPI_lag4	0.36*			0.46**					-0.22*		0.10*	
lag8						-0.12*						
lag2			-0.17**		-0.23**	-0.25**						
lag3[, x]			-0.17**					0.14*				
lag4			-0.18**						0.16*			
lag5									0.14*			
lag6			0.26**		0.22**				0.14*		-0.15**	
CPI_lag8	0.44**		0.44*									
lag10		0.14*			-0.13**			0.14*				
lag12		0.23**	0.31**		0.38**	0.19**			0.21**	0.38**	0.12*	
CPI_lag3		0.50**	0.67**									
CPI_lag5				0.34*								
CPI_lag1							0.66**				0.13**	0.24**
CPI_lag6		0.66**		-0.35*			-0.48*					
CPI_lag7		-0.45*			0.64**	0.27**						
CPI_lag12							0.55*					
time_Aug	-0.56**	0.03	0.73**	-0.78*	-0.003	0.50**	-0.31	0.06	-0.01	-0.02	-0.02	-0.10
time_Dec	-0.24	-0.33	0.71	0.23	0.88**	-0.30*	-1.51*	-0.12	0.08	-0.28	-0.27**	-0.37**
time_Apr	-0.76**	1.64**	0.82	-0.11	-0.29	0.30**	-1.33*	0.22	0.18	0.10	0.11	-0.23
time_Jan	-0.86**	1.41**	-1.50**	-0.53**	-1.23**	0.05	-0.63	-0.13	-0.36**	1.62*	-0.40**	-0.39**
time_Jul	-0.86**	1.40**	-0.87	-1.13**	-0.40	-0.42	-0.26	-0.09	-0.03	-0.20	0.17	-0.38**
time_Jun	-0.69**	-0.14	0.95*	-0.66	-0.42	-0.73**	-0.58	-0.07	0.05	0.01	0.11	-0.42**
time_Mar	-0.56**	0.12	0.11	-0.16	-0.21	-0.05	-0.79*	-0.15	0.01	-0.01	-0.05	-0.32*
time_May	0.15	0.52*	0.24	-0.81*	-0.14	-0.50**	-1.08*	-0.06	-0.06	0.01	0.39**	-0.36**
time_Nov	-0.09	-0.57*	0.59	0.12	-0.60**	-0.69**	-1.44*	-0.13	0.02	-0.27	-0.14*	-0.29**
time_Oct	-0.54**	-0.39	1.19*	0.11	0.04	-0.72**	-1.23*	0.12	0.20	0.82	0.03	-0.21
time_Sep	-0.26	0.74	2.95**	-0.54	-0.21	-0.21	-1.56*	-0.11	0.18	1.63**	0.03	-0.27*
VAT1	-0.69	-0.41	-3.56**	-0.76	-2.92**	-1.04**	-0.08	-1.98**	-1.14**	0.12	-0.40*	-0.51
VAT2	-0.22	1.80**	-1.78*	0.93	0.44	0.15	0.79	1.22	0.63*	-0.18	0.36*	0.38
VAT3	0.01	2.41**	-0.50	0.27	1.52**	0.11	0.94	1.21	0.19	0.55	1.21**	-0.45
Recession	0.38*	0.13	-0.58**	0.29	0.40**	-0.10	-0.06	0.25	0.25**	-0.10	0.06	0.06
Trend	-0.0003	-0.0001	0.003**	-0.0001	0.0004	-0.001**	0.0000	0.001**	0.0004	-0.0004	-0.0004**	-0.001**
growth6						-0.24**					0.11**	
growth8		0.41**				0.13*						
growth9		-0.26*									0.08**	
growth12			-0.28*							0.67*		
growth2				0.26*			0.51**					
growth3							-0.41*					
growth11				0.29**			-0.59**			-0.78**		
growth10						-0.19**	0.66**					
Constant	0.48**	-0.27	-1.17**	0.27	0.13	0.78**	0.94*	-0.16	-0.02	0.16	0.28**	0.58**
Observations	273	273	273	273	273	273	273	273	273	273	273	273
R2	0.28	0.64	0.93	0.33	0.92	0.49	0.63	0.20	0.37	0.60	0.56	0.18
Adjusted R2	0.23	0.61	0.92	0.26	0.91	0.44	0.59	0.14	0.32	0.57	0.52	0.12
Residual Std. Error	0.55	0.57	0.70	0.53	0.46	0.33	0.72	0.62	0.30	1.21	0.15	0.29
F Statistic	5.21**	18.55**	134.95**	5.23**	133.10**	9.66**	18.12**	3.42**	6.77**	19.72**	13.76**	3.02**
Note:											*p<0.05; **p<0.01; ***p<[0.***]	

Figure 3: consumption-division output