Practical_324

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load libraries

```
library(tidyverse)
```

```
## -- Attaching packages ------------------------------------------------------------------------ tidyver
## v ggplot2 3.3.2     v purrr   0.3.4
## v tibble  3.0.3     v dplyr   1.0.2
## v tidyr   1.1.1     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0
## -- Conflicts --------------------------------------------------------------------------- tidyverse_co
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(magrittr)
```

```
##
## Attaching package: 'magrittr'
## The following object is masked from 'package:purrr':
##
##     set_names
## The following object is masked from 'package:tidyr':
##
##     extract
```

```
library(psych)
```

```
##
## Attaching package: 'psych'
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
library(stargazer)
```

```
##
## Please cite as:
##  Hlavac, Marek (2018). stargazer: Well-Formatted Regression and Summary Statistics Tables.
##  R package version 5.2.2. https://CRAN.R-project.org/package=stargazer
```

```
library(zoo)
```

```
##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
library(car)
```

```
## Loading required package: carData

##
## Attaching package: 'car'

## The following object is masked from 'package:psych':
##
##     logit

## The following object is masked from 'package:dplyr':
##
##     recode

## The following object is masked from 'package:purrr':
##
##     some
```

```
library(lmtest)
library(lm.beta)
```

load data

```
leicester_2011OAC <- readr::read_csv("2011_OAC_Raw_uVariables_Leicester.csv")
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   OA11CD = col_character(),
##   LSOA11CD = col_character(),
##   LSO11ANM = col_character(),
##   MSOA11CD = col_character(),
##   MSOA11NM = col_character(),
##   LAD11CD = col_character(),
##   LAD11NM = col_character(),
##   supgrpname = col_character(),
##   grpcode = col_character(),
##   grpname = col_character(),
##   subgrpcode = col_character(),
##   subgrpname = col_character()
## )

## See spec(...) for full column specifications.
```

Exercise 324.1

Question 324.1.1:

Create a model having as outcome variable the presence of people using private transport for commuting to work, and using a stepwise "both" approach, having all the variables created for the example above and related to the presence of people working in different industry sectors (perc_u141 to perc_u158) as scope.

```
# Select and
# normalise variables
leicester_2011OAC_transp_q1 <-
leicester_2011OAC %>%
dplyr::select(
OA11CD,
Total_Pop_No_NI_Students_16_to_74, Total_Employment_16_to_74,
u121, u141:u158
) %>%
# percentage method of travel
dplyr::mutate(
u121 = (u121 / Total_Pop_No_NI_Students_16_to_74) * 100
) %>%
# percentage across industry sector columns
dplyr::mutate(
dplyr::across(
u141:u158,
function(x){ (x / Total_Employment_16_to_74) * 100 }
)
) %>%
# rename columns
dplyr::rename_with(
function(x){ paste0("perc_", x) },
c(u121, u141:u158)
)
```

```
library(MASS)
```

```
##
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:dplyr':
##
##     select
```

```
# Selected variables
# perc_u120: Method of Travel to Work, Private Transport
# perc_u142: Industry Sector, Mining and quarrying
# perc_u144: Industry Sector, Electricity, gas, steam and air conditioning ...
# perc_u146: Industry Sector, Construction
# perc_u149: Industry Sector, Accommodation and food service activities
# Create model
commuting_model_q1 <-
leicester_2011OAC_transp_q1 %$%
stepAIC(
  object =
lm(perc_u121 ~ 1),
scope =
```

```
perc_u121 ~
  perc_u141 + perc_u142 + perc_u143 + perc_u144 + perc_u145 + perc_u146 + perc_u147 + perc_u148 + perc_u
  perc_u150 + perc_u151 + perc_u152 + perc_u153 + perc_u154 + perc_u155 + perc_u156 + perc_u157 + perc_u
)
```

```
## Start:  AIC=4826.63
## perc_u121 ~ 1
##
##             Df Sum of Sq    RSS    AIC
## + perc_u149  1     40534 100288 4499.7
## + perc_u146  1     17908 122913 4696.8
## + perc_u155  1     11982 128839 4742.5
## + perc_u151  1      9796 131025 4758.8
## + perc_u154  1      7574 133247 4775.1
## + perc_u158  1      5304 135517 4791.4
## + perc_u150  1      3835 136987 4801.9
## + perc_u153  1      2981 137841 4807.9
## + perc_u157  1      2648 138173 4810.2
## + perc_u142  1      2247 138574 4813.0
## + perc_u144  1      2120 138701 4813.9
## + perc_u147  1      1912 138909 4815.4
## + perc_u152  1       792 140030 4823.2
## + perc_u148  1       527 140295 4825.0
## + perc_u143  1       296 140525 4826.6
## <none>                   140821 4826.6
## + perc_u145  1       161 140660 4827.5
## + perc_u156  1       144 140677 4827.6
## + perc_u141  1       125 140696 4827.8
##
## Step:  AIC=4499.71
## perc_u121 ~ perc_u149
##
##             Df Sum of Sq    RSS    AIC
## + perc_u146  1     10880  89408 4390.4
## + perc_u154  1      5429  94859 4447.8
## + perc_u143  1      4648  95639 4455.7
## + perc_u155  1      3918  96370 4463.1
## + perc_u151  1      3869  96418 4463.6
## + perc_u150  1      1893  98395 4483.2
## + perc_u153  1      1584  98704 4486.3
## + perc_u158  1      1431  98856 4487.8
## + perc_u142  1      1107  99181 4491.0
## + perc_u144  1      1029  99259 4491.7
## + perc_u147  1       754  99533 4494.4
## + perc_u148  1       690  99598 4495.0
## + perc_u157  1       396  99891 4497.9
## + perc_u152  1       312  99975 4498.7
## <none>                   100288 4499.7
## + perc_u156  1        27 100260 4501.4
## + perc_u145  1        10 100278 4501.6
## + perc_u141  1         8 100280 4501.6
## - perc_u149  1     40534 140821 4826.6
##
## Step:  AIC=4390.43
```

```
## perc_u121 ~ perc_u149 + perc_u146
##
##             Df Sum of Sq    RSS    AIC
## + perc_u154  1      7666  81742 4305.6
## + perc_u151  1      6822  82586 4315.5
## + perc_u155  1      5062  84345 4336.0
## + perc_u153  1      4520  84888 4342.2
## + perc_u150  1      4178  85230 4346.1
## + perc_u144  1      1889  87519 4371.7
## + perc_u143  1      1375  88033 4377.4
## + perc_u158  1      1167  88241 4379.7
## + perc_u148  1      1054  88354 4380.9
## + perc_u142  1       834  88574 4383.4
## + perc_u145  1       770  88638 4384.1
## + perc_u152  1       467  88941 4387.4
## + perc_u156  1       364  89044 4388.5
## + perc_u147  1       248  89160 4389.7
## <none>                    89408 4390.4
## + perc_u141  1         8  89400 4392.4
## + perc_u157  1         3  89405 4392.4
## - perc_u146  1     10880 100288 4499.7
## - perc_u149  1     33506 122913 4696.8
##
## Step:  AIC=4305.57
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154
##
##             Df Sum of Sq    RSS    AIC
## + perc_u151  1    4035.4  77707 4258.5
## + perc_u155  1    3181.7  78561 4269.1
## + perc_u150  1    2203.0  79539 4281.1
## + perc_u153  1    1720.7  80021 4287.0
## + perc_u144  1    1456.2  80286 4290.2
## + perc_u158  1    1335.0  80407 4291.6
## + perc_u142  1     775.0  80967 4298.3
## + perc_u143  1     695.8  81046 4299.3
## + perc_u152  1     280.8  81461 4304.2
## + perc_u147  1     251.0  81491 4304.6
## + perc_u145  1     215.5  81527 4305.0
## + perc_u148  1     194.2  81548 4305.3
## <none>                    81742 4305.6
## + perc_u156  1      98.2  81644 4306.4
## + perc_u157  1      92.1  81650 4306.5
## + perc_u141  1      19.5  81723 4307.3
## - perc_u154  1    7665.7  89408 4390.4
## - perc_u146  1   13116.3  94859 4447.8
## - perc_u149  1   30563.9 112306 4611.4
##
## Step:  AIC=4258.52
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151
##
##             Df Sum of Sq    RSS    AIC
## + perc_u155  1    2596.3  75110 4227.6
## + perc_u150  1    1260.7  76446 4244.7
## + perc_u153  1    1139.5  76567 4246.2
```

```
## + perc_u158  1    1099.7  76607 4246.7
## + perc_u144  1    1049.3  76657 4247.3
## + perc_u142  1     647.5  77059 4252.4
## + perc_u143  1     415.3  77291 4255.3
## + perc_u152  1     308.7  77398 4256.7
## <none>                    77707 4258.5
## + perc_u147  1     139.4  77567 4258.8
## + perc_u145  1      68.3  77638 4259.7
## + perc_u156  1      42.8  77664 4260.0
## + perc_u141  1      14.7  77692 4260.3
## + perc_u148  1       6.4  77700 4260.4
## + perc_u157  1       0.5  77706 4260.5
## - perc_u151  1    4035.4  81742 4305.6
## - perc_u154  1    4879.5  82586 4315.5
## - perc_u146  1   15140.9  92848 4429.0
## - perc_u149  1   25112.2 102819 4527.9
##
## Step:  AIC=4227.59
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155
##
##             Df Sum of Sq   RSS    AIC
## + perc_u158  1    1102.2 74008 4215.3
## + perc_u150  1    1086.4 74024 4215.5
## + perc_u144  1     927.2 74183 4217.5
## + perc_u142  1     889.0 74221 4218.0
## + perc_u153  1     629.4 74481 4221.4
## + perc_u156  1     262.7 74848 4226.2
## + perc_u152  1     244.8 74866 4226.4
## <none>                   75110 4227.6
## + perc_u143  1      83.3 75027 4228.5
## + perc_u148  1      48.4 75062 4229.0
## + perc_u141  1      37.0 75073 4229.1
## + perc_u157  1      32.4 75078 4229.2
## + perc_u145  1      29.5 75081 4229.2
## + perc_u147  1       0.3 75110 4229.6
## - perc_u155  1    2596.3 77707 4258.5
## - perc_u151  1    3450.1 78561 4269.1
## - perc_u154  1    3742.4 78853 4272.7
## - perc_u146  1   15660.3 90771 4409.1
## - perc_u149  1   20566.2 95677 4460.1
##
## Step:  AIC=4215.26
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158
##
##             Df Sum of Sq   RSS    AIC
## + perc_u150  1    1115.7 72893 4202.5
## + perc_u144  1     879.8 73128 4205.7
## + perc_u142  1     856.4 73152 4206.0
## + perc_u153  1     781.9 73226 4207.0
## + perc_u143  1     267.6 73741 4213.8
## + perc_u152  1     185.6 73823 4214.8
## + perc_u156  1     179.4 73829 4214.9
## <none>                   74008 4215.3
```

```
## + perc_u141  1      38.5 73970 4216.8
## + perc_u145  1      24.3 73984 4216.9
## + perc_u147  1      21.2 73987 4217.0
## + perc_u157  1      14.3 73994 4217.1
## + perc_u148  1       7.1 74001 4217.2
## - perc_u158  1    1102.2 75110 4227.6
## - perc_u155  1    2598.8 76607 4246.7
## - perc_u151  1    3234.0 77242 4254.7
## - perc_u154  1    3895.0 77903 4263.0
## - perc_u146  1   15307.3 89316 4395.4
## - perc_u149  1   18653.1 92661 4431.1
##
## Step:  AIC=4202.54
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150
##
##             Df Sum of Sq   RSS    AIC
## + perc_u142  1     772.6 72120 4194.2
## + perc_u144  1     701.2 72191 4195.2
## + perc_u153  1     479.1 72414 4198.2
## + perc_u156  1     367.9 72525 4199.6
## + perc_u152  1     182.5 72710 4202.1
## <none>                   72893 4202.5
## + perc_u143  1      89.4 72803 4203.4
## + perc_u148  1      81.3 72811 4203.5
## + perc_u141  1      46.2 72846 4203.9
## + perc_u157  1      29.6 72863 4204.1
## + perc_u145  1       7.3 72885 4204.4
## + perc_u147  1       0.1 72893 4204.5
## - perc_u150  1    1115.7 74008 4215.3
## - perc_u158  1    1131.5 74024 4215.5
## - perc_u155  1    2422.1 75315 4232.2
## - perc_u151  1    2467.5 75360 4232.8
## - perc_u154  1    3170.9 76064 4241.8
## - perc_u146  1   16161.4 89054 4394.6
## - perc_u149  1   18087.3 90980 4415.3
##
## Step:  AIC=4194.22
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142
##
##             Df Sum of Sq   RSS    AIC
## + perc_u144  1     724.9 71395 4186.4
## + perc_u153  1     531.2 71589 4189.1
## + perc_u156  1     371.4 71749 4191.2
## + perc_u152  1     232.3 71888 4193.1
## <none>                   72120 4194.2
## + perc_u143  1      81.1 72039 4195.1
## + perc_u148  1      61.8 72058 4195.4
## + perc_u141  1      46.3 72074 4195.6
## + perc_u157  1      36.1 72084 4195.7
## + perc_u145  1       6.2 72114 4196.1
## + perc_u147  1       0.1 72120 4196.2
## - perc_u142  1     772.6 72893 4202.5
```

```
## - perc_u150  1    1031.8 73152 4206.0
## - perc_u158  1    1099.0 73219 4206.9
## - perc_u151  1    2367.6 74488 4223.5
## - perc_u155  1    2644.2 74764 4227.1
## - perc_u154  1    3143.4 75263 4233.6
## - perc_u146  1   15766.4 87886 4383.8
## - perc_u149  1   17532.6 89653 4403.1
##
## Step:  AIC=4186.43
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142 + perc_u144
##
##             Df Sum of Sq   RSS    AIC
## + perc_u153  1     558.3 70837 4180.8
## + perc_u156  1     290.0 71105 4184.5
## + perc_u152  1     248.9 71146 4185.0
## <none>                   71395 4186.4
## + perc_u143  1      79.2 71316 4187.4
## + perc_u157  1      79.1 71316 4187.4
## + perc_u148  1      56.2 71339 4187.7
## + perc_u141  1      48.8 71346 4187.8
## + perc_u145  1       4.5 71391 4188.4
## + perc_u147  1       1.9 71393 4188.4
## - perc_u144  1     724.9 72120 4194.2
## - perc_u142  1     796.2 72191 4195.2
## - perc_u150  1     857.1 72252 4196.0
## - perc_u158  1    1052.8 72448 4198.6
## - perc_u151  1    2179.4 73575 4213.6
## - perc_u155  1    2553.1 73948 4218.5
## - perc_u154  1    3093.4 74489 4225.5
## - perc_u146  1   16154.6 87550 4382.1
## - perc_u149  1   17206.9 88602 4393.7
##
## Step:  AIC=4180.82
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142 + perc_u144 + perc_u153
##
##             Df Sum of Sq   RSS    AIC
## + perc_u156  1     709.1 70128 4173.1
## + perc_u152  1     194.8 70642 4180.2
## + perc_u148  1     172.5 70664 4180.5
## <none>                   70837 4180.8
## + perc_u157  1      83.9 70753 4181.7
## + perc_u141  1      56.9 70780 4182.0
## + perc_u147  1      52.1 70785 4182.1
## + perc_u145  1       1.9 70835 4182.8
## + perc_u143  1       1.0 70836 4182.8
## - perc_u153  1     558.3 71395 4186.4
## - perc_u150  1     578.0 71415 4186.7
## - perc_u144  1     752.0 71589 4189.1
## - perc_u142  1     851.0 71688 4190.4
## - perc_u158  1    1174.1 72011 4194.8
## - perc_u151  1    1986.1 72823 4205.6
## - perc_u155  1    2098.8 72936 4207.1
```

```
## - perc_u154  1    2355.3 73192 4210.5
## - perc_u146  1   16706.5 87543 4384.0
## - perc_u149  1   17008.4 87845 4387.3
##
## Step:  AIC=4173.07
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142 + perc_u144 + perc_u153 +
##     perc_u156
##
##             Df Sum of Sq   RSS    AIC
## + perc_u152  1     209.5 69918 4172.2
## + perc_u143  1     201.6 69926 4172.3
## <none>                   70128 4173.1
## + perc_u157  1     136.7 69991 4173.2
## + perc_u141  1      69.3 70058 4174.1
## + perc_u148  1      49.7 70078 4174.4
## + perc_u147  1      15.2 70113 4174.9
## + perc_u145  1       7.4 70120 4175.0
## - perc_u144  1     630.3 70758 4179.7
## - perc_u156  1     709.1 70837 4180.8
## - perc_u150  1     721.2 70849 4181.0
## - perc_u142  1     877.3 71005 4183.1
## - perc_u153  1     977.4 71105 4184.5
## - perc_u158  1    1064.7 71192 4185.7
## - perc_u151  1    1669.9 71798 4193.9
## - perc_u155  1    2393.3 72521 4203.6
## - perc_u154  1    2820.0 72948 4209.3
## - perc_u146  1   16552.5 86680 4376.4
## - perc_u149  1   16957.2 87085 4380.9
##
## Step:  AIC=4172.17
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142 + perc_u144 + perc_u153 +
##     perc_u156 + perc_u152
##
##             Df Sum of Sq   RSS    AIC
## + perc_u143  1     159.4 69759 4172.0
## + perc_u157  1     154.0 69764 4172.0
## <none>                   69918 4172.2
## - perc_u152  1     209.5 70128 4173.1
## + perc_u141  1      76.7 69842 4173.1
## + perc_u148  1      54.8 69863 4173.4
## + perc_u147  1      14.4 69904 4174.0
## + perc_u145  1       5.8 69912 4174.1
## - perc_u144  1     642.2 70560 4179.0
## - perc_u156  1     723.8 70642 4180.2
## - perc_u150  1     728.7 70647 4180.2
## - perc_u153  1     912.8 70831 4182.7
## - perc_u142  1     925.3 70844 4182.9
## - perc_u158  1     993.7 70912 4183.8
## - perc_u151  1    1693.2 71611 4193.4
## - perc_u155  1    2368.9 72287 4202.5
## - perc_u154  1    2774.6 72693 4207.9
## - perc_u146  1   16609.8 86528 4376.7
```

```
## - perc_u149  1   16796.4 86715 4378.8
##
## Step:  AIC=4171.96
## perc_u121 ~ perc_u149 + perc_u146 + perc_u154 + perc_u151 + perc_u155 +
##     perc_u158 + perc_u150 + perc_u142 + perc_u144 + perc_u153 +
##     perc_u156 + perc_u152 + perc_u143
##
##             Df Sum of Sq   RSS    AIC
## <none>                   69759 4172.0
## - perc_u143  1     159.4 69918 4172.2
## - perc_u152  1     167.4 69926 4172.3
## + perc_u147  1      87.2 69672 4172.7
## + perc_u141  1      63.7 69695 4173.1
## + perc_u157  1      36.4 69722 4173.5
## + perc_u148  1      29.2 69730 4173.6
## + perc_u145  1      20.2 69739 4173.7
## - perc_u144  1     604.6 70363 4178.3
## - perc_u150  1     641.7 70401 4178.8
## - perc_u153  1     735.5 70494 4180.1
## - perc_u156  1     882.9 70642 4182.1
## - perc_u142  1     898.1 70657 4182.4
## - perc_u158  1    1114.5 70873 4185.3
## - perc_u151  1    1587.8 71347 4191.8
## - perc_u155  1    2167.4 71926 4199.6
## - perc_u154  1    2922.2 72681 4209.7
## - perc_u146  1   11004.2 80763 4311.9
## - perc_u149  1   15080.7 84840 4359.6
```

```
# Print summary
stargazer(commuting_model_q1, type = "text")
```

```
##
## ================================================
##                         Dependent variable:
##                     ---------------------------
##                                perc_u121
## ------------------------------------------------
## perc_u149                     -1.281***
##                                (0.089)
##
## perc_u146                     1.248***
##                                (0.102)
##
## perc_u154                     -0.720***
##                                (0.114)
##
## perc_u151                     0.773***
##                                (0.166)
##
## perc_u155                     0.678***
##                                (0.125)
##
## perc_u158                     -0.555***
##                                (0.142)
##
```

```
## perc_u150                    0.584***
##                               (0.197)
##
## perc_u142                    3.867***
##                               (1.103)
##
## perc_u144                    0.669***
##                               (0.232)
##
## perc_u153                    0.442***
##                               (0.139)
##
## perc_u156                    -0.234***
##                               (0.067)
##
## perc_u152                     0.446
##                               (0.295)
##
## perc_u143                     -0.080
##                               (0.054)
##
## Constant                     36.422***
##                               (2.752)
##
## ------------------------------------------------
## Observations                    969
## R2                             0.505
## Adjusted R2                    0.498
## Residual Std. Error      8.547 (df = 955)
## F Statistic          74.834*** (df = 13; 955)
## ================================================
## Note:                *p<0.1; **p<0.05; ***p<0.01
```

```
commuting_model_q1 %>%
rstandard() %>%
shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99663, p-value = 0.03668
```

Overall, we can say that the delay model computed above is fit ($F(13, 955) = 74.83$, $p < .001$), indicating that the model might account for 49.79% of the people who use private tansport to commute. However the model is not robust. The residuals are not homoscedastic (Breusch-Pagan test, $BP = 27.606$, $p < .01$), and are not independent (Durbin-Watson test, $DW = 1.8471$, $p < 0.01$), but they are normally distributed (Shapiro-Wilk test, $W = 0.99618$, $p < 0.01$).

```
commuting_model_q1 %>%
lmtest::bptest()
```

```
##
##  studentized Breusch-Pagan test
##
## data:  .
```

```
## BP = 40.649, df = 13, p-value = 0.0001086
```

```
commuting_model_q1 %>%
lmtest::dwtest()
```

```
##
##  Durbin-Watson test
##
## data:  .
## DW = 1.8919, p-value = 0.04344
## alternative hypothesis: true autocorrelation is greater than 0
```

Question 324.1.2:

Is the presence of people using public transportation to commute to work statistically, linearly related to mean age (u020)?

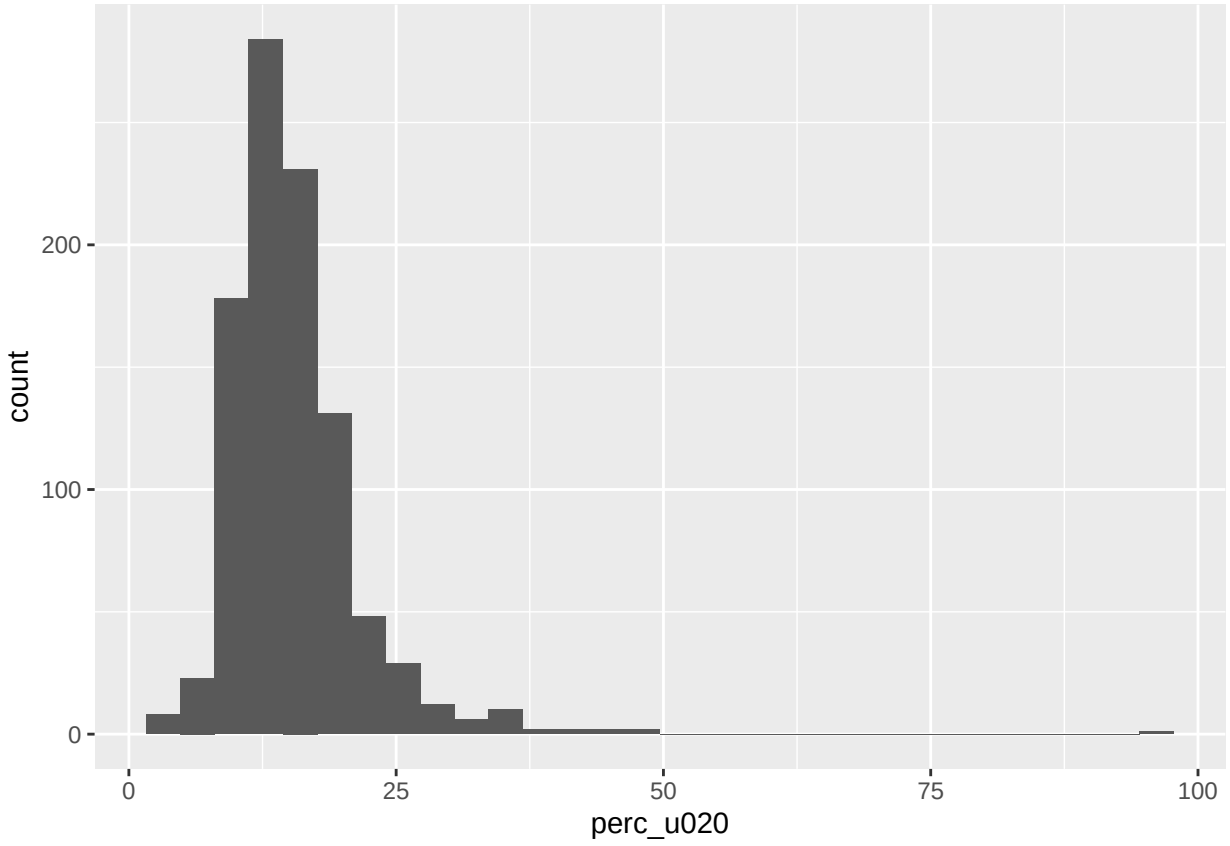
```
# Select and normalise variables
leicester_2011OAC_transp_q2 <-
leicester_2011OAC %>%
dplyr::select(
OA11CD,
Total_Pop_No_NI_Students_16_to_74, Total_Employment_16_to_74,
u020, u120
) %>%
# percentage method of travel
dplyr::mutate(
perc_u020 = (u020/ Total_Pop_No_NI_Students_16_to_74) * 100,
perc_u120 = (u120/ Total_Pop_No_NI_Students_16_to_74) * 100
)
```

Check assumptions for Pearson's

```
leicester_2011OAC_transp_q2 %$% perc_u020 %>%
stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.80132, p-value < 2.2e-16
```

```
leicester_2011OAC_transp_q2 %>%
  ggplot2::ggplot(mapping = aes(x = perc_u020)) +
  ggplot2::geom_histogram(bins = 30) +
  ggplot2::theme_gray()
```

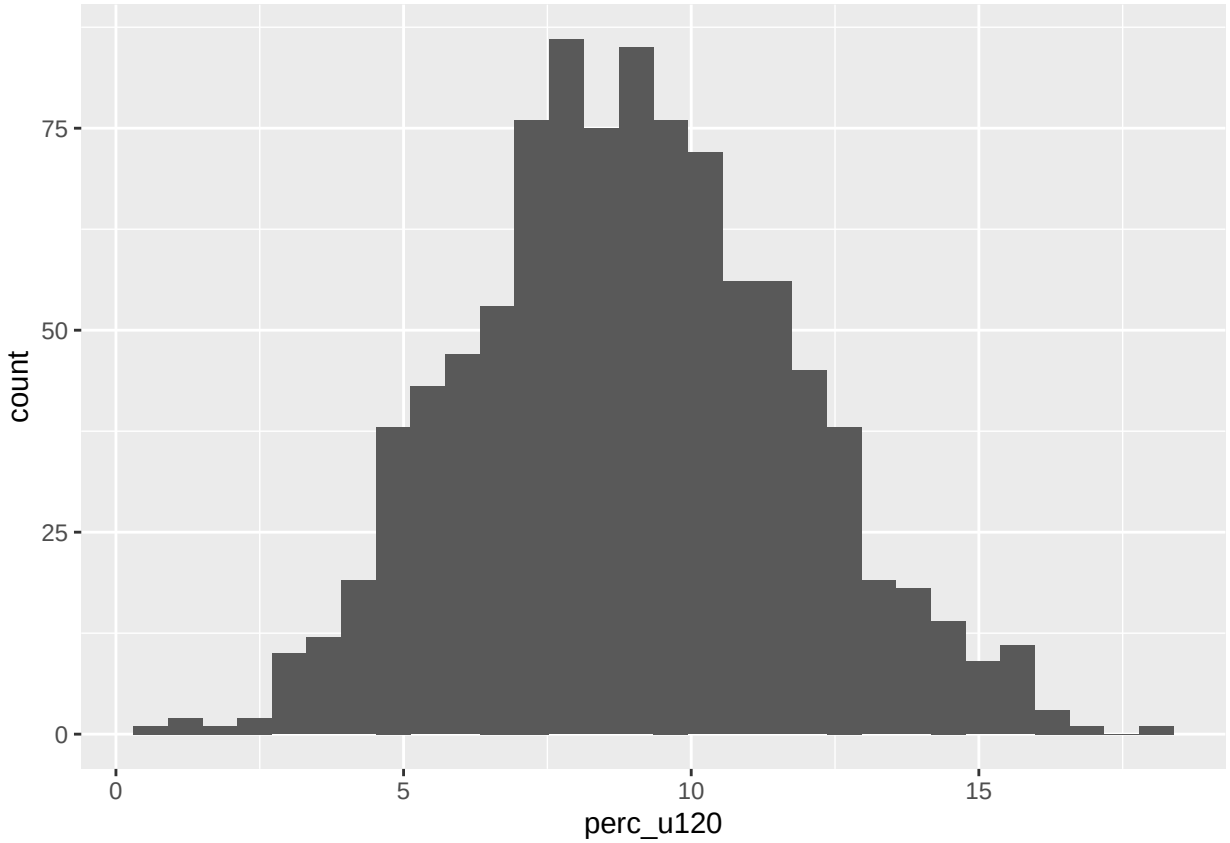


Not normally distributed.

```
leicester_2011OAC_transp_q2 %$% perc_u120 %>%
stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99743, p-value = 0.13
```

```
leicester_2011OAC_transp_q2 %>%
  ggplot2::ggplot(mapping = aes(x = perc_u120)) +
  ggplot2::geom_histogram(bins = 30) +
  ggplot2::theme_gray()
```



Is normally distributed.

```
log_mean_age <- leicester_2011OAC_transp_q2 %>%
mutate(log10_u020 = log10(perc_u020))


log_public_commute <- leicester_2011OAC_transp_q2 %>%
mutate(log10_u120 = log10(perc_u120))


log_mean_age %$% log10_u020 %>%
stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.97376, p-value = 3.208e-12
```

```
log_public_commute %$% perc_u120 %>%
stats::shapiro.test()
```

```
##
##  Shapiro-Wilk normality test
##
## data:  .
## W = 0.99743, p-value = 0.13
```

Both variables are not normaly distributed after logarithmic transformation.

Pearson's can't be used as both variables need to be norally distributed.

Check Spearson's assumptions

```
ties_check_mean_age <-
leicester_2011OAC_transp_q2 %>%
dplyr::count(perc_u020) %>%
dplyr::filter(n > 1) %>%
dplyr::count(n()) %>%
dplyr::pull(n)

ties_check_mean_age
```

```
## integer(0)
```

```
ties_check_public_commute <-
leicester_2011OAC_transp_q2 %>%
dplyr::count(perc_u120) %>%
dplyr::filter(n > 1) %>%
dplyr::count(n()) %>%
dplyr::pull(n)

ties_check_public_commute
```

```
## [1] 117
```

There are too many ties in the perc_u120 data. Spearson's cannot be used.

Kendall's Tau

```
kendall_mean_age_public_commute <-
leicester_2011OAC_transp_q2 %$%
stats::cor.test(
perc_u020, perc_u120,
method = "kendall"
)

kendall_mean_age_public_commute
```

```
##
##  Kendall's rank correlation tau
##
## data:  perc_u020 and perc_u120
## z = 3.4962, p-value = 0.0004719
## alternative hypothesis: true tau is not equal to 0
## sample estimates:
##       tau
## 0.0750281
```

Mean age has a very small but significant linear relationship with people using public transportation to commute to work (Tau = 0.08, p < 0.001).

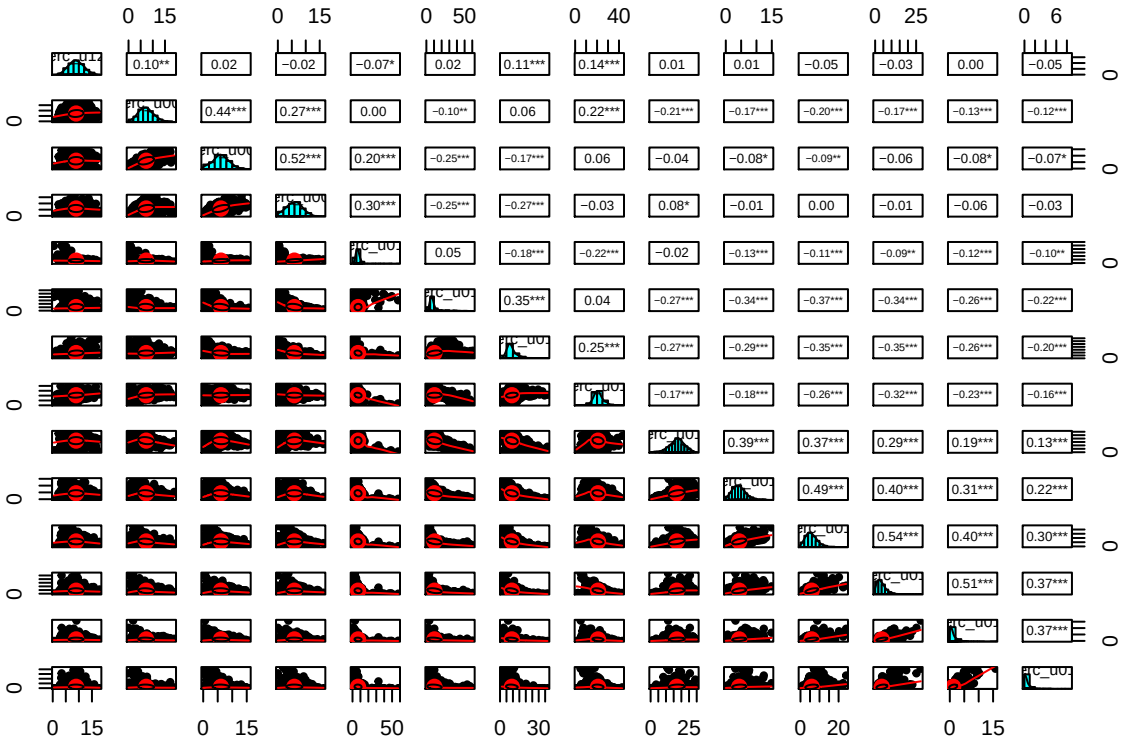
Question 324.1.3:

Is the presence of people using public transportation to commute to work statistically, linearly related to (a subset of) the age structure categories (u007 to u019)?

```
leicester_2011OAC_transp_q3 <-
leicester_2011OAC %>%
dplyr::select(
OA11CD,
Total_Population, Total_Pop_No_NI_Students_16_to_74, Total_Employment_16_to_74,
u007:u019, u120
) %>%
# percentage method of travel
dplyr::mutate(
perc_u120 = (u120/ Total_Pop_No_NI_Students_16_to_74) * 100
) %>%
#percentage across industry sector columns
dplyr::mutate(
dplyr::across(
u007:u019,
function(x){ (x / Total_Population) * 100 }
)
) %>%

# rename columns
dplyr::rename_with(
function(x){ paste0("perc_", x) },
c(u007:u019)
)

leicester_2011OAC_transp_q3 %>%
dplyr::select(perc_u120, perc_u007, perc_u008, perc_u009, perc_u010, perc_u011, perc_u012, perc_u013, p
psych::pairs.panels(method = "kendal", stars = TRUE)
```



```
commuting_model_q3 <-
leicester_2011OAC_transp_q3 %$%
lm(
perc_u120 ~ perc_u013)


# Print summary
stargazer(commuting_model_q3, type = "text")
```

========== Dependent variable: ———— perc_u120 ———— perc_u013 0.143*** (0.017)

Constant 5.971*** (0.372)

Observations 969
R2 0.066
Adjusted R2 0.065
Residual Std. Error 2.734 (df = 967)
F Statistic 67.822*** (df = 1; 967)
========== Note: *p<0.1;* ***p<0.05;*** p<0.01

Age 25 - 29 (u012) has a small but significant linear relationship with people using public transportation to

commute to work (Tau = 0.11, $p < 0.001$).

Age 30 - 44 (u013) also has a small but significant linear relationship with people using public transportation to commute to work (Tau = 0.14, $p < 0.001$).