Modelo de séries temporais para projeção da demanda de caminhões no Brasil

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Introdução

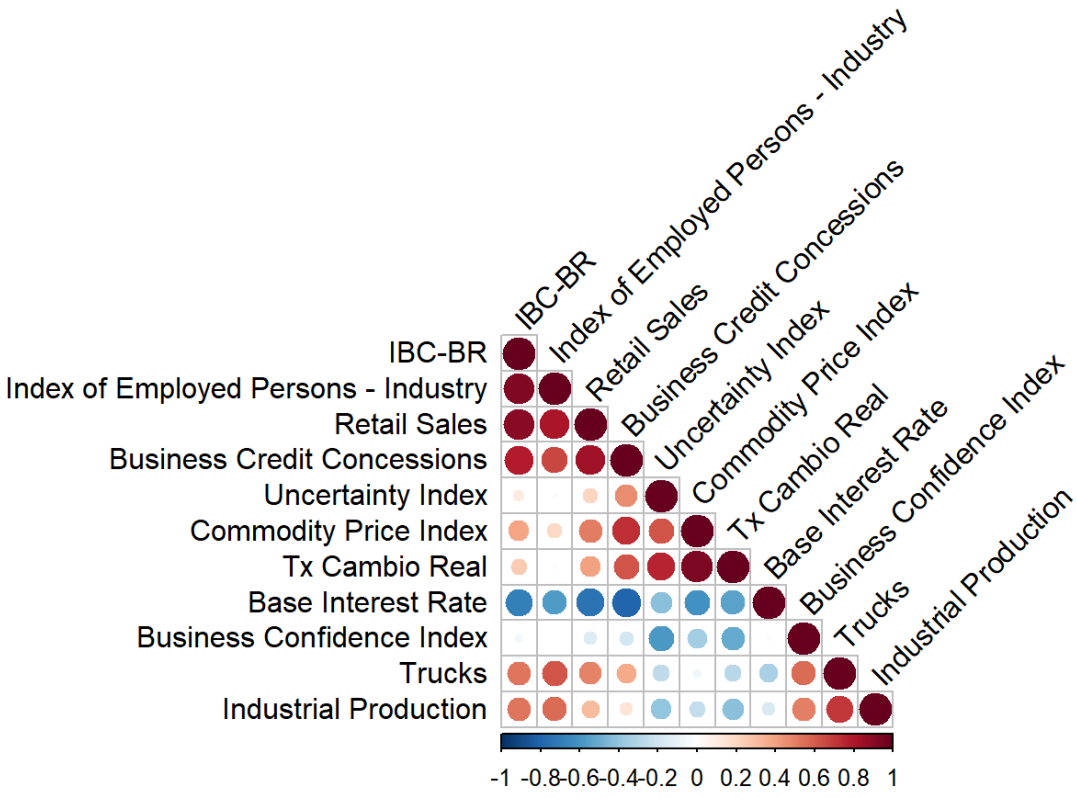
Na indústria automobilística, projeções de demanda por veiculos são de suma importância para este segmento de mercado. A partir de modelos econométricos, como *regressão linear multipla* e *análise de séries temporais* é possivel simular e estimar computacionalmente como se comporta a venda de automóveis em determinado país, região,empresa etc. Especificamente, neste teste, será modelado a demanda por caminhões no Brasil, a partir de dados mensais de vendas do periodo 2003-2021, e séries macroeconômicas como taxas de câmbio, juros e inflação. Ademais, indices de confiança, crédito e emprego serão utilizados nesta modelagem.

Analise de correlação das variaveis explicativas do modelo.

Seleção das variáveis para análise de correlação.

```
vars<- data %>%
      select(Trucks,`IBC-BR`,`Industrial Production`,`Retail Sales`,
             `Business Credit Concessions`,`Business Confidence Index`,`Commodity Price Index`,
             `Index of Employed Persons - Industry`,`Base Interest Rate`,`Uncertainty Index`,
             `Tx Cambio Real`)

rquery.cormat(vars)
```



```
## $r
##                                   IBC-BR
## IBC-BR                                 1
## Index of Employed Persons - Industry   0.92
## Retail Sales                            0.9
## Business Credit Concessions            0.78
## Uncertainty Index                      0.11
## Commodity Price Index                  0.39
## Tx Cambio Real                         0.25
## Base Interest Rate                    -0.69
## Business Confidence Index             -0.06
## Trucks                                 0.53
## Industrial Production                  0.53
##                                   Index of Employed Persons - Industry
## IBC-BR
## Index of Employed Persons - Industry                                    1
## Retail Sales                                                         0.82
## Business Credit Concessions                                          0.66
## Uncertainty Index                                                  -0.026
## Commodity Price Index                                                 0.2
## Tx Cambio Real                                                      0.023
## Base Interest Rate                                                  -0.57
## Business Confidence Index                                          0.0067
## Trucks                                                               0.62
## Industrial Production                                                0.57
##                                   Retail Sales Business Credit Concessions
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales                                 1
## Business Credit Concessions               0.84                          1
## Uncertainty Index                         0.21                       0.46
## Commodity Price Index                     0.51                       0.73
## Tx Cambio Real                             0.4                       0.62
## Base Interest Rate                        -0.74                      -0.79
## Business Confidence Index                 -0.15                      -0.19
## Trucks                                    0.49                       0.37
## Industrial Production                     0.31                       0.15
##                                   Uncertainty Index Commodity Price Index
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index                                1
## Commodity Price Index                         0.62                    1
## Tx Cambio Real                                0.76                 0.93
## Base Interest Rate                           -0.42                -0.61
## Business Confidence Index                    -0.58                -0.35
## Trucks                                       -0.26               -0.064
## Industrial Production                         -0.4                -0.25
##                                   Tx Cambio Real Base Interest Rate
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real                                1
## Base Interest Rate                         -0.54                   1
## Business Confidence Index                  -0.51              -0.022
## Trucks                                     -0.28               -0.33
```

```
## Industrial Production                          -0.42              -0.17
##                                    Business Confidence Index Trucks
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index                                       1
## Trucks                                                       0.56      1
## Industrial Production                                         0.5    0.7
##                                    Industrial Production
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index
## Trucks
## Industrial Production                                        1
##
## $p
##                                     IBC-BR
## IBC-BR                                   0
## Index of Employed Persons - Industry 4.5e-93
## Retail Sales                         5.9e-84
## Business Credit Concessions          8.3e-46
## Uncertainty Index                       0.11
## Commodity Price Index                1.5e-09
## Tx Cambio Real                         1e-04
## Base Interest Rate                   1.3e-33
## Business Confidence Index               0.37
## Trucks                               8.9e-18
## Industrial Production                1.2e-17
##                                    Index of Employed Persons - Industry
## IBC-BR
## Index of Employed Persons - Industry                                    0
## Retail Sales                                                      1.1e-55
## Business Credit Concessions                                       5.6e-29
## Uncertainty Index                                                    0.74
## Commodity Price Index                                              0.0017
## Tx Cambio Real                                                       0.65
## Base Interest Rate                                                2.4e-21
## Business Confidence Index                                            0.92
## Trucks                                                            1.8e-25
## Industrial Production                                             1.2e-20
##                                    Retail Sales Business Credit Concessions
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales                                  0
## Business Credit Concessions              7.5e-62                         0
## Uncertainty Index                         0.0017                     2.6e-13
## Commodity Price Index                    2.2e-16                       2e-44
## Tx Cambio Real                           5.6e-10                     7.1e-29
## Base Interest Rate                       2.4e-40                       7e-44
## Business Confidence Index                  0.028                      0.0046
```

```
## Trucks                                    9.6e-15                    4.4e-09
## Industrial Production                       2e-06                      0.035
##                                   Uncertainty Index Commodity Price Index
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index                                 0
## Commodity Price Index                       1.1e-24                      0
## Tx Cambio Real                              4.8e-44                2.2e-98
## Base Interest Rate                          2.6e-11                3.1e-22
## Business Confidence Index                   1.5e-21                  3e-07
## Trucks                                      0.00012                   0.64
## Industrial Production                       3.2e-10                0.00011
##                                   Tx Cambio Real Base Interest Rate
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real                                 0
## Base Interest Rate                       3.5e-18                   0
## Business Confidence Index                2.2e-15                0.75
## Trucks                                   0.00014             4.4e-07
## Industrial Production                    2.3e-11               0.011
##                                   Business Confidence Index  Trucks
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index                                 0
## Trucks                                             2.9e-20       0
## Industrial Production                              5.2e-16 6.5e-34
##                                   Industrial Production
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index
## Trucks
## Industrial Production                                0
##
## $sym
##                                   IBC-BR
## IBC-BR                            1
## Index of Employed Persons - Industry *
## Retail Sales                      +
## Business Credit Concessions       ,
## Uncertainty Index
## Commodity Price Index             .
## Tx Cambio Real
## Base Interest Rate                ,
```

```
## Business Confidence Index
## Trucks                                .
## Industrial Production                 .
##                                       Index of Employed Persons - Industry
## IBC-BR
## Index of Employed Persons - Industry 1
## Retail Sales                          +
## Business Credit Concessions           ,
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate                    .
## Business Confidence Index
## Trucks                                ,
## Industrial Production                 .
##                                       Retail Sales Business Credit Concessions
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales                          1
## Business Credit Concessions           +            1
## Uncertainty Index                                  .
## Commodity Price Index                 .            ,
## Tx Cambio Real                        .            ,
## Base Interest Rate                    ,            ,
## Business Confidence Index
## Trucks                                .            .
## Industrial Production                 .
##                                       Uncertainty Index Commodity Price Index
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index                     1
## Commodity Price Index                 ,                 1
## Tx Cambio Real                        ,                 *
## Base Interest Rate                    .                 ,
## Business Confidence Index             .                 .
## Trucks
## Industrial Production                 .
##                                       Tx Cambio Real Base Interest Rate
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real                        1
## Base Interest Rate                    .              1
## Business Confidence Index             .
## Trucks                                               .
## Industrial Production                 .
##                                       Business Confidence Index Trucks
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index             1
```

```
## Trucks                              .                         1
## Industrial Production               .                         ,
##                                     Industrial Production
## IBC-BR
## Index of Employed Persons - Industry
## Retail Sales
## Business Credit Concessions
## Uncertainty Index
## Commodity Price Index
## Tx Cambio Real
## Base Interest Rate
## Business Confidence Index
## Trucks
## Industrial Production               1
## attr(,"legend")
## [1] 0 ' ' 0.3 '.' 0.6 ',' 0.8 '+' 0.9 '*' 0.95 'B' 1
```

Destaca-se, com base na matriz de correlação acima,

- uma alta correlação entre o volume de vendas no varejo e o indice de pessoas empregadas na indústria
- volume de concessão de crédito e vendas no varejo
- volume de vendas de caminhões com indice de confiança dos empresários

Análise de causalidade via teste de Granger

Trucks x Taxa Câmbio Real

```
test1<- grangertest(Trucks~`Tx Cambio Real`, order= 3, data)

test2<-grangertest(`Tx Cambio Real`~Trucks, order=3, data)

test1
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Tx Cambio Real, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.5859 0.1937
```

```
test2
```

```
## Granger causality test
##
## Model 1: Tx Cambio Real ~ Lags(Tx Cambio Real, 1:3) + Lags(Trucks, 1:3)
## Model 2: Tx Cambio Real ~ Lags(Tx Cambio Real, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.4126   0.24
```

Com base no p-valor, constata-se que a variável `Tx Cambio Real` não é um boa preditora do volume de vendas de caminhões.

Trucks x Retail Sales

```
test3<-grangertest(Trucks~`Retail Sales`, order=3,data)

test4<-grangertest(`Retail Sales`~Trucks, order=3,data)

test3
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Retail Sales, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    216
## 2    219 -3 9.7243 4.791e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test4
```

```
## Granger causality test
##
## Model 1: Retail Sales ~ Lags(Retail Sales, 1:3) + Lags(Trucks, 1:3)
## Model 2: Retail Sales ~ Lags(Retail Sales, 1:3)
##   Res.Df Df      F  Pr(>F)
## 1    216
## 2    219 -3 2.8493 0.03839 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Neste caso, constata-se que a variável `Retail Sales` é uma boa preditora para o volume de vendas de caminhões.

Trucks x IBC_BR

```
test5<-grangertest(Trucks~`IBC-BR`,order=3,data)

test6<-grangertest(`IBC-BR`~Trucks,order=3,data)

test5
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(IBC-BR, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    217
## 2    220 -3 1.7416 0.1594
```

```
test6
```

```
## Granger causality test
##
## Model 1: IBC-BR ~ Lags(IBC-BR, 1:3) + Lags(Trucks, 1:3)
## Model 2: IBC-BR ~ Lags(IBC-BR, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    217
## 2    220 -3 9.4613 6.688e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Neste caso, a variável `IBC_BR` não é um boa preditora para o volume de vendas de caminhões.

```
test7<-grangertest(Trucks~`IBC-BR`,order=1,data)

test8<-grangertest(`IBC-BR`~Trucks,order=1,data)

test7
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:1) + Lags(IBC-BR, 1:1)
## Model 2: Trucks ~ Lags(Trucks, 1:1)
##   Res.Df Df      F Pr(>F)
## 1    223
## 2    224 -1 0.0099 0.9208
```

```
test8
```

```
## Granger causality test
##
## Model 1: IBC-BR ~ Lags(IBC-BR, 1:1) + Lags(Trucks, 1:1)
## Model 2: IBC-BR ~ Lags(IBC-BR, 1:1)
##   Res.Df Df      F Pr(>F)
## 1    223
## 2    224 -1 1.4447 0.2307
```

De fato, evidencia-se que a variável `IBC-BR` não é uma boa preditora do volume de vendas de caminhões no Brasil.

Trucks x Business Credit Concession

```
test9<-grangertest(Trucks~`Business Credit Concessions`,order=3, data)

test10<-grangertest(`Business Credit Concessions`~Trucks,order=3, data)

test9
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Business Credit Concessions, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F   Pr(>F)
## 1    218
## 2    221 -3 4.7744 0.003039 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test10
```

```
## Granger causality test
##
## Model 1: Business Credit Concessions ~ Lags(Business Credit Concessions, 1:3) + Lags(Trucks, 1:3)
## Model 2: Business Credit Concessions ~ Lags(Business Credit Concessions, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.5287  0.208
```

Neste caso, a variável `Business Credit Concessions` é uma boa preditora do volume de vendas de caminhões.

Trucks x Business Confidence Index

```
test11<-grangertest(Trucks~`Business Confidence Index`, order=3, data)

test12<-grangertest(`Business Confidence Index`~Trucks, order=3, data)

test11
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Business Confidence Index, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F   Pr(>F)
## 1    218
## 2    221 -3 7.5937 7.47e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test12
```

```
## Granger causality test
##
## Model 1: Business Confidence Index ~ Lags(Business Confidence Index, 1:3) + Lags(Trucks, 1:3)
## Model 2: Business Confidence Index ~ Lags(Business Confidence Index, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.6215 0.1853
```

Neste caso, a variável `Business Confidence - Index` é uma boa preditora do volume de vendas de caminhões.

Trucks x Uncentainy Index

```
test13<-grangertest(Trucks~`Uncertainty Index`,order=3, data)

test14<-grangertest(`Uncertainty Index`~Trucks,order=3, data)

test13
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Uncertainty Index, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F  Pr(>F)
## 1    218
## 2    221 -3 2.7071 0.04618 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test14
```

```
## Granger causality test
##
## Model 1: Uncertainty Index ~ Lags(Uncertainty Index, 1:3) + Lags(Trucks, 1:3)
## Model 2: Uncertainty Index ~ Lags(Uncertainty Index, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.2012 0.3102
```

Neste caso, a variável `Uncertainy Index` é uma boa preditora do volume de vendas de caminhões.

```
test15<-grangertest(Trucks~`Base Interest Rate`, order=3, data)

test16<-grangertest(`Base Interest Rate`~Trucks, order=3, data)

test15
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Base Interest Rate, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 1.1832  0.317
```

```
test16
```

```
## Granger causality test
##
## Model 1: Base Interest Rate ~ Lags(Base Interest Rate, 1:3) + Lags(Trucks, 1:3)
## Model 2: Base Interest Rate ~ Lags(Base Interest Rate, 1:3)
##   Res.Df Df      F  Pr(>F)
## 1    218
## 2    221 -3 2.6094 0.05244 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Portanto, neste caso, a variável `Base Interest Rate` não é uma boa preditora do volume de vendas de caminhões.

Trucks x Industry Employ

```
test17<-grangertest(Trucks~`Index of Employed Persons - Industry`, order=3, data)

test18<-grangertest(`Index of Employed Persons - Industry`~Trucks, order=3, data)

test17
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Index of Employed Persons - Industry, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    217
## 2    220 -3 15.005 6.549e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test18
```

```
## Granger causality test
##
## Model 1: Index of Employed Persons - Industry ~ Lags(Index of Employed Persons - Industry, 1:3) + L
ags(Trucks, 1:3)
## Model 2: Index of Employed Persons - Industry ~ Lags(Index of Employed Persons - Industry, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    217
## 2    220 -3 9.9266 3.686e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Portanto, a variável `Index of Employed Person - Industry` é uma boa preditora do volume de vendas de caminhões.

Trucks x Industrial Production

```
test19<-grangertest(Trucks~`Industrial Production`, order=3, data)

test20<-grangertest(`Industrial Production`~Trucks, order=3, data)

test19
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Industrial Production, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    217
## 2    220 -3 14.644 1.017e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test20
```

```
## Granger causality test
##
## Model 1: Industrial Production ~ Lags(Industrial Production, 1:3) + Lags(Trucks, 1:3)
## Model 2: Industrial Production ~ Lags(Industrial Production, 1:3)
##   Res.Df Df      F    Pr(>F)
## 1    217
## 2    220 -3 11.415 5.574e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Logo, a variável `Industrial Production` é uma boa preditora do volume de vendas de caminhões.

Trucks x Commodity Price Index

```
test21<-grangertest(Trucks~`Commodity Price Index`, order=3, data)

test22<-grangertest(`Commodity Price Index`~Trucks, order=3, data)

test21
```

```
## Granger causality test
##
## Model 1: Trucks ~ Lags(Trucks, 1:3) + Lags(Commodity Price Index, 1:3)
## Model 2: Trucks ~ Lags(Trucks, 1:3)
##   Res.Df Df      F Pr(>F)
## 1    218
## 2    221 -3 0.1364 0.9382
```

```
test22
```

```
## Granger causality test
##
## Model 1: Commodity Price Index ~ Lags(Commodity Price Index, 1:3) + Lags(Trucks, 1:3)
## Model 2: Commodity Price Index ~ Lags(Commodity Price Index, 1:3)
##   Res.Df Df      F  Pr(>F)
## 1    218
## 2    221 -3 2.3124 0.07701 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Logo, a variável `Commodity Price Index` não é uma boa preditora para a o volume de vendas de caminhões.

Estimação do modelo por Minimos Quadrados Ordinários (MQO)

```
lm1<-lm(Trucks~`IBC-BR`+`Industrial Production`+`Retail Sales`+`Business Credit Concessions`+
          `Business Confidence Index`+`Commodity Price Index`+`Index of Employed Persons - Industry`+
          `Base Interest Rate`+`Uncertainty Index`+`Tx Cambio Real`, data)

summary(lm1)
```

```
##
## Call:
## lm(formula = Trucks ~ `IBC-BR` + `Industrial Production` + `Retail Sales` +
##     `Business Credit Concessions` + `Business Confidence Index` +
##     `Commodity Price Index` + `Index of Employed Persons - Industry` +
##     `Base Interest Rate` + `Uncertainty Index` + `Tx Cambio Real`,
##     data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3742.4  -992.1    -4.4   907.0  3651.2
##
## Coefficients:
##                                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)                         -32444.717   3436.944  -9.440  < 2e-16
## `IBC-BR`                               -102.668     30.253  -3.394 0.000821
## `Industrial Production`                  75.857     19.038   3.984 9.26e-05
## `Retail Sales`                          106.500     14.623   7.283 6.08e-12
## `Business Credit Concessions`            16.137      4.614   3.497 0.000571
## `Business Confidence Index`             165.177     14.577  11.331  < 2e-16
## `Commodity Price Index`                  13.036      6.112   2.133 0.034062
## `Index of Employed Persons - Industry`   82.980     23.552   3.523 0.000521
## `Base Interest Rate`                    217.808     40.412   5.390 1.85e-07
## `Uncertainty Index`                      67.076     10.969   6.115 4.50e-09
## `Tx Cambio Real`                      -1668.718    479.342  -3.481 0.000604
##
## (Intercept)                          ***
## `IBC-BR`                             ***
## `Industrial Production`              ***
## `Retail Sales`                       ***
## `Business Credit Concessions`        ***
## `Business Confidence Index`          ***
## `Commodity Price Index`              *
## `Index of Employed Persons - Industry` ***
## `Base Interest Rate`                 ***
## `Uncertainty Index`                  ***
## `Tx Cambio Real`                     ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1406 on 215 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.8211, Adjusted R-squared:  0.8128
## F-statistic:  98.7 on 10 and 215 DF,  p-value: < 2.2e-16
```

Estimação do modelo por MQO apenas com as variáveis que apresentaram capacidade preditiva através do *Teste de Granger*

```
lm2<-lm(Trucks~`Industrial Production`+`Retail Sales`+`Business Credit Concessions`+
          `Business Confidence Index`+`Index of Employed Persons - Industry`+
          `Uncertainty Index`, data)

summary(lm2)
```

```
##
## Call:
## lm(formula = Trucks ~ `Industrial Production` + `Retail Sales` +
##     `Business Credit Concessions` + `Business Confidence Index` +
##     `Index of Employed Persons - Industry` + `Uncertainty Index`,
##     data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3920.9 -1209.5   -23.4  1054.0  5121.2
##
## Coefficients:
##                                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)                         -26485.852   2470.092 -10.723  < 2e-16
## `Industrial Production`                72.773     18.647   3.903 0.000127
## `Retail Sales`                         32.234     14.940   2.158 0.032047
## `Business Credit Concessions`           2.230      4.649   0.480 0.631993
## `Business Confidence Index`           145.487     13.610  10.690  < 2e-16
## `Index of Employed Persons - Industry`  72.231     17.765   4.066 6.67e-05
## `Uncertainty Index`                     16.506     10.137   1.628 0.104893
##
## (Intercept)                         ***
## `Industrial Production`             ***
## `Retail Sales`                      *
## `Business Credit Concessions`
## `Business Confidence Index`         ***
## `Index of Employed Persons - Industry` ***
## `Uncertainty Index`
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1706 on 219 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.7318, Adjusted R-squared:  0.7244
## F-statistic: 99.57 on 6 and 219 DF,  p-value: < 2.2e-16
```

```
pred_values_mqo<-lm2$fitted.values
```

As variáveis preditoras apresentam o sinal esperado e são estatisticamente significantes:

- 1%: `Intercepto` , `Industrial Production` , `Business Confidence Index` , `Index of Employed Persons - Industry`
- 5%: `Retail Sales`

O R^2 apresenta valor igual a 0.7318, ou seja, 73.18% da variabilidade do volume de vendas de caminhões é explicado pelas variaveis preditoras do modelo.

Análise de Séries Temporais

Modelo Auto - Regressivo (AR)

Em modelos auto-regressivos, utiliza-se a variável de interesse, defasada em determinados periodos para prever seu valor em um cenario futuro. Desta forma, o modelo de previsão de vendas de caminhões, utilizará a variável `Trucks` defasada em 1,4,6 10 e 12 meses.

Estimação do modelo autoregressivo com defasagens de 1,4,6,10 e 12 meses.

```
ar_model<-arma(Trucks,lag=list(ar=c(1,4,6,10,12),ma=NULL), coef = NULL,
include.intercept = TRUE, series = data, qr.tol = 1e-07)
```

```
## Warning in arma(Trucks, lag = list(ar = c(1, 4, 6, 10, 12), ma = NULL), : order
## is ignored
```

```
summary(ar_model)
```

```
##
## Call:
## arma(x = Trucks, lag = list(ar = c(1, 4, 6, 10, 12), ma = NULL),     coef = NULL, include.intercept
= TRUE, series = data, qr.tol = 1e-07)
##
## Model:
## ARMA(12,0)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5517.1  -628.3  -122.5   749.8  4872.0
##
## Coefficient(s):
##            Estimate  Std. Error  t value Pr(>|t|)
## ar1         0.77054     0.05185   14.862  < 2e-16 ***
## ar4         0.15111     0.06140    2.461   0.0139 *
## ar6        -0.04439     0.06189   -0.717   0.4732
## ar10       -0.13783     0.06030   -2.286   0.0223 *
## ar12        0.20999     0.05388    3.898 9.72e-05 ***
## intercept 498.82248   267.19963    1.867   0.0619 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Fit:
## sigma^2 estimated as 1686797,  Conditional Sum-of-Squares = 362661297,  AIC = 3928.18
```

```
pred_values<-ar_model$fitted.values #Predicted values
```

Portanto, o modelo auto-regressivo estimado para o volume de vendas de caminhões segue a seguinte forma funcional

$$\widehat{Trucks}_t = 498.82 + 0.77Trucks_{t-1} + 0.15Trucks_{t-4} - 0.04Trucks_{t-6} - 0.13Trucks_{t-10} + 0.20Trucks_{t-12}$$

A partir do gráfico abaixo, é possivel perceber algumas tendências do comportamento das vendas de caminhões no Brasil. È possivel perceber que no ano de 2008 houve uma queda abrupta, em decorrência da crise financeira internacional que escasseou o crédito e fluxo de capitais para os mercados emergentes como o Brasil. No ano de 2009, como forma de atenuar o impacto sobre a indústria automobilística, o governo reduziu o IPI para estimular o setor. Em 2010, os efeitos positivos da medida se refletiram em maior nivel de vendas de caminhões, puxados em parte pelo aquecimento da atividade econômica. No ano de 2015, também houve uma queda acentuada da venda de caminhões no Brasil.

Neste ano, o Brasil passava por uma grave crise econômica, com um nível geral de preços elevado, desemprego crescente e a taxa de juros SELIC subindo para atenuar os efeitos deletérios da inflação. Considerando o biênio 2015-2016, a queda do PIB foi de aproximadamente 8,0%. A partir do 2º semestre de 2016 e ao longo do ano de 2017, com o país consolidando importantes reformas estruturais, no campo fiscal a PEC do Teto de Gastos, no campo microeconômico a Reforma Trabalhista, além da queda consistente da Taxa Selic, o nivel de confiança dos empresarios e a atração capital estrangeiro contribuiram de forma expressiva para a retomada do crescimento economico consistente, o que levou as vendas de caminhões voltar a subir gradualmente. No entanto, como mostra o gráfico 1, no

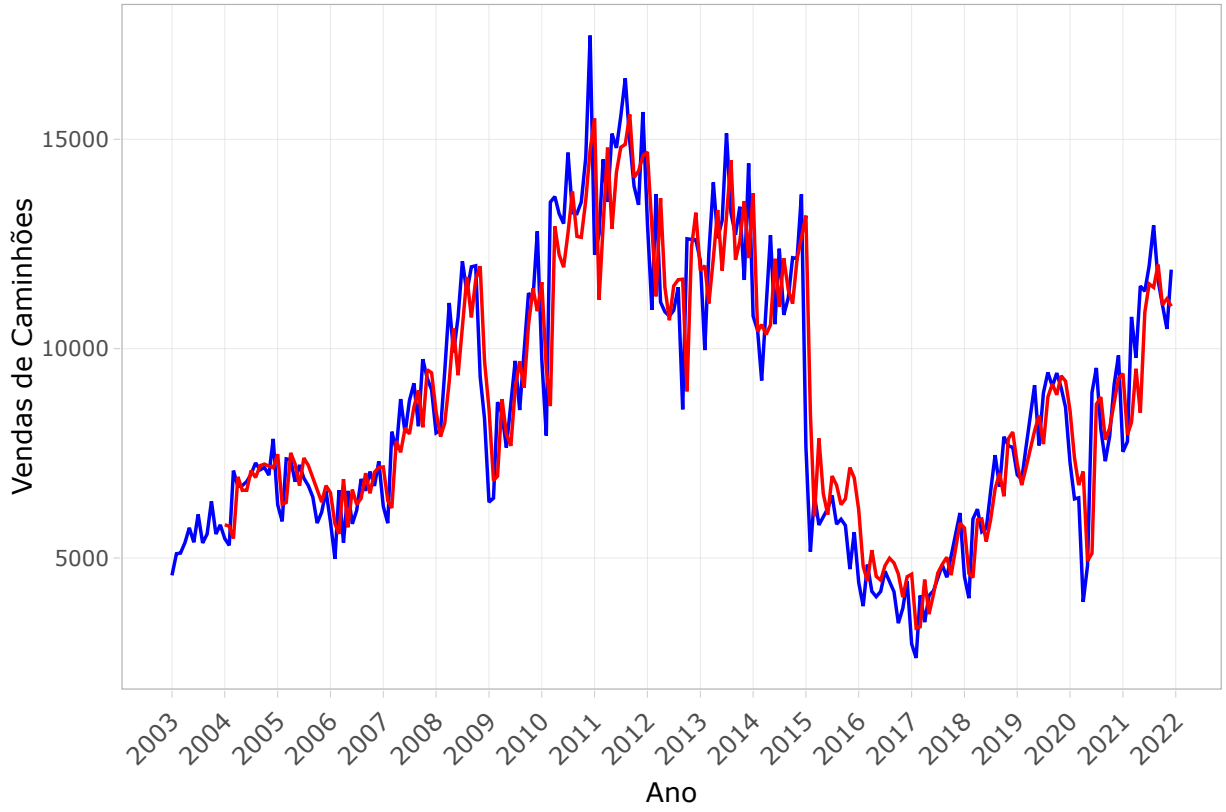
ano de 2020, devido a pandemia do coronavirus, a venda de caminhões voltou a apresentar forte queda. Ao longo de 2021, com a parcial normalização das atividades econômicas, o setor se recuperou com elevação gradual do volume de vendas de caminhões.

```
data$Date<-as.Date(Date)

graf<-ggplotly(ggplot(data, aes(x=Date)) +
    geom_line(aes(y=Trucks), colour="blue") +
    geom_line(aes(y=pred_values), colour="red")+
    theme_light() +
    scale_x_date(date_labels = "%Y", date_breaks = "1 year")+
    labs(x="Ano", y="Vendas de Caminhões", title=" Grafico 1: Evolução da venda de caminhões no Brasil
- Valores efetivos vs valores estimados") +
    theme(plot.title = element_text(hjust=0.5, size=10, face="bold"),
          axis.text.x=element_text(angle=45, size=10)))

graf
```

Grafico 1: Evolução da venda de caminhões no Brasil - Valores efetivos vs valores estin



Conclusões

Como mostram os resultados obtidos, a venda de caminhões no Brasil é fortemente dependente das condições macroeconômicas em âmbito nacional e internacional. Em âmbito nacional, variáveis como Vendas no Varejo, Produção Industrial e Concessão de Crédito impactam de forma significativa o volume de vendas de caminhões. Além disso, como esperado, o indice de confiança dosempresários também apresenta impacto relavante sobre os negócios deste setor.

Os resultados obtidos, nos modelos de MQO e AR foram estatisticamente significantes, representando de forma acurada a variável “Venda de Caminhões no Brasil”, o que corrobora a apropriada especificação dos modelos. Como mostrado no gráfico 1, a evolução efetiva e estimada do volume de vendas de caminhões seguem uma tendência bastante similar, o que indica evidências de uma boa calibragem do modelo AR aos dados.