Where is the Next Croq' Pain?

Group 4 Lei Duan | Nehal Jain | Qingqing Long | Xiaochen Li
Prof. Terrence August
Nov 07, 2017

Part 1. Case Overview

1.1 Background

Croq'Pain is a chain of French-style fast food restaurants that has wide branches in Paris. According to the store revenue report, seven out of ten new stores opened in last 10 years did not perform well. Thus, an improving system on location selection of new stores need to be constructed to help stakeholders in Croq'Pain identify the right locations for future store openings.

1.2 Objectives

- Identify the most significant explanatory variables that affect operating earnings;
- Develop a regression model on operating earnings based on the most impactful variables from historical data;
- Select the optimal locations for new stores based on prediction.

Part 2. Data Processing

2.1 Data Cleaning

Firstly, we explored data by reading the description and viewing its histogram, scatterplot and correlation plots to check if abnormality exists. Two problems were found as shown below:

- There are five duplicate values in dataset;
- There is an extreme value in earning in store 1.

After cross checking all data, we believe that the outlier (see in *Exhibit 1*) is caused by a mistake of data entry. Since the unit of earning is $1000 and all other store earnings are ranged from -40 to 399 thousand dollars, it's highly possible that the original earning of store 1 was inputted in a raw format instead of being divided by 1000.

Thus, we removed all duplicates and divided the earning value in store 1 by 1000 for further processing.

2.2 Data Exploration

2.2.1 Histogram plot

After cleansing, we plotted the most variables' distribution, all of which look acceptable.

(See in *Exhibit 2*)

2.2.2 Scatterplots and correlation plots on total and P15 - P55 variables

By drawing scatterplots and correlation plots, high correlation is found among the population in each age group with 'total' population within 3 km of the restaurant, which indicates the high potential of multi-collinearity. (see *Table* 1 and *Figure 1* and more details in *Exhibit 3*)

```
Correlation
Data     : CroqPainFix
Method   : pearson
Variables: total, P15, P25, P35, P45, P55
Null hyp.: variables x and y are not correlated
Alt. hyp.: variables x and y are correlated

Correlation matrix:
    total P15  P25  P35  P45
P15 0.96
P25 0.58  0.42
P35 0.96  0.98 0.43
P45 0.96  0.98 0.41 0.99
P55 0.77  0.68 0.29 0.67 0.65

p.values:
    total P15  P25  P35  P45
P15 0.00
P25 0.00  0.00
P35 0.00  0.00 0.00
P45 0.00  0.00 0.00 0.00
P55 0.00  0.00 0.03 0.00 0.00
```

Table 1

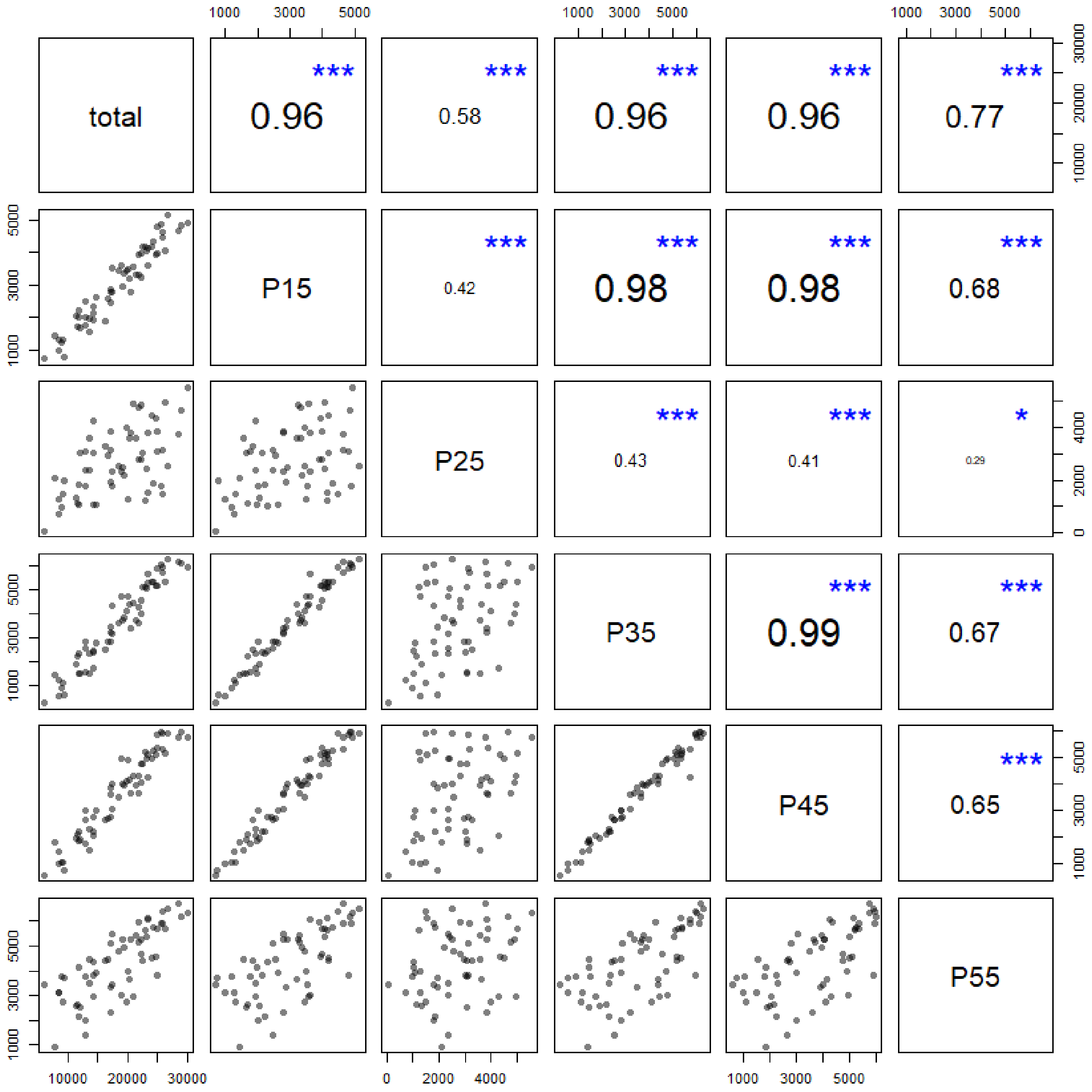


Figure 1

Part 3. Model Building

Firstly, we normalized variables 'EARN', 'COMP', 'NCOMP', 'NREST' and all age group variables (i.e. P15-P55) by total amount of residents. By comparing the dashboard of regression using un-normalized and normalized variables, we prefer to normalize data for further analysis based on more accountable variables (i.e., earnings per person and population proportion in each age group) to eliminate the impact of total population on other variables (see *Exhibit 4-5*).

Moreover, we used "stepwise" approach to select variables in regression model based on significance (see *Exhibit 6-7*) and made further adjustment by removing P15 and P25 (i.e. age groups from 15 to 34) and adding back P35 (i.e. age group from 35-44), as people aged from 35 to 44 are the target customers of Croq'Pain. (see following *Table* 2)

Thus, our final model contains the following variables as predictors:

- K: capital investment;
- INC: regional income level;
- Size: the size of the restaurant;
- P_35_total : the proportion of residents aged from 35-44 in the region;
- NREST_total: the amount of non-restaurant business per person in the region;

```
Linear regression (OLS)
Data     : CroqPainFix
Response variable    : EARN_total
Explanatory variables: K, INC, SIZE, P35_total, NREST_total
Null hyp.: the effect of x on EARN_total is zero
Alt. hyp.: the effect of x on EARN_total is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)       0.000     0.037   0.000   1.000
 K                -0.449     0.130  -3.450   0.001 **
 INC               0.440     0.077   5.715  < .001 ***
 SIZE              0.861     0.127   6.761  < .001 ***
 P35_total         0.307     0.083   3.707  < .001 ***
 NREST_total       0.468     0.082   5.712  < .001 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.706,  Adjusted R-squared: 0.678
F-statistic: 25.886 df(5,54), p.value < .001
Nr obs: 60

Variance Inflation Factors
        K  SIZE P35_total NREST_total   INC
VIF 3.108 2.972     1.260       1.231 1.087
Rsq 0.678 0.664     0.206       0.188 0.080
```

Table 2

Part 4. Model Validation

To validate the model, we split the dataset into two parts: '50 historical restaurants before 1994' and '10 restaurants after 1994'. Then we applied data of first 50 restaurants to amend regression model (result seen in *Table* 3) and to predict which restaurant opened after 1994 would reach the performance ratio target of Croq'Pain (i.e., 26%).

```
Linear regression (OLS)
Data     : CroqPainFix_<= 50
Response variable    : EARN_total
Explanatory variables: K, SIZE, INC, P35_total, NREST_total
Null hyp.: the effect of x on EARN_total is zero
Alt. hyp.: the effect of x on EARN_total is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)      -0.000     0.039  -0.000   1.000
 K                -0.377     0.134  -2.812   0.007 **
 SIZE              0.676     0.131   5.153  < .001 ***
 INC               0.524     0.086   6.102  < .001 ***
 P35_total         0.377     0.094   3.998  < .001 ***
 NREST_total       0.576     0.093   6.177  < .001 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.724,  Adjusted R-squared: 0.692
F-statistic: 23.067 df(5,44), p.value < .001
Nr obs: 50

Variance Inflation Factors
        K  SIZE P35_total NREST_total   INC
VIF 2.870 2.743     1.414       1.386 1.175
Rsq 0.652 0.635     0.293       0.278 0.149
```

Table 3

It's shown that only store 57 and store 60 (see in *Table* 4) could reach the 26% performance ratio according to our prediction model.

```
  STOR pred_Ratio
1   57  0.3670888
2   60  0.4060865
```

Table 4

In fact, three restaurants, which are store 51, store 57, store 60 (see in *Table* 5), achieved the goal and store 51 reached approximately 27% which is slightly over 26%, so we believe that our model accuracy is acceptable.

```
  STOR real_Ratio
1   51  0.2787193
2   57  0.3168194
3   60  0.4033956
```

Table 5

Part 5. Model Prediction

Based on the model, we predicted the potential earning of 10 restaurants opened after 1994 and calculated their performance ratios accordingly. It turned out that only "Toulouse" and "Montpellier" (see in *Table* 6) exceeded 26% level of performance ratio.

```
       STOR   pred_Ratio
1   Toulouse  0.3370087
2 Montpellier  0.3620923
```

Table 6

Part 6. Conclusion and Advice in Location Choice

According to the model and prediction result, we highly recommend that Craq'pain should take the following factors into consideration when selecting location for new stores: **capital investment, regional income level, restaurant size, the proportion of residents aging from 35-44 in the region and the number of non-restaurant business per person in the region**.

To reach performance ratio goal and achieve future success for new restaurants, we recommend choosing **'Toulouse'** and **'Montpellier'** to invest.

Part 7. Appendix

Exhibit 1. Distribution plot of earning.

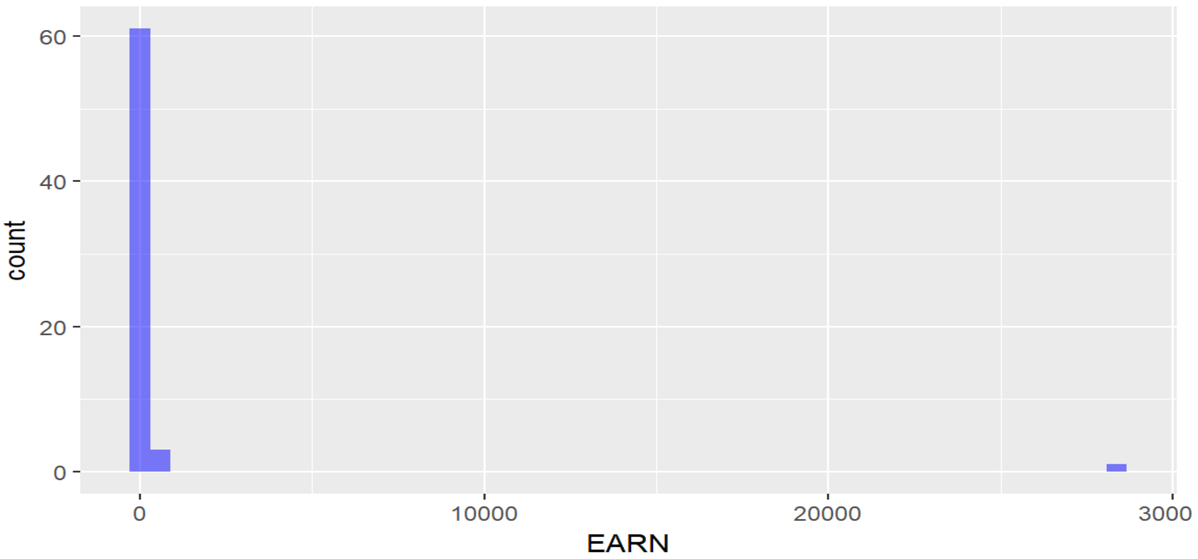
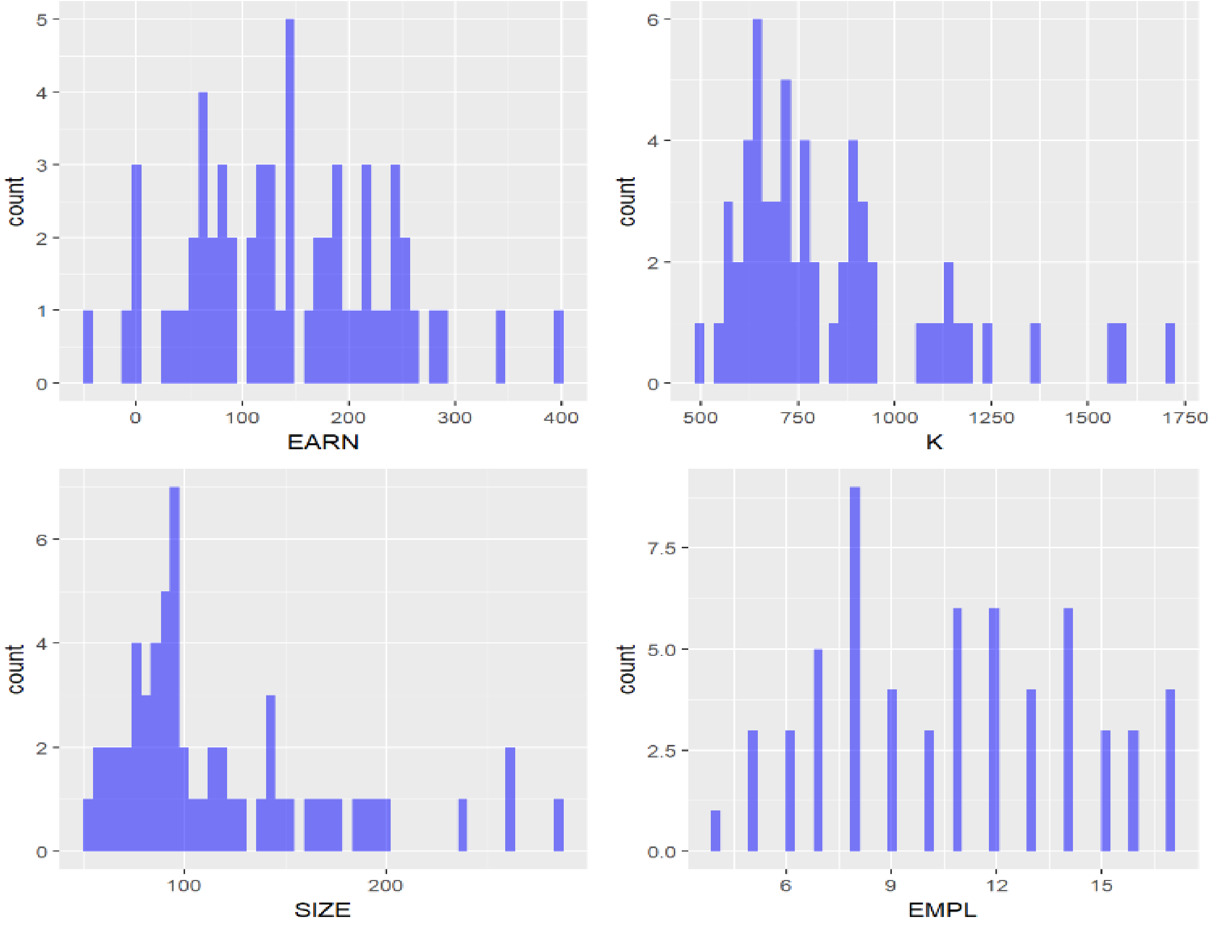
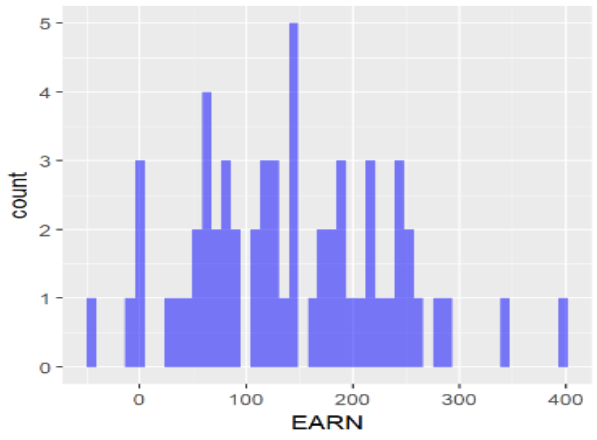
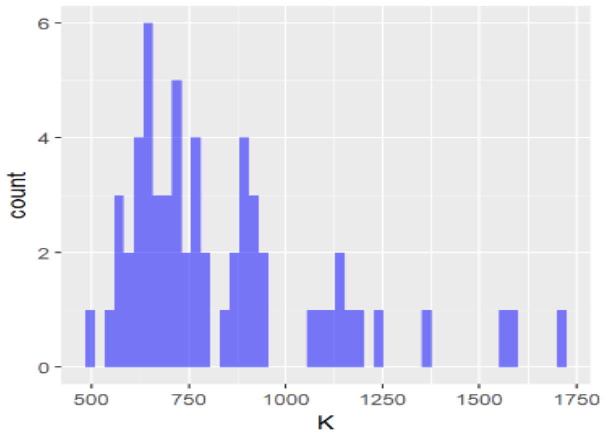
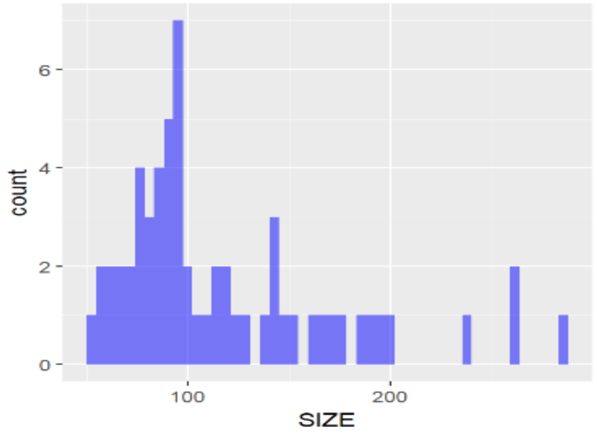


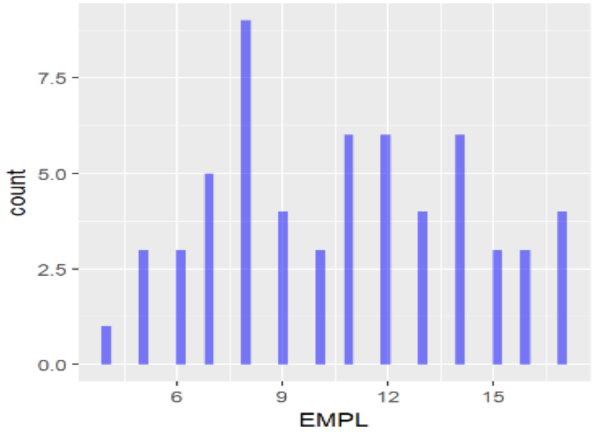
Exhibit 2. Histogram of variables

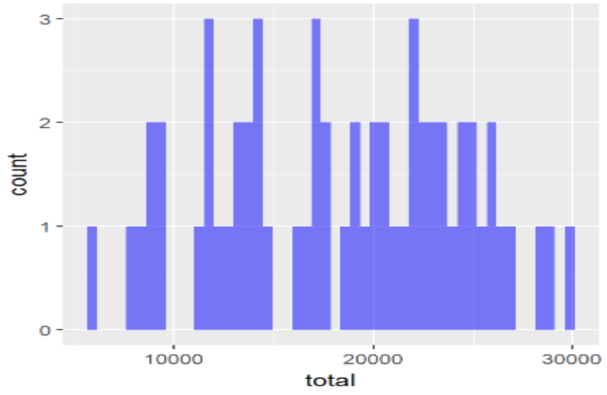


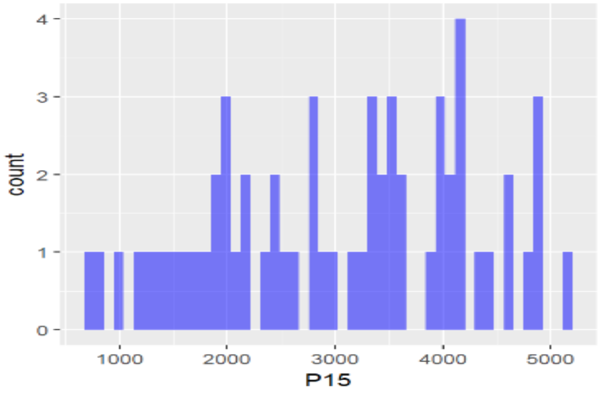

count
0
1
2
3
4
5
0
100
200
300
400
EARN

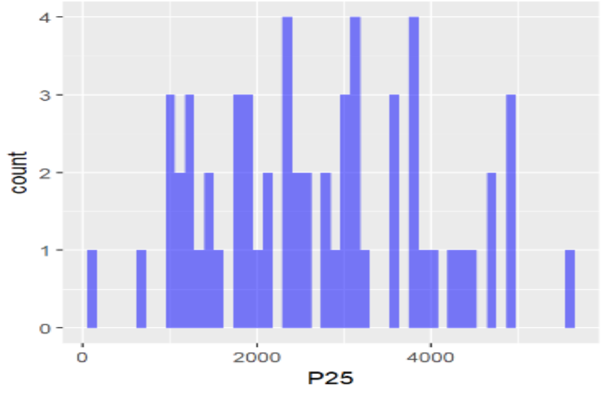

count
0
2
4
6
500
750
1000
1250
1500
1750
K

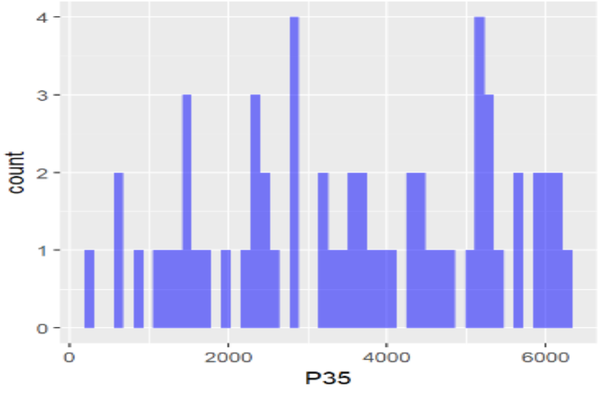

count
0
2
4
6
100
200
SIZE

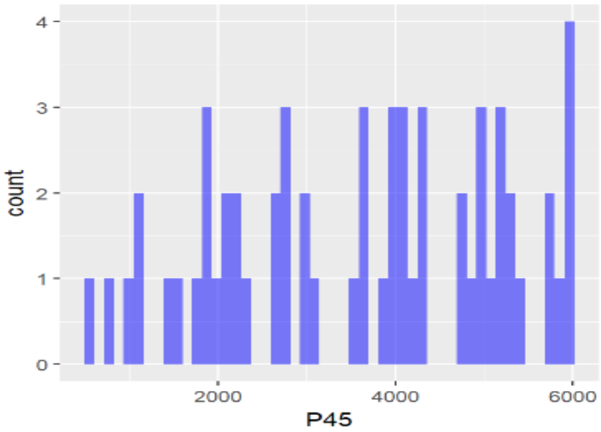

count
0.0
2.5
5.0
7.5
6
9
12
15
EMPL

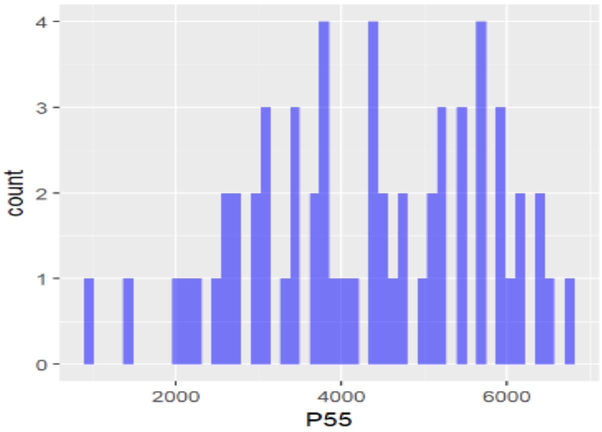

count
0
1
2
3
10000
20000
30000
total

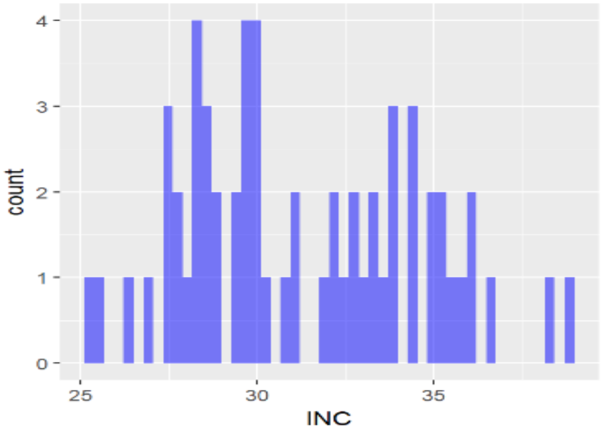

count
0
1
2
3
4
1000
2000
3000
4000
5000
P15

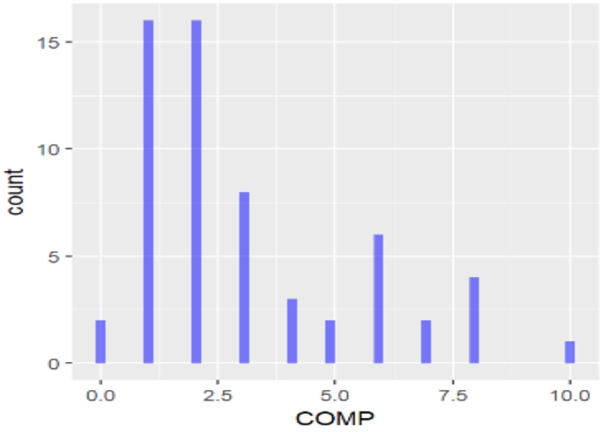

count
0
1
2
3
4
0
2000
4000
P25

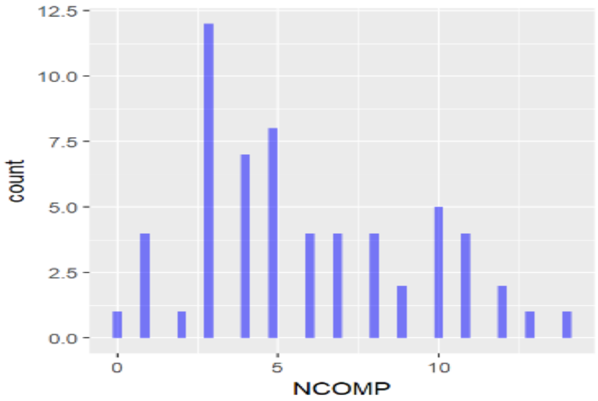

count
0
1
2
3
4
0
2000
4000
6000
P35

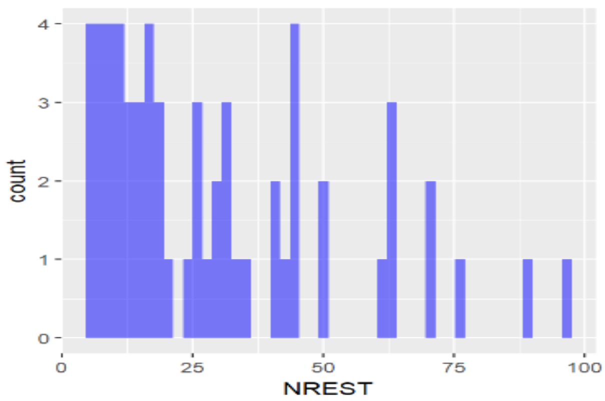

count
0
1
2
3
4
2000
4000
6000
P45

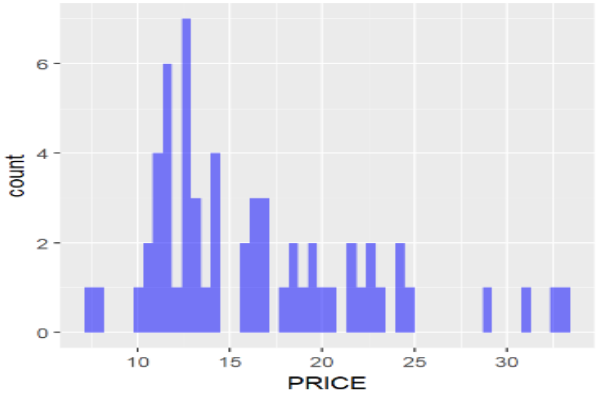

count
0
1
2
3
4
2000
4000
6000
P55


count
0
1
2
3
4
25
30
35
INC


count
0
5
10
15
0.0
2.5
5.0
7.5
10.0
COMP


count
0.0
2.5
5.0
7.5
10.0
12.5
0
5
10
NCOMP


count
0
1
2
3
4
0
25
50
75
100
NREST


count
0
2
4
6
10
15
20
25
30
PRICE

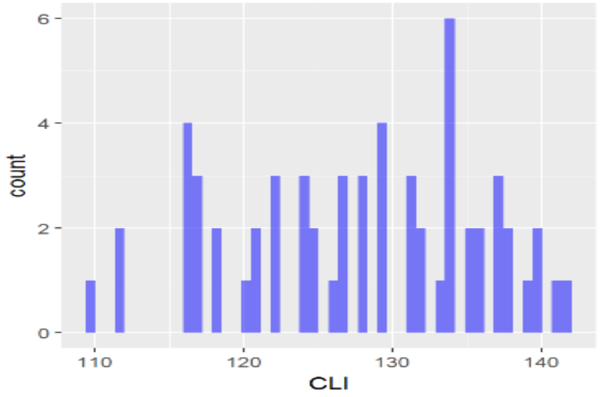

count
0
2
4
6
110
120
130
140
CLI

Exhibit 3. Scatterplots of age group with total population

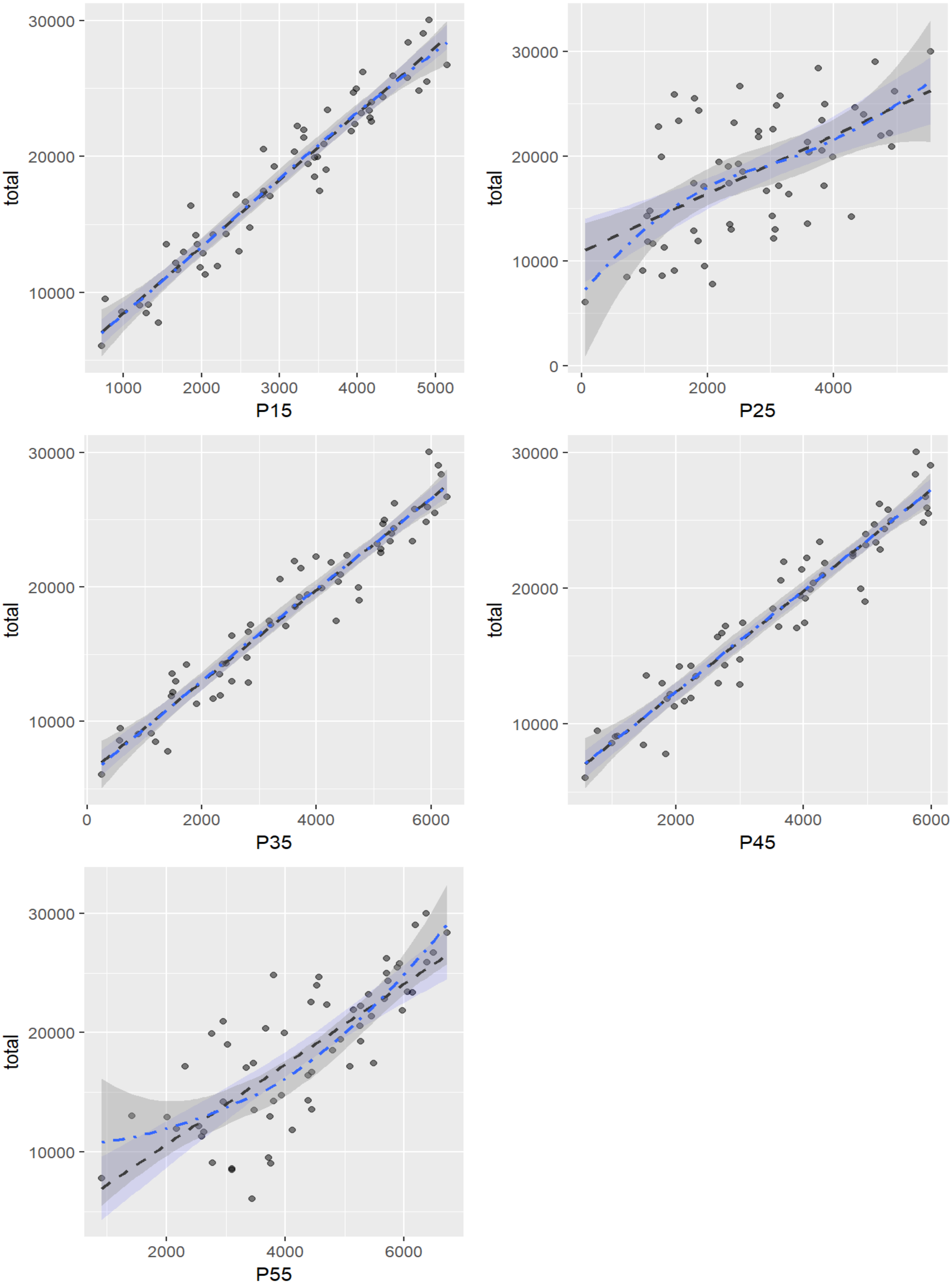


Exhibit 4. Regression with untransformed variables

```
Linear regression (OLS)
Data     : CroqPainFix
Response variable    : EARN
Explanatory variables: K, SIZE, EMPL, total, P15, P25, P35, P45, P55, INC, CO
MP, NCOMP, NREST, PRICE, CLI
Null hyp.: the effect of x on EARN is zero
Alt. hyp.: the effect of x on EARN is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)       0.000     0.026   0.000   1.000
 K                -0.516     0.319  -1.619   0.113
 SIZE              0.851     0.251   3.389   0.001 **
 EMPL             -0.066     0.060  -1.100   0.277
 total            -0.346     0.854  -0.405   0.687
 P15               0.761     0.356   2.141   0.038 *
 P25               0.092     0.191   0.480   0.633
 P35               0.109     0.417   0.260   0.796
 P45              -0.089     0.556  -0.160   0.873
 P55               0.079     0.216   0.365   0.717
 INC               0.352     0.063   5.636  < .001 ***
 COMP             -0.059     0.061  -0.969   0.338
 NCOMP            -0.007     0.058  -0.113   0.910
 NREST             0.365     0.060   6.116  < .001 ***
 PRICE             0.084     0.190   0.445   0.659
 CLI               0.040     0.063   0.642   0.524

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.875,  Adjusted R-squared: 0.832
F-statistic: 20.453 df(15,44), p.value < .001
Nr obs: 60

Variance Inflation Factors
         VIF   Rsq
total 255.640 0.996
P45   108.367 0.991
P35    61.141 0.984
P15    44.350 0.977
K      35.614 0.972
SIZE   22.127 0.955
P55    16.407 0.939
P25    12.739 0.922
PRICE  12.656 0.921
INC     1.372 0.271
CLI     1.371 0.271
COMP    1.291 0.225
NREST   1.252 0.201
```

```
EMPL     1.245 0.197
NCOMP    1.177 0.150
```

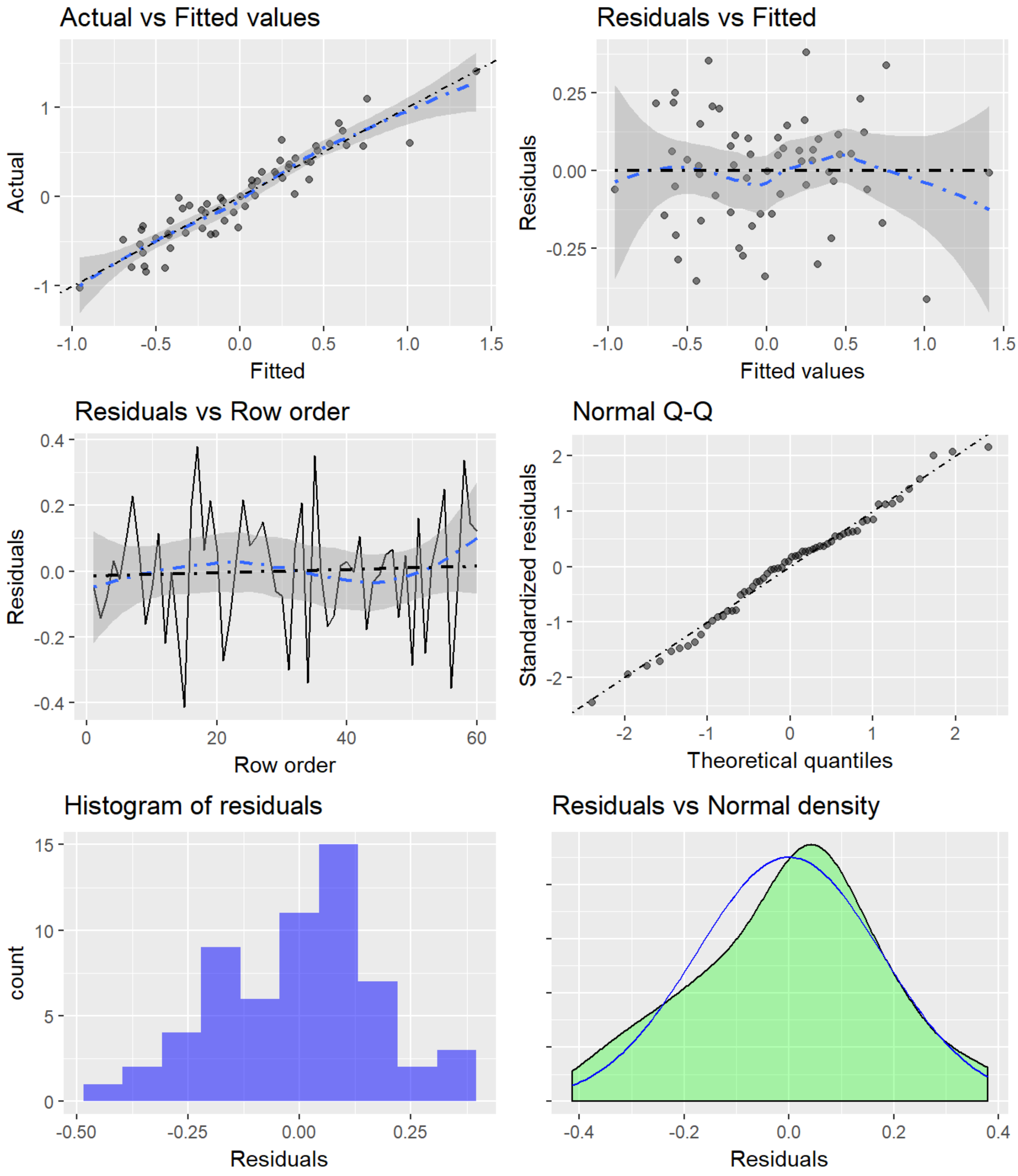


Exhibit 5. Regression with normalized variables

```
Linear regression (OLS)
Data     : CroqPainFix
Response variable    : EARN_total
Explanatory variables: K, SIZE, EMPL, INC, PRICE, CLI, P15_total, P25_total,
P35_total, P45_total, P55_total, COMP_total, NCOMP_total, NREST_total
Null hyp.: the effect of x on EARN_total is zero
Alt. hyp.: the effect of x on EARN_total is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)       0.000     0.036   0.000   1.000
 K                -0.765     0.428  -1.788   0.081 .
 SIZE              1.134     0.334   3.396   0.001 **
 EMPL             -0.100     0.081  -1.223   0.228
 INC               0.409     0.085   4.797  < .001 ***
 PRICE             0.187     0.249   0.750   0.457
 CLI               0.096     0.084   1.146   0.258
 P15_total         0.308     0.154   1.999   0.052 .
 P25_total         0.081     0.169   0.482   0.632
 P35_total         0.236     0.243   0.973   0.336
 P45_total        -0.229     0.269  -0.853   0.398
 P55_total        -0.038     0.225  -0.167   0.868
 COMP_total       -0.189     0.107  -1.762   0.085 .
 NCOMP_total       0.135     0.092   1.474   0.147
 NREST_total       0.583     0.101   5.760  < .001 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.766,  Adjusted R-squared: 0.693
F-statistic: 10.506 df(14,45), p.value < .001
Nr obs: 60

Variance Inflation Factors
               VIF   Rsq
K           35.143 0.972
SIZE        21.438 0.953
P45_total   13.888 0.928
PRICE       11.895 0.916
P35_total   11.315 0.912
P55_total    9.701 0.897
P25_total    5.486 0.818
P15_total    4.563 0.781
COMP_total   2.217 0.549
NREST_total  1.967 0.492
NCOMP_total  1.609 0.379
INC          1.395 0.283
CLI          1.358 0.264
EMPL         1.272 0.214
```

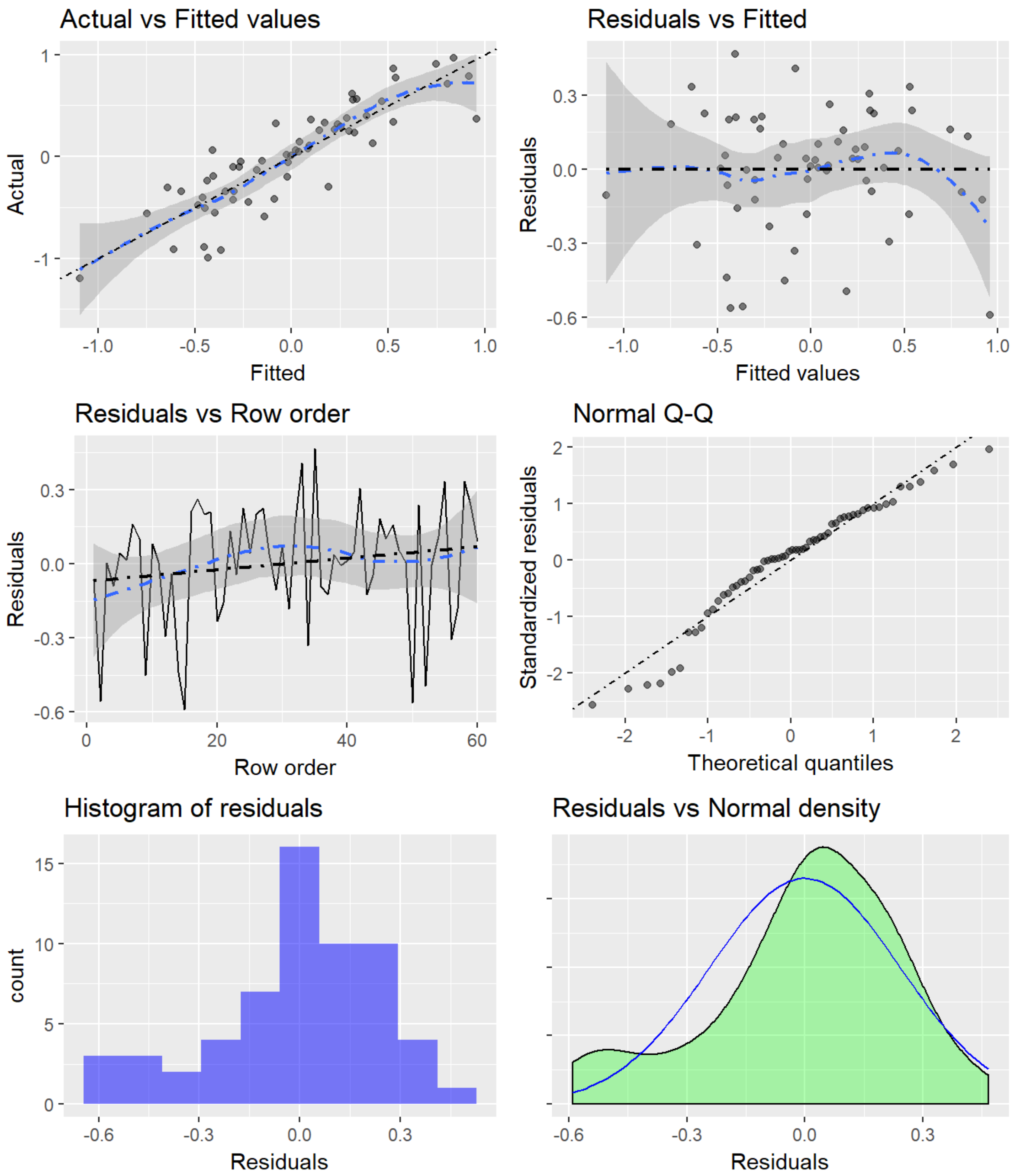

Actual vs Fitted values
Actual
1
0
-1
-1.0
-0.5
0.0
0.5
1.0
Fitted
Residuals vs Fitted
Residuals
0.3
0.0
-0.3
-0.6
-1.0
-0.5
0.0
0.5
1.0
Fitted values
Residuals vs Row order
Residuals
0.3
0.0
-0.3
-0.6
0
20
40
60
Row order
Normal Q-Q
Standardized residuals
2
1
0
-1
-2
-2
-1
0
1
2
Theoretical quantiles
Histogram of residuals
count
15
10
5
0
-0.6
-0.3
0.0
0.3
Residuals
Residuals vs Normal density
-0.6
-0.3
0.0
0.3
Residuals

Exhibit 6. Regression model we initially built

```
Linear regression (OLS)
Data     : CroqPainFix
Response variable    : EARN_total
Explanatory variables: K, INC, PRICE, P15_total, P25_total, COMP_total, NREST
_total
Null hyp.: the effect of x on EARN_total is zero
Alt. hyp.: the effect of x on EARN_total is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)       0.000     0.039   0.000   1.000
 K                 0.655     0.107   6.109  < .001 ***
 INC               0.322     0.085   3.789  < .001 ***
 PRICE            -0.589     0.101  -5.822  < .001 ***
 P15_total         0.384     0.099   3.890  < .001 ***
 P25_total         0.203     0.093   2.193   0.033 *
 COMP_total       -0.200     0.096  -2.084   0.042 *
 NREST_total       0.554     0.100   5.534  < .001 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.679,  Adjusted R-squared: 0.636
F-statistic: 15.714 df(7,52), p.value < .001
Nr obs: 60

Variance Inflation Factors
        K PRICE NREST_total P15_total COMP_total P25_total   INC
VIF 1.864 1.655       1.623     1.583      1.499     1.388 1.172
Rsq 0.463 0.396       0.384     0.368      0.333     0.280 0.147
```

Exhibit 7. Regression with transformed variables with stepwise function

```
Start:  AIC=-141.26
EARN_total ~ K + SIZE + EMPL + INC + PRICE + CLI + P15_total + 
    P25_total + P35_total + P45_total + P55_total + COMP_total + 
    NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- P55_total    1   0.00215 3.4576 -143.23
- P25_total    1   0.01785 3.4733 -142.96
- PRICE        1   0.04318 3.4986 -142.52
- P45_total    1   0.05582 3.5112 -142.30
- P35_total    1   0.07272 3.5281 -142.01
- CLI          1   0.10077 3.5562 -141.54
- EMPL         1   0.11485 3.5703 -141.30
<none>                     3.4554 -141.26
```

```
- NCOMP_total  1   0.16694 3.6224 -140.43
- COMP_total   1   0.23828 3.6937 -139.26
- K            1   0.24541 3.7008 -139.15
- P15_total    1   0.30691 3.7623 -138.16
- SIZE         1   0.88547 4.3409 -129.58
- INC          1   1.76719 5.2226 -118.48
- NREST_total  1   2.54757 6.0030 -110.12

Step:  AIC=-143.23
EARN_total ~ K + SIZE + EMPL + INC + PRICE + CLI + P15_total + 
    P25_total + P35_total + P45_total + COMP_total + NCOMP_total + 
    NREST_total

              Df Sum of Sq    RSS     AIC
- PRICE        1   0.04106 3.4986 -144.52
- P45_total    1   0.06320 3.5208 -144.14
- P35_total    1   0.07898 3.5366 -143.87
- CLI          1   0.09885 3.5564 -143.53
- P25_total    1   0.10248 3.5601 -143.47
- EMPL         1   0.11279 3.5704 -143.30
<none>                     3.4576 -143.23
- NCOMP_total  1   0.16482 3.6224 -142.43
- COMP_total   1   0.23877 3.6964 -141.22
- K            1   0.24564 3.7032 -141.11
- P15_total    1   0.33677 3.7943 -139.65
- SIZE         1   0.90085 4.3584 -131.33
- INC          1   1.76743 5.2250 -120.45
- NREST_total  1   2.56211 6.0197 -111.96

Step:  AIC=-144.52
EARN_total ~ K + SIZE + EMPL + INC + CLI + P15_total + P25_total + 
    P35_total + P45_total + COMP_total + NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- P45_total    1    0.0703 3.5690 -145.32
- EMPL         1    0.0811 3.5797 -145.14
- P35_total    1    0.0989 3.5975 -144.85
- CLI          1    0.1097 3.6083 -144.67
<none>                     3.4986 -144.52
- P25_total    1    0.1395 3.6382 -144.17
- NCOMP_total  1    0.1580 3.6567 -143.87
- COMP_total   1    0.2719 3.7705 -142.03
- P15_total    1    0.3306 3.8292 -141.10
- K            1    0.8302 4.3289 -133.74
- INC          1    1.8326 5.3313 -121.25
- NREST_total  1    2.6964 6.1951 -112.24
- SIZE         1    3.5636 7.0623 -104.38

Step:  AIC=-145.32
```

```
EARN_total ~ K + SIZE + EMPL + INC + CLI + P15_total + P25_total + 
    P35_total + COMP_total + NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- P35_total    1    0.0294 3.5984 -146.83
- CLI          1    0.0777 3.6467 -146.03
- EMPL         1    0.0871 3.6561 -145.88
- NCOMP_total  1    0.1200 3.6890 -145.34
<none>                     3.5690 -145.32
- P25_total    1    0.1530 3.7220 -144.81
- P15_total    1    0.2702 3.8392 -142.94
- COMP_total   1    0.2905 3.8595 -142.63
- K            1    0.8365 4.4055 -134.69
- INC          1    1.8656 5.4346 -122.09
- NREST_total  1    2.6302 6.1992 -114.20
- SIZE         1    3.5138 7.0828 -106.20

Step:  AIC=-146.83
EARN_total ~ K + SIZE + EMPL + INC + CLI + P15_total + P25_total + 
    COMP_total + NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- CLI          1    0.0917 3.6901 -147.32
- EMPL         1    0.1014 3.6998 -147.16
- NCOMP_total  1    0.1025 3.7009 -147.15
<none>                     3.5984 -146.83
- P25_total    1    0.1704 3.7688 -146.06
- COMP_total   1    0.3838 3.9822 -142.75
- K            1    0.8998 4.4982 -135.44
- P15_total    1    1.0401 4.6386 -133.60
- INC          1    1.8470 5.4454 -123.97
- NREST_total  1    2.6020 6.2004 -116.18
- SIZE         1    3.7359 7.3344 -106.11

Step:  AIC=-147.32
EARN_total ~ K + SIZE + EMPL + INC + P15_total + P25_total + 
    COMP_total + NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- EMPL         1    0.0865 3.7765 -147.93
- NCOMP_total  1    0.1003 3.7904 -147.71
<none>                     3.6901 -147.32
- P25_total    1    0.1572 3.8472 -146.82
- COMP_total   1    0.3296 4.0197 -144.19
- K            1    0.8096 4.4996 -137.42
- P15_total    1    1.1243 4.8144 -133.37
- INC          1    1.8656 5.5557 -124.77
- NREST_total  1    2.5430 6.2331 -117.87
- SIZE         1    3.6599 7.3500 -107.98
```

```
Step:  AIC=-147.93
EARN_total ~ K + SIZE + INC + P15_total + P25_total + COMP_total + 
    NCOMP_total + NREST_total

              Df Sum of Sq    RSS     AIC
- NCOMP_total  1    0.0903 3.8669 -148.51
<none>                     3.7765 -147.93
- P25_total    1    0.1635 3.9400 -147.39
- COMP_total   1    0.4331 4.2097 -143.42
- K            1    0.8358 4.6124 -137.94
- P15_total    1    1.1119 4.8884 -134.45
- INC          1    1.8112 5.5877 -126.43
- NREST_total  1    2.7495 6.5261 -117.11
- SIZE         1    3.6805 7.4570 -109.11

Step:  AIC=-148.51
EARN_total ~ K + SIZE + INC + P15_total + P25_total + COMP_total + 
    NREST_total

              Df Sum of Sq    RSS     AIC
<none>                     3.8669 -148.51
- P25_total    1    0.2518 4.1187 -146.73
- COMP_total   1    0.3453 4.2122 -145.38
- K            1    0.8945 4.7614 -138.03
- P15_total    1    1.1331 5.0000 -135.09
- INC          1    2.0322 5.8990 -125.17
- NREST_total  1    2.7938 6.6607 -117.89
- SIZE         1    3.9542 7.8211 -108.25

----------------------------------------------------
Backward stepwise selection of variables
----------------------------------------------------
Linear regression (OLS)
Data     : CroqPainFix
Response variable    : EARN_total
Explanatory variables: K, SIZE, EMPL, INC, PRICE, CLI, P15_total, P25_total, 
P35_total, P45_total, P55_total, COMP_total, NCOMP_total, NREST_total
Null hyp.: the effect of x on EARN_total is zero
Alt. hyp.: the effect of x on EARN_total is not zero
**Standardized coefficients shown (2 X SD)**

             coefficient std.error t.value p.value
 (Intercept)       0.000     0.035   0.000   1.000
 K                -0.453     0.131  -3.468   0.001 **
 SIZE              0.903     0.124   7.292  < .001 ***
 INC               0.396     0.076   5.228  < .001 ***
 P15_total         0.349     0.089   3.904  < .001 ***
 P25_total         0.154     0.084   1.840   0.071 .
 COMP_total       -0.186     0.086  -2.155   0.036 *
 NREST_total       0.554     0.090   6.129  < .001 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.738,  Adjusted R-squared: 0.703
F-statistic: 20.907 df(7,52), p.value < .001
Nr obs: 60

Variance Inflation Factors
        K  SIZE NREST_total P15_total COMP_total P25_total   INC
VIF 3.381 3.039       1.621     1.587      1.476     1.385 1.140
Rsq 0.704 0.671       0.383     0.370      0.323     0.278 0.123
```