

Modeller

```
# Jeg leser fra data mappen. Ser at det er en liten forskjell i størrelsen
# på de to csv filene
pm2 <- read_csv("data/pm2.csv", show_col_types = FALSE)
```

```
pm2 <- pm2 %>%
  mutate(
    fnr = str_sub(knr, 1,2),
    aar_f = str_sub(aar)
  )
```

```
head(pm2)
```

```
## # A tibble: 6 x 18
##   knr      aar knavn   pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr>  <dbl>    <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427     59.7       56.8       58.3  24.5  13.6
## 2 0101   2009 Halden 13095     59.8       57.0       58.4  24.4  14.1
## 3 0101   2010 Halden 13832     59.6       57.1       58.3  23.9  13.7
## 4 0101   2011 Halden 14915     59.8       57.2       58.5   24    14
## 5 0101   2012 Halden 15473     59.5       57.0       58.2  23.9   14
## 6 0101   2013 Halden 15461     59.0       56.7       57.9  24.1  13.4
## # ... with 9 more variables: uni_k_mf <dbl>, uni_k_m <dbl>, uni_k_f <dbl>,
## #   uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>, Trade_p <dbl>, fnr <chr>,
## #   aar_f <chr>
```

```
pm2 %>%
  mutate(
    fnr = parse_factor(fnr, levels = fnr),
    aar_f = parse_factor(aar_f, levels = aar_f)
  )
```

```
## # A tibble: 2,140 x 18
##   knr      aar knavn   pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr>  <dbl>    <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427     59.7       56.8       58.3  24.5  13.6
## 2 0101   2009 Halden 13095     59.8       57.0       58.4  24.4  14.1
## 3 0101   2010 Halden 13832     59.6       57.1       58.3  23.9  13.7
## 4 0101   2011 Halden 14915     59.8       57.2       58.5   24    14
## 5 0101   2012 Halden 15473     59.5       57.0       58.2  23.9   14
## 6 0101   2013 Halden 15461     59.0       56.7       57.9  24.1  13.4
## 7 0101   2014 Halden 17164     58.8       56.7       57.7  23.9  13.5
## 8 0101   2015 Halden 17427     58.7       56.8       57.8   24    13.7
## 9 0101   2016 Halden 18941     58.7       56.6       57.7   24    13.8
## 10 0101  2017 Halden 20143     58.9       56.9       57.9  23.7   14
## # ... with 2,130 more rows, and 9 more variables: uni_k_mf <dbl>,
## #   uni_k_m <dbl>, uni_k_f <dbl>, uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>,
## #   Trade_p <dbl>, fnr <fct>, aar_f <fct>
```

```
pm2 <- pm2 %>%
  mutate(
    Trade_pc_100K = Trade_p/100000
  )
```

```
head(pm2, n = 4)
```

```
## # A tibble: 4 x 19
##   knr      aar knavn   pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr>  <dbl>      <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427      59.7      56.8      58.3  24.5  13.6
## 2 0101   2009 Halden 13095      59.8      57.0      58.4  24.4  14.1
## 3 0101   2010 Halden 13832      59.6      57.1      58.3  23.9  13.7
## 4 0101   2011 Halden 14915      59.8      57.2      58.5  24    14
## # ... with 10 more variables: uni_k_mf <dbl>, uni_k_m <dbl>, uni_k_f <dbl>,
## #   uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>, Trade_p <dbl>, fnr <chr>,
## #   aar_f <chr>, Trade_pc_100K <dbl>
```

Modell

```
mod1 <- 'pm2 ~ aar_f + Total_ya_p + inc_k1 + inc_k5 + uni_k_mf + uni_l_mf + Trade_pc_100K'
```

```
lm1 = lm(mod1, data = pm2)
```

```
summary(lm1)
```

```
##
## Call:
## lm(formula = mod1, data = pm2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -8516.6 -1472.1   -29.9   1467.3 15736.3
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -20400.74   2663.02  -7.661 2.79e-14 ***
## aar_f2009         104.15    244.77   0.426 0.670512
## aar_f2010         908.13    245.16   3.704 0.000217 ***
## aar_f2011        1663.93    245.86   6.768 1.68e-11 ***
## aar_f2012        2240.48    247.10   9.067 < 2e-16 ***
## aar_f2013        2869.30    248.31  11.555 < 2e-16 ***
## aar_f2014        2863.22    250.54  11.428 < 2e-16 ***
## aar_f2015        3525.22    253.08  13.929 < 2e-16 ***
## aar_f2016        4274.99    255.81  16.711 < 2e-16 ***
## aar_f2017        5146.33    258.50  19.909 < 2e-16 ***
## Total_ya_p         582.44     38.94  14.957 < 2e-16 ***
## inc_k1          -376.99     30.29 -12.445 < 2e-16 ***
## inc_k5           194.35     22.87   8.498 < 2e-16 ***
## uni_k_mf         -82.02     29.42  -2.788 0.005357 **
## uni_l_mf        1206.86     42.22  28.585 < 2e-16 ***
## Trade_pc_100K     871.99    218.42   3.992 6.77e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 2531 on 2124 degrees of freedom
## Multiple R-squared: 0.8346, Adjusted R-squared: 0.8334
## F-statistic: 714.3 on 15 and 2124 DF, p-value: < 2.2e-16
```

ii

```
pm2 %>%
  add_residuals(lm1)

## # A tibble: 2,140 x 20
##   knr      aar knavn    pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr> <dbl>    <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427    59.7        56.8        58.3  24.5  13.6
## 2 0101   2009 Halden 13095    59.8        57.0        58.4  24.4  14.1
## 3 0101   2010 Halden 13832    59.6        57.1        58.3  23.9  13.7
## 4 0101   2011 Halden 14915    59.8        57.2        58.5  24    14
## 5 0101   2012 Halden 15473    59.5        57.0        58.2  23.9  14
## 6 0101   2013 Halden 15461    59.0        56.7        57.9  24.1  13.4
## 7 0101   2014 Halden 17164    58.8        56.7        57.7  23.9  13.5
## 8 0101   2015 Halden 17427    58.7        56.8        57.8  24    13.7
## 9 0101   2016 Halden 18941    58.7        56.6        57.7  24    13.8
## 10 0101  2017 Halden 20143    58.9        56.9        57.9  23.7  14
## # ... with 2,130 more rows, and 11 more variables: uni_k_mf <dbl>,
## #   uni_k_m <dbl>, uni_k_f <dbl>, uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>,
## #   Trade_p <dbl>, fnr <chr>, aar_f <chr>, Trade_pc_100K <dbl>, resid <dbl>
```

Residualene fra linær modell i datasettet pm2

```
pm2 %>%
  add_residuals(lm1)

## # A tibble: 2,140 x 20
##   knr      aar knavn    pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr> <dbl>    <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427    59.7        56.8        58.3  24.5  13.6
## 2 0101   2009 Halden 13095    59.8        57.0        58.4  24.4  14.1
## 3 0101   2010 Halden 13832    59.6        57.1        58.3  23.9  13.7
## 4 0101   2011 Halden 14915    59.8        57.2        58.5  24    14
## 5 0101   2012 Halden 15473    59.5        57.0        58.2  23.9  14
## 6 0101   2013 Halden 15461    59.0        56.7        57.9  24.1  13.4
## 7 0101   2014 Halden 17164    58.8        56.7        57.7  23.9  13.5
## 8 0101   2015 Halden 17427    58.7        56.8        57.8  24    13.7
## 9 0101   2016 Halden 18941    58.7        56.6        57.7  24    13.8
## 10 0101  2017 Halden 20143    58.9        56.9        57.9  23.7  14
## # ... with 2,130 more rows, and 11 more variables: uni_k_mf <dbl>,
## #   uni_k_m <dbl>, uni_k_f <dbl>, uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>,
## #   Trade_p <dbl>, fnr <chr>, aar_f <chr>, Trade_pc_100K <dbl>, resid <dbl>
head(pm2, n=4)

## # A tibble: 4 x 19
##   knr      aar knavn    pm2 Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1 inc_k5
##   <chr> <dbl> <chr> <dbl>    <dbl>      <dbl>      <dbl> <dbl> <dbl>
## 1 0101   2008 Halden 13427    59.7        56.8        58.3  24.5  13.6
```

```
## 2 0101    2009 Halden 13095      59.8      57.0      58.4    24.4    14.1
## 3 0101    2010 Halden 13832      59.6      57.1      58.3    23.9    13.7
## 4 0101    2011 Halden 14915      59.8      57.2      58.5     24     14
## # ... with 10 more variables: uni_k_mf <dbl>, uni_k_m <dbl>, uni_k_f <dbl>,
## #   uni_l_mf <dbl>, uni_l_m <dbl>, uni_l_f <dbl>, Trade_p <dbl>, fnr <chr>,
## #   aar_f <chr>, Trade_pc_100K <dbl>
```

Forklaring

i

I år 2009 øker pm2 104, i 2010 med 908, ..., i år 2017 øker pm2 med 5146. Året 2009 er ikke signifikant, men koeffisientene er signifikante på 0.1% signifikansnivå fra 2010-2017. Her forekommer økning i koeffisientene fra et år til neste.

Heteroskedastisitet

i.

```
bptest(lm1)
```

```
##
## studentized Breusch-Pagan test
##
## data:  lm1
## BP = 352.89, df = 15, p-value < 2.2e-16
```

```
# smart!
```

```
library(gvlma)
gvlma(lm1)
```

```
##
## Call:
## lm(formula = mod1, data = pm2)
##
## Coefficients:
## (Intercept)      aar_f2009      aar_f2010      aar_f2011      aar_f2012
## -20400.74         104.15         908.13         1663.93         2240.48
##      aar_f2013      aar_f2014      aar_f2015      aar_f2016      aar_f2017
##  2869.30         2863.22         3525.22         4274.99         5146.33
##   Total_ya_p      inc_k1      inc_k5      uni_k_mf      uni_l_mf
##    582.44        -376.99         194.35        -82.02        1206.86
## Trade_pc_100K
##    871.99
##
##
## ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
## USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
## Level of Significance = 0.05
##
## Call:
## gvlma(x = lm1)
##
##
## Value p-value Decision
## Global Stat 733.35 0.000e+00 Assumptions NOT satisfied!
## Skewness 48.82 2.804e-12 Assumptions NOT satisfied!
```

```
## Kurtosis          538.05 0.000e+00 Assumptions NOT satisfied!
## Link Function      96.62 0.000e+00 Assumptions NOT satisfied!
## Heteroscedasticity 49.86 1.652e-12 Assumptions NOT satisfied!
```

iii.

```
coeftest(lm1)
```

```
##
## t test of coefficients:
##
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -20400.742   2663.022  -7.6607 2.790e-14 ***
## aar_f2009     104.150    244.767    0.4255 0.6705118
## aar_f2010     908.129    245.156    3.7043 0.0002174 ***
## aar_f2011    1663.926    245.857    6.7679 1.685e-11 ***
## aar_f2012    2240.475    247.095    9.0672 < 2.2e-16 ***
## aar_f2013    2869.297    248.315   11.5551 < 2.2e-16 ***
## aar_f2014    2863.224    250.537   11.4283 < 2.2e-16 ***
## aar_f2015    3525.223    253.083   13.9291 < 2.2e-16 ***
## aar_f2016    4274.990    255.812   16.7114 < 2.2e-16 ***
## aar_f2017    5146.326    258.498   19.9086 < 2.2e-16 ***
## Total_ya_p     582.436     38.941   14.9568 < 2.2e-16 ***
## inc_k1        -376.989     30.291  -12.4455 < 2.2e-16 ***
## inc_k5         194.354     22.871    8.4979 < 2.2e-16 ***
## uni_k_mf       -82.023     29.424   -2.7876 0.0053574 **
## uni_l_mf      1206.857     42.219   28.5853 < 2.2e-16 ***
## Trade_pc_100K  871.993     218.422    3.9922 6.768e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
vcovHC(lm1)
```

```
##              (Intercept)    aar_f2009    aar_f2010    aar_f2011    aar_f2012
## (Intercept)  9297989.37 -26519.17426 -34751.3931 -64358.9799 -88195.7750
## aar_f2009    -26519.17  42579.51052  22306.6988  22379.0191  22461.1963
## aar_f2010    -34751.39  22306.69876  41857.2132  22643.0594  22816.5776
## aar_f2011    -64358.98  22379.01911  22643.0594  45210.7304  23406.9880
## aar_f2012    -88195.78  22461.19628  22816.5776  23406.9880  47055.4187
## aar_f2013    -93332.22  22562.49160  23016.0483  23690.1311  24270.5328
## aar_f2014   -128032.51  22647.20878  23232.1454  24076.5421  24791.9383
## aar_f2015   -177893.27  22637.74268  23267.9132  24237.7165  25055.0255
## aar_f2016   -229170.12  22623.80635  23323.0788  24446.1520  25385.7301
## aar_f2017   -231919.09  22624.44448  23352.3686  24515.4258  25408.7607
## Total_ya_p   -134378.95    89.41919    277.8154    681.8928   1112.5721
## inc_k1       -48847.48   -46.78668   -117.7882    188.8338    193.4766
## inc_k5       -26724.41   110.78484    126.8286    397.1950    455.5137
## uni_k_mf     -23624.40  -129.42390   -212.3787   -468.5265   -572.7298
## uni_l_mf      79213.28   -45.36231   -237.3954   -324.3915   -491.9711
## Trade_pc_100K 145568.84   497.16540   1261.8579    987.3383    936.1196
##              aar_f2013    aar_f2014    aar_f2015    aar_f2016    aar_f2017
## (Intercept) -93332.21682 -128032.5143 -177893.2733 -229170.1243 -231919.0869
## aar_f2009    22562.49160  22647.2088  22637.7427  22623.8064  22624.4445
## aar_f2010    23016.04825  23232.1454  23267.9132  23323.0788  23352.3686
## aar_f2011    23690.13111  24076.5421  24237.7165  24446.1520  24515.4258
```

```
## aar_f2012      24270.53282    24791.9383    25055.0255    25385.7301    25408.7607
## aar_f2013      49220.90256    25428.8815    25755.4473    26135.5595    26169.5465
## aar_f2014      25428.88146    53475.4422    27156.8674    27482.0673    27045.3309
## aar_f2015      25755.44730    27156.8674    63394.1122    28309.5656    27655.2812
## aar_f2016      26135.55952    27482.0673    28309.5656    75087.4602    28071.1160
## aar_f2017      26169.54649    27045.3309    27655.2812    28071.1160    89424.5717
## Total_ya_p      1311.74280     1662.7240     2349.7551     3130.9906     3266.6554
## inc_k1          -23.25608      237.9932      438.1822      706.9105      723.9683
## inc_k5          419.80206      750.9501      927.6337     1166.2786     1178.1709
## uni_k_mf        -695.90501     -198.2867      136.4018     -110.1222     -816.2879
## uni_l_mf        -632.27758     -2195.0185    -3034.7846    -2540.7427    -1110.7783
## Trade_pc_100K   2510.69810     2684.4013     2764.2300     282.6406     1862.4720
##               Total_ya_p      inc_k1      inc_k5      uni_k_mf      uni_l_mf
## (Intercept)    -134378.94615 -48847.47803 -26724.4053 -23624.40438 79213.27980
## aar_f2009         89.41919     -46.78668      110.7848    -129.42390    -45.36231
## aar_f2010        277.81538    -117.78822      126.8286    -212.37867    -237.39541
## aar_f2011        681.89276     188.83384      397.1950    -468.52650    -324.39148
## aar_f2012       1112.57212     193.47663      455.5137    -572.72977    -491.97106
## aar_f2013       1311.74280     -23.25608      419.8021    -695.90501    -632.27758
## aar_f2014       1662.72401     237.99318      750.9501    -198.28673    -2195.01848
## aar_f2015       2349.75511     438.18220      927.6337     136.40176    -3034.78456
## aar_f2016       3130.99055     706.91052     1166.2786    -110.12216    -2540.74265
## aar_f2017       3266.65535     723.96826     1178.1709    -816.28793    -1110.77830
## Total_ya_p       2167.75020     426.37025     133.2185      51.21924    -614.02732
## inc_k1           426.37025     801.89764     496.4444     158.26504    -500.25996
## inc_k5           133.21845     496.44438     547.3448     104.53767    -690.28424
## uni_k_mf          51.21924     158.26504     104.5377     1515.96690    -2398.54359
## uni_l_mf         -614.02732    -500.25996    -690.2842    -2398.54359     5463.68941
## Trade_pc_100K   -1619.34164    -2293.03278    -115.1786    -2608.77275     651.94105
##               Trade_pc_100K
## (Intercept)     145568.8365
## aar_f2009         497.1654
## aar_f2010        1261.8579
## aar_f2011         987.3383
## aar_f2012         936.1196
## aar_f2013        2510.6981
## aar_f2014        2684.4013
## aar_f2015        2764.2300
## aar_f2016        282.6406
## aar_f2017       1862.4720
## Total_ya_p       -1619.3416
## inc_k1           -2293.0328
## inc_k5           -115.1786
## uni_k_mf         -2608.7728
## uni_l_mf          651.9410
## Trade_pc_100K    60897.1826
```

iv.

```
pm2 <- pm2 %>%
  add_residuals(lm1)
```

v.

```
pm2 <- pm2 %>%  
  # må paste på "-01-01" for at date skal virke  
  # make_date ser ut til å lage et datetime objekt  
  # Vi trenger ikke tidspunkt ;-)  
  mutate(aar_d = date(paste0(aar, "-01-01")))
```

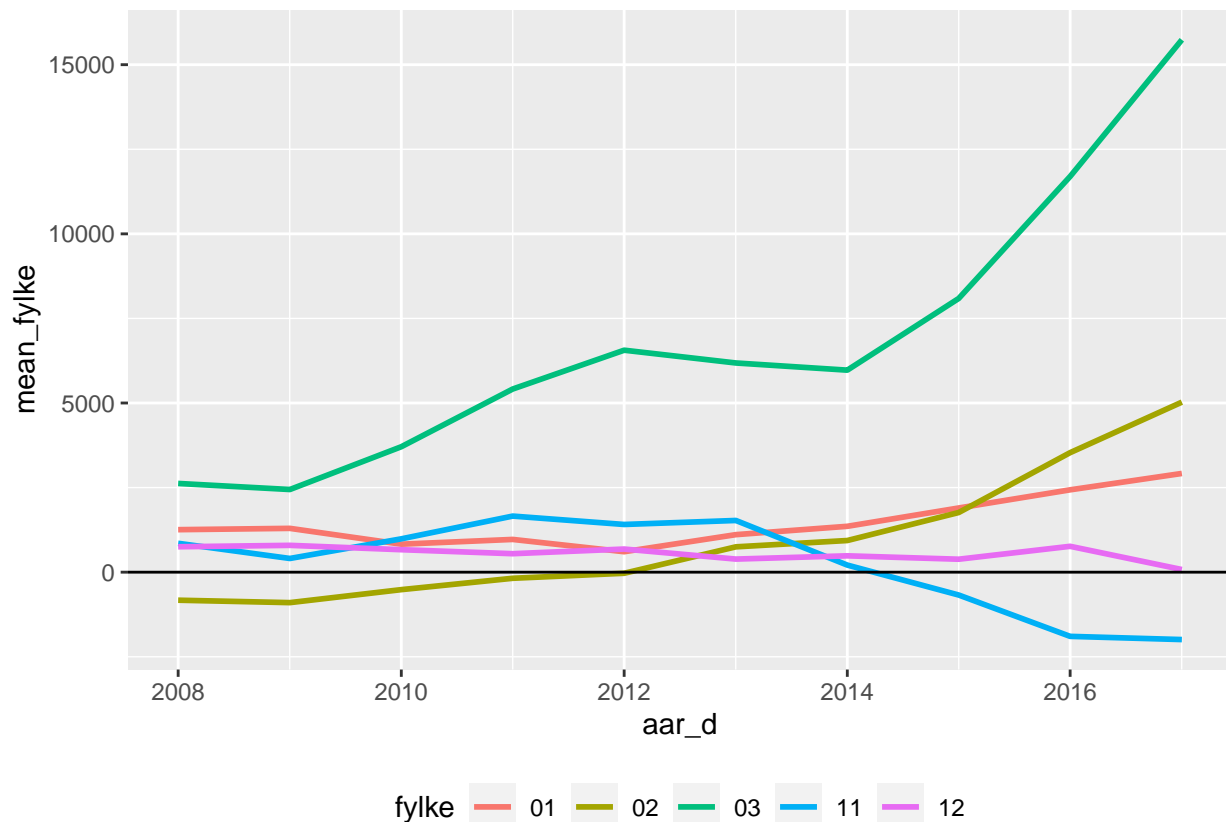
vi.

```
pm2 <- pm2 %>%  
  mutate(fylke = substr(knr, start = 1, stop = 2))
```

vii og viii.

```
pm2 %>%  
  filter(fylke %in% c("01", "02", "03", "11", "12")) %>%  
  unnest(c(fylke)) %>%  
  group_by(fylke, aar_d) %>%  
  summarize(mean_fylke = mean(resid)  
            ) %>%  
  ggplot(aes(x = aar_d, y = mean_fylke, colour = fylke)) +  
  geom_line(lwd=1) +  
  theme(legend.position = "bottom")+  
  geom_hline(yintercept = 0, colour = "black")
```

'summarise()' has grouped output by 'fylke'. You can override using the '.groups' argument.



Dummy fylke og år

i og ii.

Innfører en dummy for hvert fylke hvert år. (Husk * gir interaksjonsvariabler automatisk i Rs formula).
Bruk interaksjon mellom fnr og aar_f istedenfor aar_f. La modell 2 ellers være lik modell 1.

```
mod2 <- 'pm2 ~ aar_f*fnr + Total_ya_p + inc_k1 + inc_k5 + uni_k_mf + uni_l_mf + Trade_pc_100K'  
lm2 <- lm(mod2, data = pm2)  
summary(lm2)
```

```
##  
## Call:  
## lm(formula = mod2, data = pm2)  
##  
## Residuals:  
##      Min       1Q   Median       3Q      Max   
## -8546  -1191       32    1198   8328   
##  
## Coefficients:  
##              Estimate Std. Error t value Pr(>|t|)      
## (Intercept)   -21200.688    2521.645  -8.407 < 2e-16 ***  
## aar_f2009         94.009     744.240   0.126 0.899496   
## aar_f2010        417.129     744.379   0.560 0.575290   
## aar_f2011       1280.914     744.731   1.720 0.085597 .   
## aar_f2012       1455.525     745.679   1.952 0.051088 .   
## aar_f2013       2479.533     746.367   3.322 0.000910 ***  
## aar_f2014       2795.831     747.254   3.741 0.000188 ***  
## aar_f2015       3987.973     748.109   5.331 1.09e-07 ***  
## aar_f2016       5264.965     749.169   7.028 2.89e-12 ***  
## aar_f2017       6618.572     749.430   8.831 < 2e-16 ***  
## fnr02          -1482.789     702.970  -2.109 0.035045 *   
## fnr03           3248.234    2190.443   1.483 0.138260   
## fnr04          -1049.219     774.264  -1.355 0.175537   
## fnr05          -1937.388     758.293  -2.555 0.010696 *   
## fnr06          -2172.731     772.094  -2.814 0.004941 **  
## fnr07           -737.995    1080.348  -0.683 0.494620   
## fnr08          -3213.279     878.620  -3.657 0.000262 ***  
## fnr09          -1219.813     913.691  -1.335 0.182020   
## fnr10           -281.375     852.265  -0.330 0.741323   
## fnr11           -565.360     771.927  -0.732 0.464012   
## fnr12           -903.071     742.464  -1.216 0.224012   
## fnr14          -3339.829    1182.013  -2.826 0.004768 **  
## fnr15          -3619.198     715.832  -5.056 4.69e-07 ***  
## fnr16          -1093.217     759.677  -1.439 0.150296   
## fnr17          -2005.965     917.216  -2.187 0.028860 *   
## fnr18          -1567.503     774.530  -2.024 0.043126 *   
## fnr19          -2856.881    1326.142  -2.154 0.031341 *   
## fnr20          -2656.315    1180.088  -2.251 0.024500 *   
## Total_ya_p       511.787      36.100  14.177 < 2e-16 ***  
## inc_k1          -243.050      27.007  -9.000 < 2e-16 ***  
## inc_k5           251.645      22.916  10.981 < 2e-16 ***  
## uni_k_mf         178.253      28.157   6.331 3.02e-10 ***  
## uni_l_mf         732.442      42.235  17.342 < 2e-16 ***  
## Trade_pc_100K   1067.760     190.885   5.594 2.54e-08 ***
```


## aar_f2009:fnr02	-40.505	978.026	-0.041	0.966969	
## aar_f2010:fnr02	792.694	978.020	0.811	0.417747	
## aar_f2011:fnr02	992.480	978.070	1.015	0.310359	
## aar_f2012:fnr02	1565.161	978.102	1.600	0.109716	
## aar_f2013:fnr02	1953.373	978.298	1.997	0.045996	*
## aar_f2014:fnr02	2019.269	978.649	2.063	0.039214	*
## aar_f2015:fnr02	2401.120	979.036	2.453	0.014273	*
## aar_f2016:fnr02	3656.344	979.067	3.735	0.000193	***
## aar_f2017:fnr02	4707.776	979.374	4.807	1.65e-06	***
## aar_f2009:fnr03	84.133	3068.211	0.027	0.978127	
## aar_f2010:fnr03	2004.378	3068.354	0.653	0.513677	
## aar_f2011:fnr03	3891.025	3068.768	1.268	0.204970	
## aar_f2012:fnr03	5674.403	3069.281	1.849	0.064642	.
## aar_f2013:fnr03	5108.375	3070.149	1.664	0.096297	.
## aar_f2014:fnr03	4938.603	3071.105	1.608	0.107979	
## aar_f2015:fnr03	6985.367	3073.112	2.273	0.023131	*
## aar_f2016:fnr03	10264.572	3074.072	3.339	0.000856	***
## aar_f2017:fnr03	13986.613	3075.071	4.548	5.74e-06	***
## aar_f2009:fnr04	-330.219	1089.318	-0.303	0.761813	
## aar_f2010:fnr04	-191.813	1089.355	-0.176	0.860250	
## aar_f2011:fnr04	-775.700	1089.399	-0.712	0.476523	
## aar_f2012:fnr04	-808.528	1089.510	-0.742	0.458115	
## aar_f2013:fnr04	-1206.685	1089.615	-1.107	0.268240	
## aar_f2014:fnr04	-1456.367	1089.708	-1.336	0.181550	
## aar_f2015:fnr04	-1912.336	1089.754	-1.755	0.079446	.
## aar_f2016:fnr04	-2459.017	1089.893	-2.256	0.024169	*
## aar_f2017:fnr04	-3549.658	1089.920	-3.257	0.001146	**
## aar_f2009:fnr05	416.862	1069.758	0.390	0.696816	
## aar_f2010:fnr05	655.342	1069.794	0.613	0.540221	
## aar_f2011:fnr05	183.865	1069.834	0.172	0.863563	
## aar_f2012:fnr05	820.104	1070.017	0.766	0.443507	
## aar_f2013:fnr05	-198.536	1070.094	-0.186	0.852832	
## aar_f2014:fnr05	-254.055	1070.253	-0.237	0.812388	
## aar_f2015:fnr05	-1326.089	1070.254	-1.239	0.215480	
## aar_f2016:fnr05	-2117.228	1070.338	-1.978	0.048059	*
## aar_f2017:fnr05	-2397.820	1070.176	-2.241	0.025165	*
## aar_f2009:fnr06	-163.759	1089.292	-0.150	0.880516	
## aar_f2010:fnr06	189.332	1089.409	0.174	0.862046	
## aar_f2011:fnr06	33.963	1089.394	0.031	0.975132	
## aar_f2012:fnr06	800.976	1089.455	0.735	0.462302	
## aar_f2013:fnr06	410.281	1089.375	0.377	0.706497	
## aar_f2014:fnr06	571.152	1089.474	0.524	0.600167	
## aar_f2015:fnr06	22.631	1089.626	0.021	0.983431	
## aar_f2016:fnr06	-598.671	1089.701	-0.549	0.582801	
## aar_f2017:fnr06	60.036	1089.704	0.055	0.956069	
## aar_f2009:fnr07	134.353	1525.051	0.088	0.929808	
## aar_f2010:fnr07	728.914	1525.112	0.478	0.632745	
## aar_f2011:fnr07	275.017	1525.266	0.180	0.856930	
## aar_f2012:fnr07	1047.940	1525.235	0.687	0.492122	
## aar_f2013:fnr07	890.998	1525.236	0.584	0.559173	
## aar_f2014:fnr07	582.123	1525.332	0.382	0.702772	
## aar_f2015:fnr07	990.944	1525.354	0.650	0.515996	
## aar_f2016:fnr07	447.813	1525.278	0.294	0.769099	
## aar_f2017:fnr07	960.018	1525.236	0.629	0.529146	

## aar_f2009:fnr08	329.317	1240.237	0.266	0.790631	
## aar_f2010:fnr08	1281.636	1240.345	1.033	0.301597	
## aar_f2011:fnr08	646.495	1240.336	0.521	0.602269	
## aar_f2012:fnr08	1090.416	1240.413	0.879	0.379470	
## aar_f2013:fnr08	575.599	1240.249	0.464	0.642628	
## aar_f2014:fnr08	689.084	1240.251	0.556	0.578548	
## aar_f2015:fnr08	-776.910	1240.290	-0.626	0.531130	
## aar_f2016:fnr08	-1716.491	1240.468	-1.384	0.166595	
## aar_f2017:fnr08	-2045.538	1240.415	-1.649	0.099294	.
## aar_f2009:fnr09	686.715	1288.922	0.533	0.594245	
## aar_f2010:fnr09	986.486	1288.914	0.765	0.444149	
## aar_f2011:fnr09	599.582	1288.944	0.465	0.641860	
## aar_f2012:fnr09	1071.846	1289.011	0.832	0.405779	
## aar_f2013:fnr09	64.585	1289.204	0.050	0.960050	
## aar_f2014:fnr09	-186.541	1289.179	-0.145	0.884965	
## aar_f2015:fnr09	-1242.730	1289.232	-0.964	0.335201	
## aar_f2016:fnr09	-1987.219	1289.181	-1.541	0.123368	
## aar_f2017:fnr09	-3223.036	1289.344	-2.500	0.012510	*
## aar_f2009:fnr10	231.288	1199.909	0.193	0.847172	
## aar_f2010:fnr10	924.121	1199.916	0.770	0.441302	
## aar_f2011:fnr10	168.648	1199.944	0.141	0.888243	
## aar_f2012:fnr10	321.458	1200.216	0.268	0.788856	
## aar_f2013:fnr10	-515.180	1200.200	-0.429	0.667793	
## aar_f2014:fnr10	-674.319	1200.339	-0.562	0.574335	
## aar_f2015:fnr10	-1492.749	1200.502	-1.243	0.213856	
## aar_f2016:fnr10	-3090.918	1200.777	-2.574	0.010124	*
## aar_f2017:fnr10	-3807.142	1200.767	-3.171	0.001545	**
## aar_f2009:fnr11	-414.412	1069.772	-0.387	0.698515	
## aar_f2010:fnr11	642.468	1069.866	0.601	0.548235	
## aar_f2011:fnr11	1243.418	1070.024	1.162	0.245359	
## aar_f2012:fnr11	1467.212	1070.665	1.370	0.170728	
## aar_f2013:fnr11	1179.371	1071.062	1.101	0.270979	
## aar_f2014:fnr11	-183.391	1071.523	-0.171	0.864124	
## aar_f2015:fnr11	-1489.385	1072.451	-1.389	0.165063	
## aar_f2016:fnr11	-3274.743	1072.946	-3.052	0.002303	**
## aar_f2017:fnr11	-3863.610	1073.185	-3.600	0.000326	***
## aar_f2009:fnr12	21.853	1036.805	0.021	0.983186	
## aar_f2010:fnr12	381.898	1036.801	0.368	0.712658	
## aar_f2011:fnr12	165.379	1036.901	0.159	0.873297	
## aar_f2012:fnr12	669.171	1037.128	0.645	0.518864	
## aar_f2013:fnr12	-69.430	1037.183	-0.067	0.946636	
## aar_f2014:fnr12	-147.825	1037.277	-0.143	0.886690	
## aar_f2015:fnr12	-711.755	1037.476	-0.686	0.492767	
## aar_f2016:fnr12	-901.775	1037.688	-0.869	0.384941	
## aar_f2017:fnr12	-2046.447	1038.104	-1.971	0.048828	*
## aar_f2009:fnr14	-220.698	1663.985	-0.133	0.894498	
## aar_f2010:fnr14	536.844	1663.957	0.323	0.747009	
## aar_f2011:fnr14	1984.847	1664.012	1.193	0.233090	
## aar_f2012:fnr14	1739.551	1664.177	1.045	0.296018	
## aar_f2013:fnr14	208.353	1664.208	0.125	0.900381	
## aar_f2014:fnr14	253.302	1664.812	0.152	0.879084	
## aar_f2015:fnr14	-1695.187	1665.139	-1.018	0.308783	
## aar_f2016:fnr14	-1552.417	1665.259	-0.932	0.351330	
## aar_f2017:fnr14	-2074.192	1665.271	-1.246	0.213077	

## aar_f2009:fnr15	205.720	998.429	0.206	0.836779
## aar_f2010:fnr15	548.008	998.671	0.549	0.583249
## aar_f2011:fnr15	463.880	998.884	0.464	0.642414
## aar_f2012:fnr15	463.860	999.265	0.464	0.642556
## aar_f2013:fnr15	7.994	999.213	0.008	0.993617
## aar_f2014:fnr15	-481.056	999.093	-0.481	0.630220
## aar_f2015:fnr15	-587.449	999.385	-0.588	0.556727
## aar_f2016:fnr15	-1872.887	999.582	-1.874	0.061126 .
## aar_f2017:fnr15	-2799.827	999.681	-2.801	0.005149 **
## aar_f2009:fnr16	-346.631	1069.772	-0.324	0.745955
## aar_f2010:fnr16	-237.962	1069.934	-0.222	0.824020
## aar_f2011:fnr16	-497.945	1069.952	-0.465	0.641705
## aar_f2012:fnr16	380.682	1070.437	0.356	0.722154
## aar_f2013:fnr16	-347.235	1070.757	-0.324	0.745754
## aar_f2014:fnr16	-229.362	1070.812	-0.214	0.830418
## aar_f2015:fnr16	-139.973	1070.880	-0.131	0.896019
## aar_f2016:fnr16	-1074.143	1070.970	-1.003	0.316004
## aar_f2017:fnr16	-2278.453	1070.923	-2.128	0.033499 *
## aar_f2009:fnr17	-288.412	1288.940	-0.224	0.822969
## aar_f2010:fnr17	-422.338	1289.001	-0.328	0.743214
## aar_f2011:fnr17	257.671	1289.086	0.200	0.841590
## aar_f2012:fnr17	637.493	1289.624	0.494	0.621133
## aar_f2013:fnr17	203.405	1289.762	0.158	0.874704
## aar_f2014:fnr17	-61.073	1289.824	-0.047	0.962239
## aar_f2015:fnr17	-867.834	1289.740	-0.673	0.501107
## aar_f2016:fnr17	-1612.215	1290.487	-1.249	0.211703
## aar_f2017:fnr17	-2761.733	1290.527	-2.140	0.032479 *
## aar_f2009:fnr18	-148.285	1089.412	-0.136	0.891744
## aar_f2010:fnr18	402.939	1089.510	0.370	0.711545
## aar_f2011:fnr18	252.454	1089.674	0.232	0.816812
## aar_f2012:fnr18	482.679	1089.761	0.443	0.657871
## aar_f2013:fnr18	201.272	1090.026	0.185	0.853524
## aar_f2014:fnr18	-393.115	1090.258	-0.361	0.718459
## aar_f2015:fnr18	-439.127	1090.372	-0.403	0.687190
## aar_f2016:fnr18	-1361.291	1090.771	-1.248	0.212178
## aar_f2017:fnr18	-2661.041	1090.689	-2.440	0.014785 *
## aar_f2009:fnr19	453.061	1872.733	0.242	0.808864
## aar_f2010:fnr19	982.125	1872.779	0.524	0.600045
## aar_f2011:fnr19	-669.729	1872.850	-0.358	0.720682
## aar_f2012:fnr19	727.671	1872.902	0.389	0.697670
## aar_f2013:fnr19	278.261	1873.128	0.149	0.881921
## aar_f2014:fnr19	1688.165	1873.121	0.901	0.367563
## aar_f2015:fnr19	369.085	1873.412	0.197	0.843839
## aar_f2016:fnr19	906.286	1873.612	0.484	0.628646
## aar_f2017:fnr19	-716.410	1873.886	-0.382	0.702272
## aar_f2009:fnr20	-927.061	1664.164	-0.557	0.577542
## aar_f2010:fnr20	-547.207	1664.063	-0.329	0.742313
## aar_f2011:fnr20	-542.321	1664.293	-0.326	0.744568
## aar_f2012:fnr20	-378.342	1664.741	-0.227	0.820240
## aar_f2013:fnr20	-1110.163	1664.836	-0.667	0.504960
## aar_f2014:fnr20	-1563.827	1665.176	-0.939	0.347778
## aar_f2015:fnr20	-3266.760	1665.444	-1.961	0.049964 *
## aar_f2016:fnr20	-3169.910	1665.821	-1.903	0.057200 .
## aar_f2017:fnr20	-3922.387	1665.464	-2.355	0.018615 *

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2105 on 1944 degrees of freedom
## Multiple R-squared:  0.8953, Adjusted R-squared:  0.8848
## F-statistic: 85.21 on 195 and 1944 DF,  p-value: < 2.2e-16
```

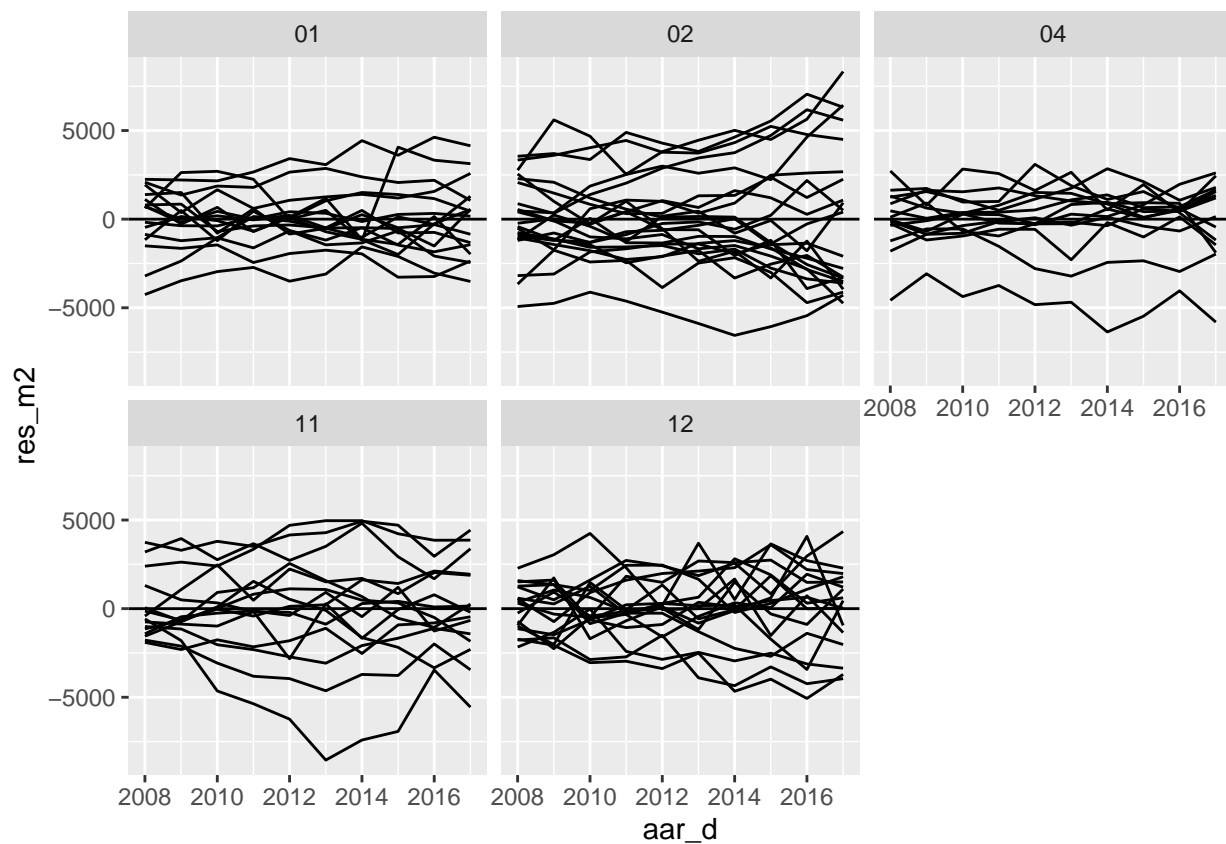
iii.

```
pm2 <- pm2 %>%
  mutate(res_m2 = resid(lm2))
```

iv.

Delplott

```
pm2 %>% filter(fnr %in% c("01", "02", "04", "11", "12")) %>%
  ggplot(mapping = aes(x = aar_d, y = res_m2)) +
  geom_line(aes(group = knavn)) +
  scale_size_manual(values = c(seq(2.0, 0.5, by = -0.1))) +
  geom_hline(yintercept = 0) +
  theme(legend.position = 'bottom') +
  facet_wrap(~fylke)
```

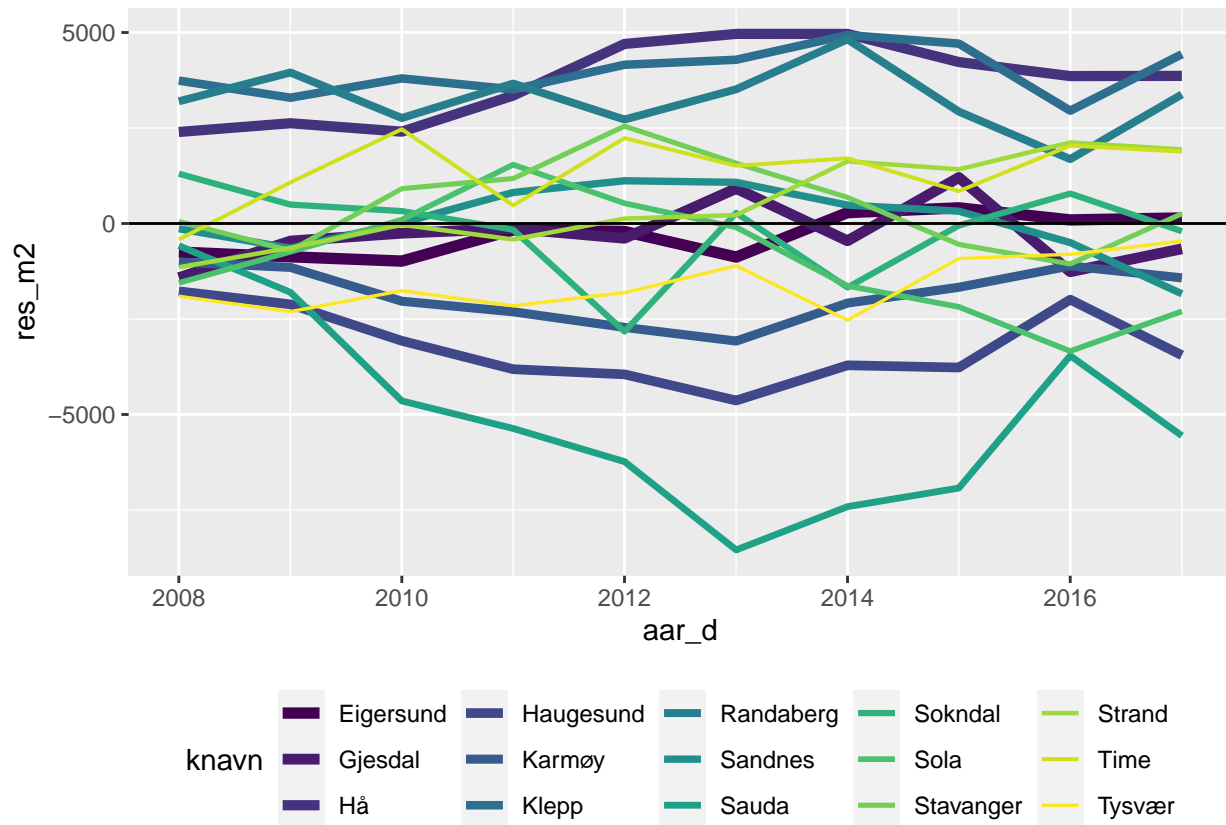


i, ii.

Kvaliteten på modellen er ikke helt optimal da den mangler noen variabler. Dette kan ha noe med heteroskedastisitet i modell at det er stor variasjon. Det er store residualer, spesielt i Rogaland.

iii.

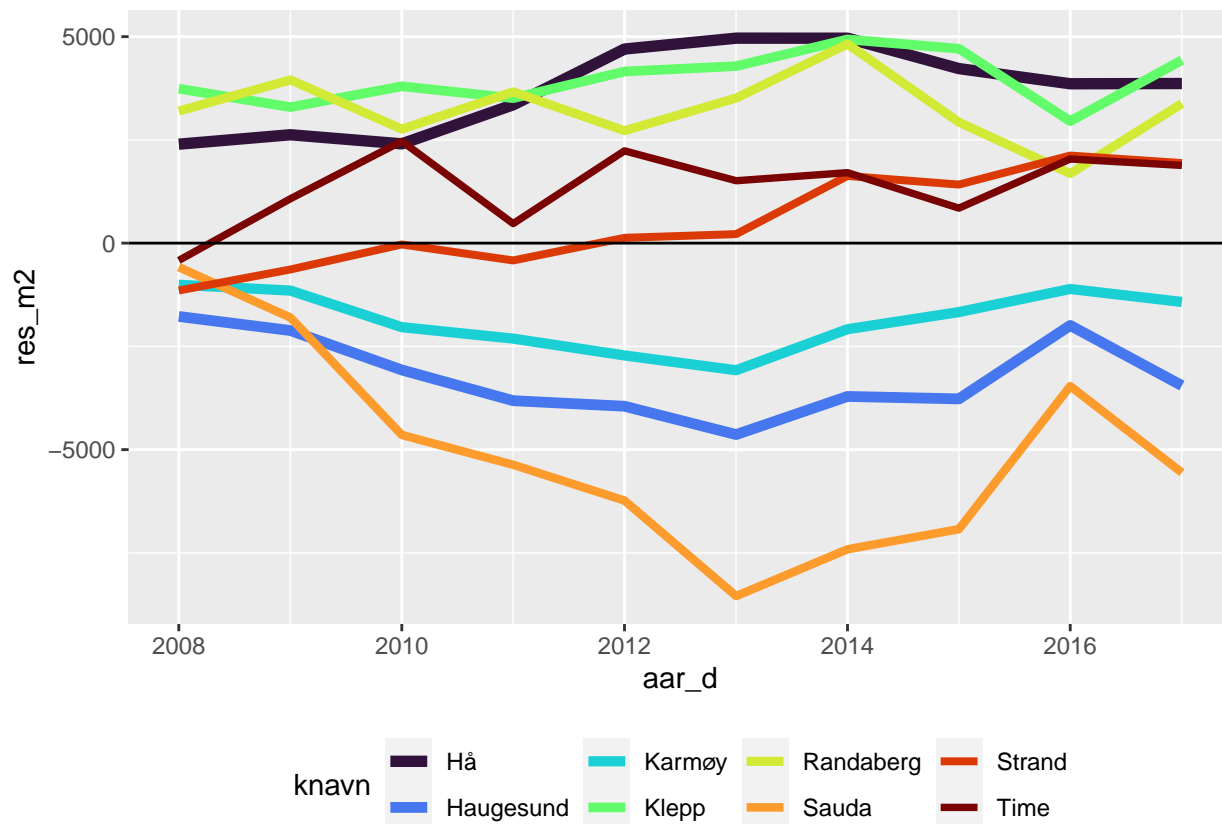
```
pm2 %>% filter(fnr %in% c("11")) %>%
  ggplot(mapping = aes(x = aar_d, y = res_m2)) +
  scale_color_viridis(discrete = TRUE, option = "D") +
  geom_line(aes(group = knavn, colour = knavn, size = knavn)) +
  scale_size_manual(values = c(seq(2.0, 0.5, by = -0.1))) +
  geom_hline(yintercept = 0) +
  theme(legend.position = 'bottom')
```



Det er ikke stor nok fargeskala for alle kommunene.

#i.

```
pm2 %>% filter(knr %in% c("1119", "1120", "1127", "1121", "1130", "1135", "1106", "1149")) %>%
  ggplot(mapping = aes(x = aar_d, y = res_m2)) +
  scale_color_viridis(discrete = TRUE, option = "H") +
  geom_line(aes(group = knavn, colour = knavn, size = knavn)) +
  scale_size_manual(values = c(seq(2.0, 0.5, by = -0.1))) +
  geom_hline(yintercept = 0) +
  theme(legend.position = 'bottom')
```



ii.

De som ligger nærmere Stavanger overvurderes.

Modell for hvert år

```
pm2_n <- pm2 %>%
  # tar med aar_d. Velger først variablene
  select(pm2, fnr, knr, aar, aar_f, aar_d, Menn_ya_p, Kvinner_ya_p, Total_ya_p, inc_k1, inc_k5, uni_k_m)
  group_by(aar) %>%
  nest()
```

pm2_n

```
## # A tibble: 10 x 2
## # Groups:   aar [10]
##   aar data
##   <dbl> <list>
## 1 2008 <tibble [214 x 13]>
## 2 2009 <tibble [214 x 13]>
## 3 2010 <tibble [214 x 13]>
## 4 2011 <tibble [214 x 13]>
## 5 2012 <tibble [214 x 13]>
## 6 2013 <tibble [214 x 13]>
## 7 2014 <tibble [214 x 13]>
## 8 2015 <tibble [214 x 13]>
```

```

## 9 2016 <tibble [214 x 13]>
## 10 2017 <tibble [214 x 13]>

pm2_n$data[[1]] %>%
head(n = 5)

## # A tibble: 5 x 13
##   pm2 fnr knr aar_f aar_d Menn_ya_p Kvinner_ya_p Total_ya_p inc_k1
##   <dbl> <chr> <chr> <chr> <date> <dbl> <dbl> <dbl> <dbl>
## 1 13427 01 0101 2008 2008-01-01 59.7 56.8 58.3 24.5
## 2 18299 01 0104 2008 2008-01-01 60.7 58.7 59.7 22.8
## 3 14981 01 0105 2008 2008-01-01 60.9 58.1 59.5 22.2
## 4 15671 01 0106 2008 2008-01-01 59.8 57.8 58.8 21.8
## 5 18844 01 0111 2008 2008-01-01 61.7 61.3 61.5 17.8
## # ... with 4 more variables: inc_k5 <dbl>, uni_k_mf <dbl>, uni_l_mf <dbl>,
## # Trade_pc_100K <dbl>

dim(pm2_n)

## [1] 10 2

# data må være lik a_df som er argumentet
kom_model <- function(a_df) {
  lm(pm2 ~ fnr + Total_ya_p + inc_k1 + inc_k5 + uni_k_mf + uni_l_mf + Trade_pc_100K, data = a_df)
}

pm2_n <- pm2_n %>%
  mutate(model = map(data, .f = kom_model))

# kom_model(pm2_n$aar) %>%
# summary()

pm2_n %>%
  filter(aar%in% c("2008")) %>%
  .$model %>%
  map_df(glance) %>%
  print()

## # A tibble: 1 x 12
##   r.squared adj.r.squared sigma statistic p.value df logLik AIC BIC
##   <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 0.873 0.857 1701. 54.2 1.19e-71 24 -1882. 3817. 3904.
## # ... with 3 more variables: deviance <dbl>, df.residual <int>, nobs <int>

mod_sum <- pm2_n %>%
  # filter(aar %in% c("2008", "2009", "2010", "2011", "2012", "2013", "2014", "2015", "2016", "2017"))
  mutate(mod_summary = map(.x = model, .f = glance)) %>%
  unnest(mod_summary) %>%
  print()

## # A tibble: 10 x 15
## # Groups: aar [10]
##   aar data model r.squared adj.r.squared sigma statistic p.value df
##   <dbl> <list> <lis> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 2008 <tibble [~ <lm> 0.873 0.857 1701. 54.2 1.19e-71 24
## 2 2009 <tibble [~ <lm> 0.886 0.871 1614. 61.2 5.63e-76 24
## 3 2010 <tibble [~ <lm> 0.888 0.874 1743. 62.4 1.13e-76 24
## 4 2011 <tibble [~ <lm> 0.883 0.868 1925. 59.4 6.50e-75 24

```

```
## 5 2012 <tibble [~ <lm>      0.891      0.877 1953.      64.2 1.06e-77      24
## 6 2013 <tibble [~ <lm>      0.895      0.881 2026.      67.0 3.03e-79      24
## 7 2014 <tibble [~ <lm>      0.884      0.869 2149.      60.1 2.30e-75      24
## 8 2015 <tibble [~ <lm>      0.879      0.863 2361.      57.1 1.57e-73      24
## 9 2016 <tibble [~ <lm>      0.883      0.869 2467.      59.7 4.19e-75      24
## 10 2017 <tibble [~ <lm>      0.895      0.882 2614.      67.0 2.84e-79      24
## # ... with 6 more variables: logLik <dbl>, AIC <dbl>, BIC <dbl>,
## #   deviance <dbl>, df.residual <int>, nobs <int>

# Plukker ut modeeellen
coef_df <- mod_sum$model %>%
  # 1 henter ut koeffisientene, 2 residualene etc.
  map_df(1) %>%
  # trenger ikke endre til tibble, bare si at vi ønsker en tibble
  tibble()
```

Den siste delen mangler

Her er min kode for avslutningen.

i. Lag en ny variabel av type date i `coef_df` som angir år.

```
coef_df <- coef_df %>%
mutate(
  aar = ymd(paste(2008:2017, "-01-01", sep = ""))
) %>%
select(aar, everything())
```

i. Pivot_longer `coef_df` til `coef_df_long`.

```
coef_df_long <- coef_df %>%
pivot_longer(
  cols = `(Intercept)`:`Trade_pc_100K`,
  names_to = "variables",
  values_to = "coef"
)
```

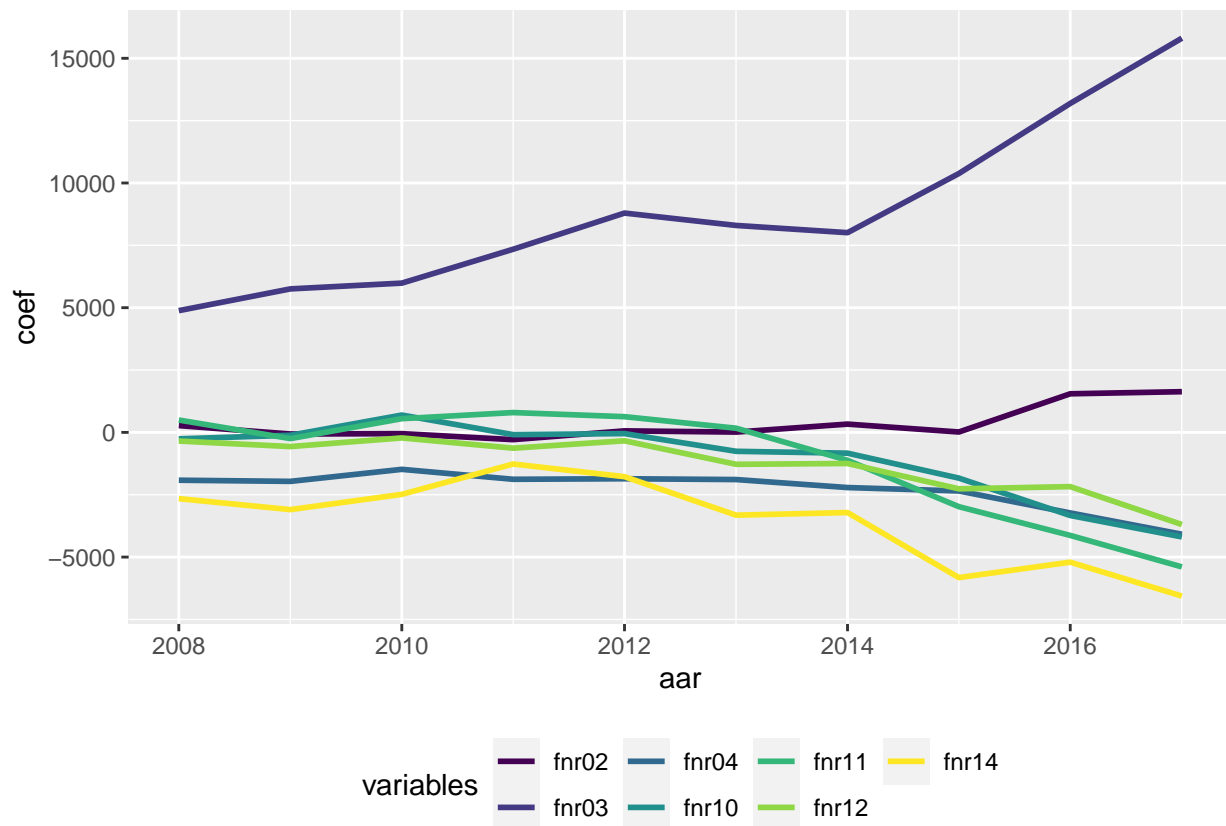
i. Lag så et plot av fylke-faktorvariablenes koeffisienter for fylkene “fnr02”, “fnr03”, “fnr04”, “fnr10”, “fnr11”, “fnr12”, “fnr14” fra år 2008 til 2017.

ii. Hva sier plot-et oss om prisutviklingen i disse fylkene?

iii. Hva skjedde i 2014?

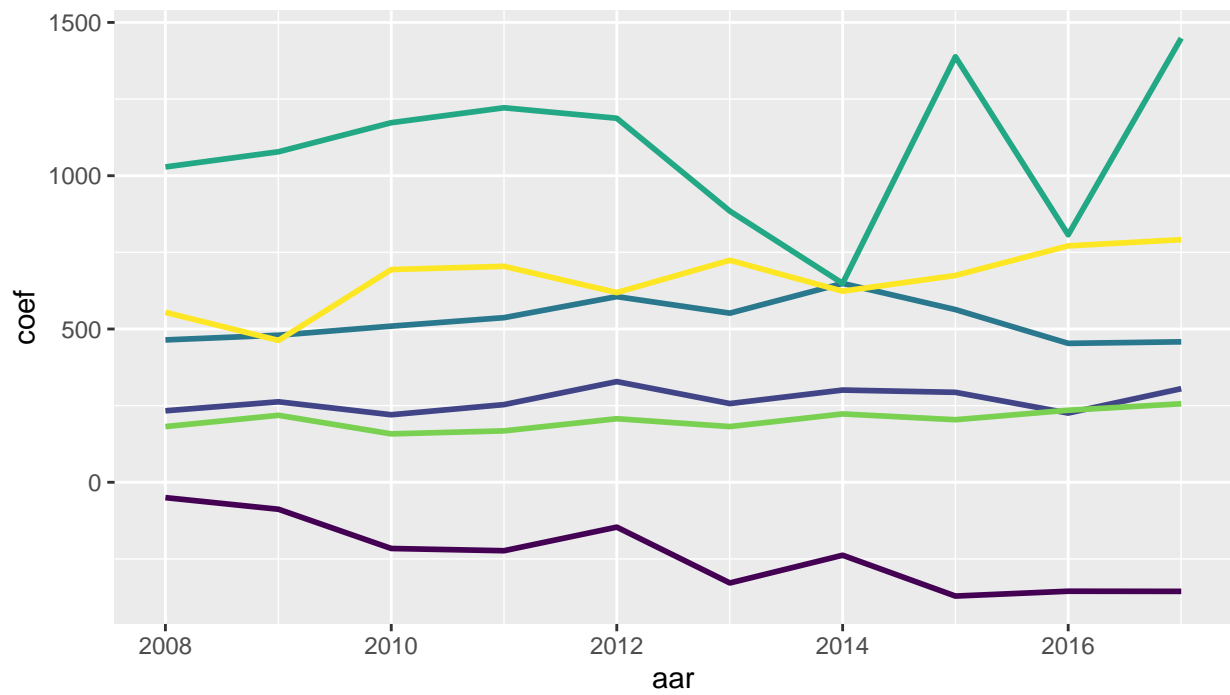
Her er kode for å lage plottet:

```
coef_df_long %>%
  select(aar, variables, coef) %>%
  filter(
    variables %in% c("fnr02", "fnr03", "fnr04", "fnr10", "fnr11", "fnr12", "fnr14")
  ) %>%
  ggplot(mapping = aes(x = aar, y = coef, colour = variables)) +
  scale_color_viridis(discrete = TRUE, option = "D") +
  geom_line(aes(group = variables), lwd = 1) +
  theme(legend.position = 'bottom')
```

- i. Lag et plot tilsvarende det ovenfor for fnr, men nå for variablene Total_ya_p, inc_k1, inc_k5, uni_k_mf, uni_l_mf og Trade_pc_100K. (Plottet er gjengitt nedenfor, dere skal gjenskape det vha ggplot)
- ii. Diskuter om koeffisientene ser ut til å være stabile over tid.

```
coef_df_long %>%
  select(aar, variables, coef) %>%
  filter(variables %in% c("Total_ya_p", "inc_k1", "inc_k5",
    "uni_k_mf", "uni_l_mf", "Trade_pc_100K"))
) %>%
ggplot(
  mapping = aes(x = aar, y = coef, colour = variables)
) +
scale_color_viridis(discrete = TRUE, option = "D") +
geom_line(aes(group = variables), lwd = 1) +
theme(legend.position = 'bottom')
```



variables

- inc_k1
- inc_k5
- Total_ya_p
- Trade_pc_100K
- uni_k_mf
- uni_l_mf

#siste