Unemployment, Inflation and Violence: a VAR approach for Brazil

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The objective of this work is to examine the relationship between unemployment, inflation and violence in Brazil using a vector autoregressive and vector error correction models. Our hypothesis is that unemployment and inflation increase violence measures.

Increasing unemployment create incentives for people to enter the crime market, specially related to property crimes. Violent crimes increase due to social instability from unemployment.

Inflation can increase violent crimes through the costs of living. If a family is going through economic difficulties this can increase the propensity of some of member to enter illegal activity or crimes, and the instability created can increase violent crimes.

It is unlikely that unemployment may have an impact in violent crimes commited by hardened criminals. But the persistence of unemployment induces people to enter the criminal activity and increse cases of violent crimes.

There is a difference between violent crime and property crime. The last have an economic motivation and have been widely studied specially using cross-section and panel data (Saridakis 2004). But violent crime does not have necessarily an economic motivation and have a space for more research.

Tang (2009) studies the relation among crime, unemployment and inflation in Malaysia. He found long-run equilibruim relationship between unemployment, inflation and crime. There is Granger causality from unemployment and inflation to crime, but there is no reverse causality. The cointegrating vector shows that increasing unemployment and inflation increse crime. He uses data from 1970 to 2006 with violent crimes and property crimes.

Saridakis (2004) studies the relationship between socio-economic variables and violence in the USA from 1960 to 2000. The author find no long-run relationship between socio-economic variables and violence. But he finds short-run relatioship. His violence variables include: murder, rape and assault. He find that unemployment play an unimportant role in explaining violence.

Saridakis (2011) using cointegration analyzes the long run relationthip between violent crimes, economic conditions, justice system and beer comsuption in England and Wales. He finds that there is long-run relationship between economic variables, police deterrence and aggravated assault.

Using cointegration, Santos and Kassouf (2014) investigate how violent crime is related with unemployment and law-enforcement activities in the city of São Paulo. They find that violent crimes are positively related to unemployment and negatively related to real wages.

For some types of crimes we find some relationships between unemployment and inflation and violent crime, but for most varibles analyzed we do not find statistically significant relations. Santos and Kassouf (2014) do not find short-run relationship between those variables. The authors use data about homicide and robbery aggravated by death.

Corman, Joyce, and Lovitch (1987) use a VAR model to study the relatioship between unemployment, demographics and police and property-related felony crimes, for 1970 to 1984 in New York city. They find a weak positive relation between unemployment and violence.

The variables used are:

- Unemployment 2001-10 ~ 2016-02
- Inflation 1999-01 ~ 2018-10
- Violence measures 2004-01 ~ 2017-06
  - rape
  - homicides
  - vehicle theft
  - vehicle robbery
  - personal injury and death
  - felony murder

The VAR/VECM methods applied use variable of unemployment, inflation and one of the violence measures. When restricting for the three variables the time period is: 2004-01 ~ 2016-02 there are 146 periods.

After estimatioing VAR model there are many investigations to apply:

- Diagnostic tests:
  - absence of autocorrelation in the residuals
  - heteroskedasticity
  - non normality
- causal inference
- impulse response function
- forecast error variance decomposition

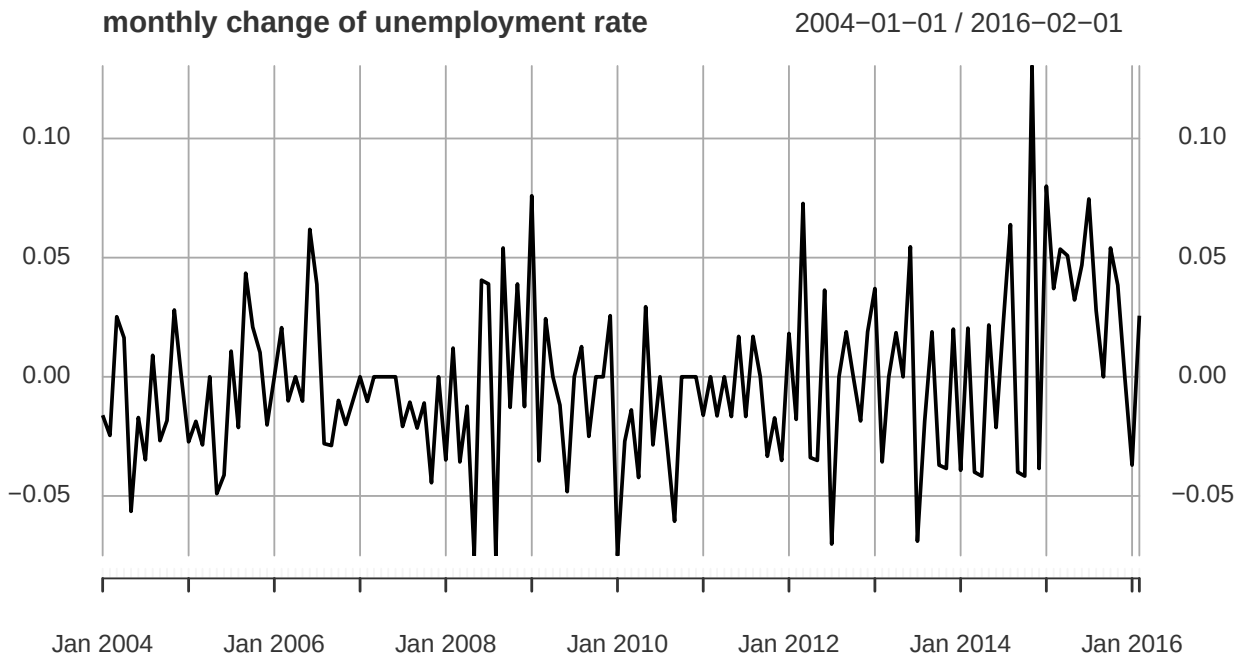
The variables are not all stationary, we apply in the next section analysis with rate of change of violence and unemployment and inflation.

Given that the variables are not all I(0) we need to test if there is cointegration, if there is the next procedure is to apply a VECM.

Analysis for rate of change

This section analyzes the variables of unemployment, inflation and violence measures in their rate of change. The overall result is that there is dim or no relation between the three variables.

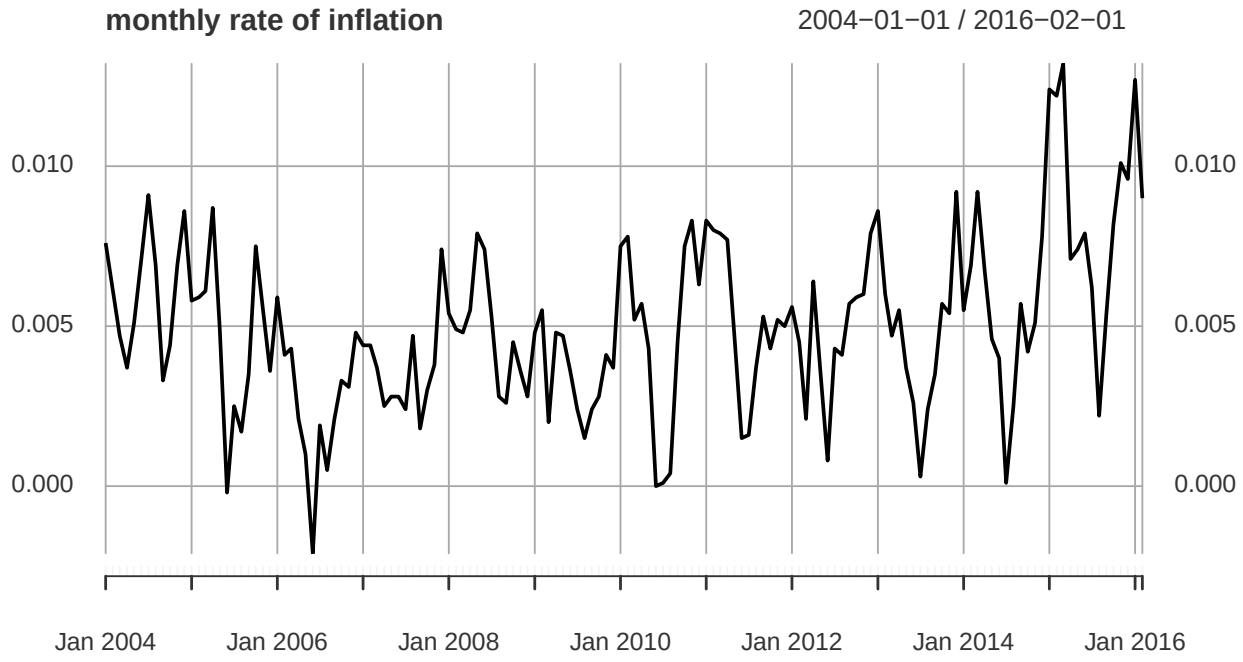
Unemployment




```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -13.17    0.01
## [2,]   1  -7.64    0.01
## [3,]   2  -4.87    0.01
## [4,]   3  -3.89    0.01
## [5,]   4  -3.43    0.01
## Type 2: with drift no trend
##      lag    ADF p.value
## [1,]   0 -13.19   0.010
## [2,]   1  -7.66   0.010
## [3,]   2  -4.89   0.010
## [4,]   3  -3.92   0.010
## [5,]   4  -3.44   0.012
## Type 3: with drift and trend
##      lag    ADF p.value
## [1,]   0 -13.84  0.0100
## [2,]   1  -8.18  0.0100
## [3,]   2  -5.33  0.0100
## [4,]   3  -4.40  0.0100
## [5,]   4  -3.82  0.0199
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

Monthly rate of change of unemployment is stationary.

Inflation

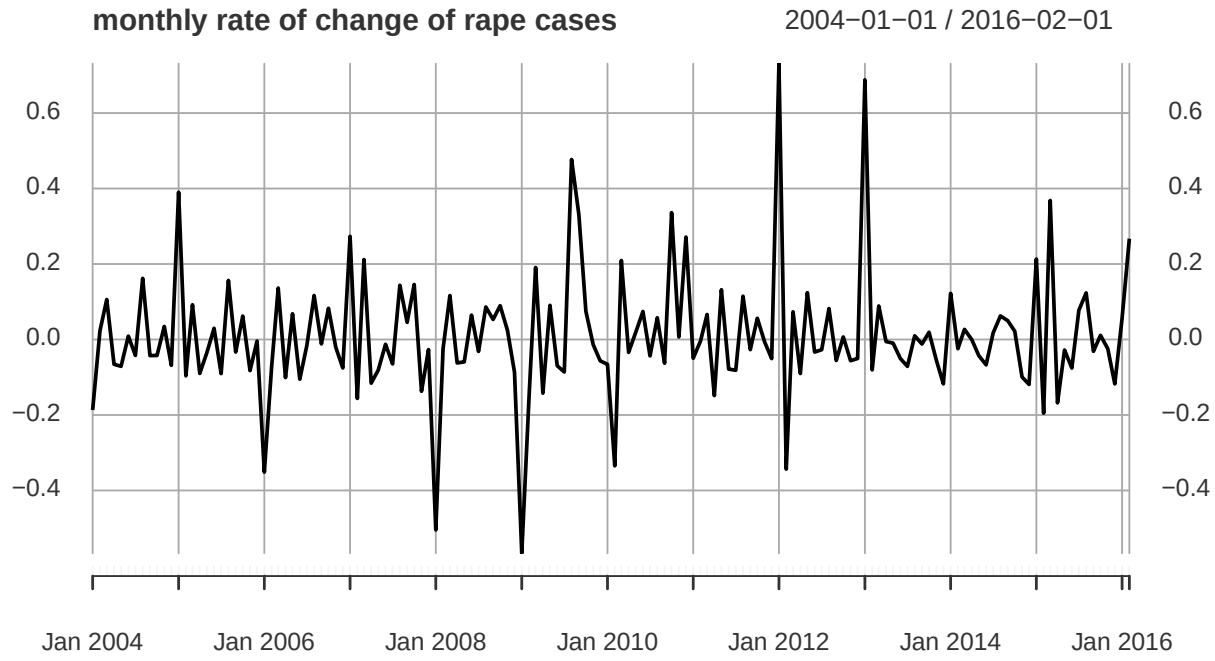



```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag   ADF p.value
## [1,]   0 -2.27  0.0237
## [2,]   1 -2.03  0.0430
## [3,]   2 -1.64  0.0960
## [4,]   3 -1.42  0.1705
## [5,]   4 -1.31  0.2094
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -5.21    0.01
## [2,]   1 -5.23    0.01
## [3,]   2 -4.78    0.01
## [4,]   3 -4.72    0.01
## [5,]   4 -4.69    0.01
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 -5.59    0.01
## [2,]   1 -5.65    0.01
## [3,]   2 -5.22    0.01
## [4,]   3 -5.19    0.01
## [5,]   4 -5.28    0.01
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

Inflation rate per month is stationary.

Rape variable

Test for unit-root in rate of change of rape cases. Present VAR model with three variables: rate of change of unemployment, inflation rate, rate of change of rape.



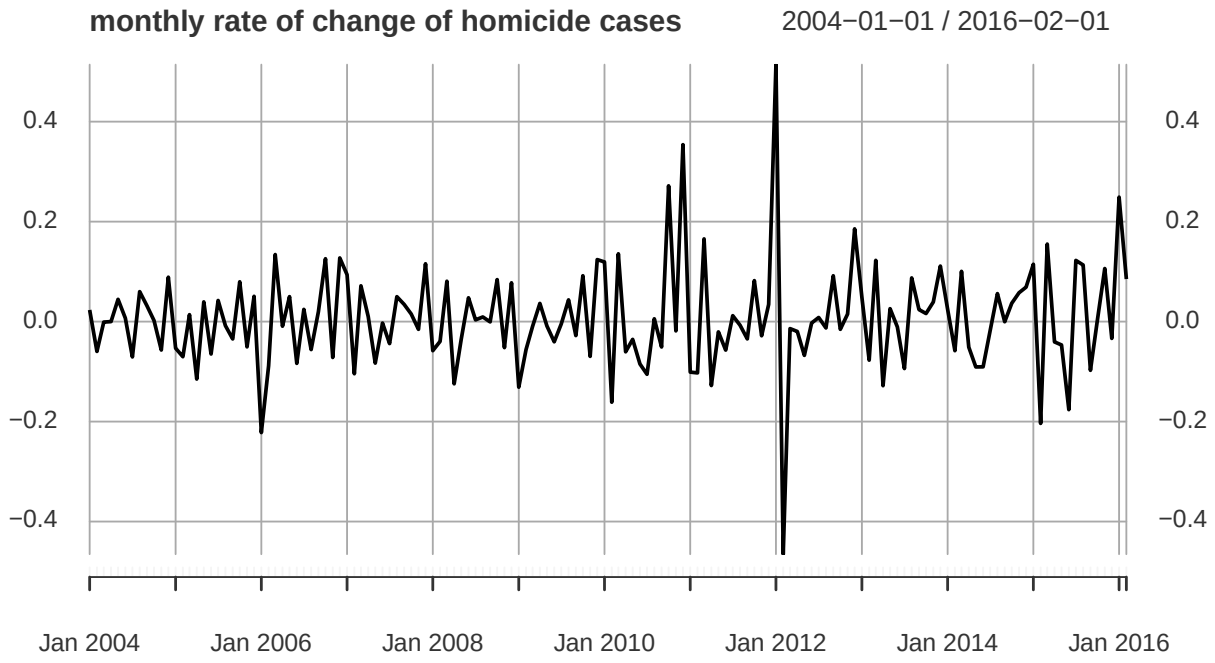

```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -14.72    0.01
## [2,]   1  -8.67    0.01
## [3,]   2  -7.33    0.01
## [4,]   3  -7.36    0.01
## [5,]   4  -5.89    0.01
## Type 2: with drift no trend
##      lag    ADF p.value
## [1,]   0 -14.73    0.01
## [2,]   1  -8.70    0.01
## [3,]   2  -7.36    0.01
## [4,]   3  -7.42    0.01
## [5,]   4  -5.97    0.01
## Type 3: with drift and trend
##      lag    ADF p.value
## [1,]   0 -14.73    0.01
## [2,]   1  -8.72    0.01
## [3,]   2  -7.41    0.01
## [4,]   3  -7.49    0.01
## [5,]   4  -6.03    0.01
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, rape
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 1031.761
## Roots of the characteristic polynomial:
## 0.9278 0.2293 0.06622
## Call:
## VAR(y = base.temp2, p = 1, type = "none")
##
##
## Estimation results for equation rape:
## =====================================
## rape = rt.unem.l1 + rt.inflation.month.l1 + rape.l1
##
##                       Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1            -0.34382    0.38572  -0.891   0.3742
## rt.inflation.month.l1  2.93029    2.37161   1.236   0.2187
## rape.l1               -0.20526    0.08203  -2.502   0.0135 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1601 on 142 degrees of freedom
## Multiple R-Squared: 0.05793, Adjusted R-squared: 0.03803
## F-statistic: 2.911 on 3 and 142 DF,  p-value: 0.03667
##
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month       rape
## rt.unem             1.203e-03         -2.282e-07  2.596e-04
## rt.inflation.month -2.282e-07          4.457e-06 -2.392e-05
## rape                2.596e-04         -2.392e-05  2.561e-02
##
## Correlation matrix of residuals:
##                       rt.unem rt.inflation.month     rape
## rt.unem             1.000000          -0.003117  0.04677
## rt.inflation.month -0.003117           1.000000 -0.07080
## rape                0.046766          -0.070802  1.00000
## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause rape
##
## data:  VAR object m.rape.inf.unem
## F-Test = 1.1987, df1 = 2, df2 = 426, p-value = 0.3026
##
##
## $Instant
##
```

```
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and rape
##
## data:  VAR object m.rape.inf.unem
## Chi-squared = 1.1053, df = 2, p-value = 0.5754
```

Unemployment and inflation are not significant and do not Granger cause rape.

Homicide rate of change

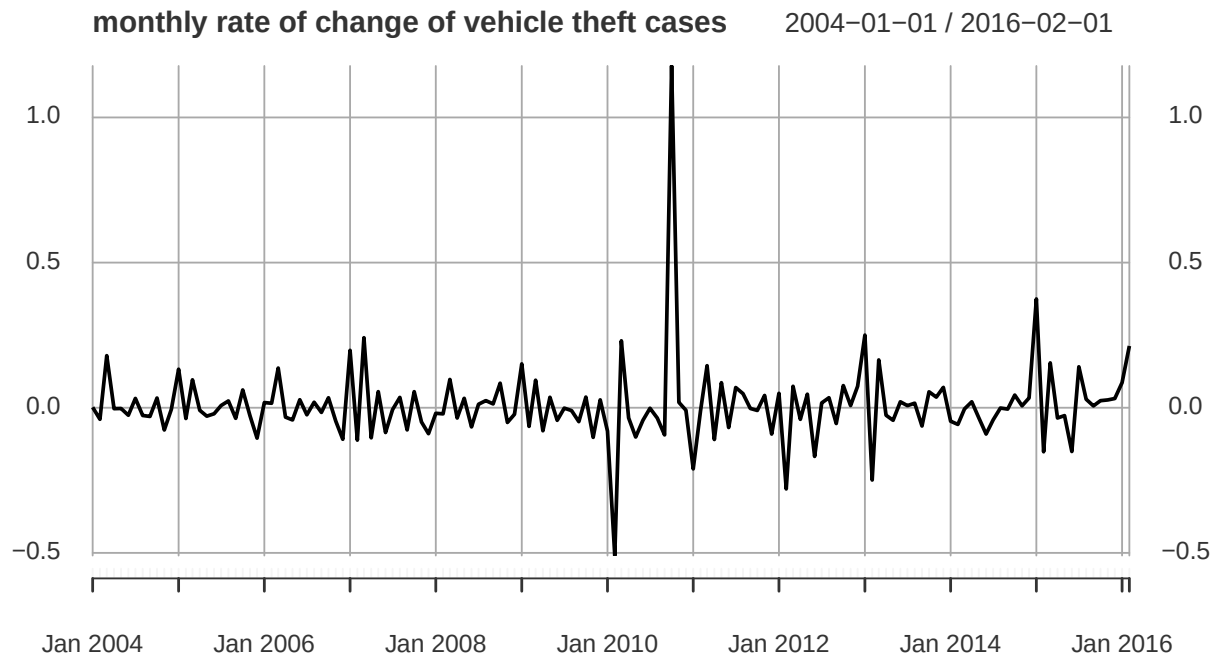



```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, homicide
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 1103.06
## Roots of the characteristic polynomial:
## 0.9281 0.3431 0.07753
## Call:
## VAR(y = base.temp2, p = 1, type = "none")
##
##
## Estimation results for equation homicide:
## =========================================
## homicide = rt.unem.l1 + rt.inflation.month.l1 + homicide.l1
##
##                       Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1            -0.09630    0.23985  -0.402    0.689
## rt.inflation.month.l1  1.94726    1.48438   1.312    0.192
```

```
## homicide.l1           -0.33010    0.07983  -4.135 6.04e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.09956 on 142 degrees of freedom
## Multiple R-Squared: 0.1137,  Adjusted R-squared: 0.095
## F-statistic: 6.074 on 3 and 142 DF,  p-value: 0.0006418
##
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month  homicide
## rt.unem            1.195e-03          2.274e-07 7.820e-05
## rt.inflation.month 2.274e-07          4.454e-06 4.003e-05
## homicide           7.820e-05          4.003e-05 9.907e-03
##
## Correlation matrix of residuals:
##                     rt.unem rt.inflation.month homicide
## rt.unem            1.000000           0.003117  0.02273
## rt.inflation.month 0.003117           1.000000  0.19058
## homicide           0.022727           0.190580  1.00000

## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause homicide
##
## data:  VAR object m.homicide.inf.unem
## F-Test = 0.96217, df1 = 2, df2 = 426, p-value = 0.3829
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and homicide
##
## data:  VAR object m.homicide.inf.unem
## Chi-squared = 4.8307, df = 2, p-value = 0.08934

##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object m.homicide.inf.unem
## Chi-squared = 186.56, df = 135, p-value = 0.002197
```

Homicide rate of change is stationary. Unemployment and inflation are not significant in the equation for homicide. Unemployment and inflation do not Granger cause rate of change of homicide.

Vehicle theft rate of change




```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, vehicle_theft
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 1057.087
## Roots of the characteristic polynomial:
## 0.9282 0.2042 0.1051
## Call:
## VAR(y = base.temp2, p = 1, type = "none")
##
##
## Estimation results for equation vehicle_theft:
## ==============================================
## vehicle_theft = rt.unem.l1 + rt.inflation.month.l1 + vehicle_theft.l1
##
##                       Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1            -0.30499    0.33141  -0.920    0.359
## rt.inflation.month.l1  2.41640    2.03417   1.188    0.237
## vehicle_theft.l1      -0.21168    0.08323  -2.543    0.012 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1366 on 142 degrees of freedom
## Multiple R-Squared: 0.05954, Adjusted R-squared: 0.03967
## F-statistic: 2.996 on 3 and 142 DF,  p-value: 0.03285
##
```

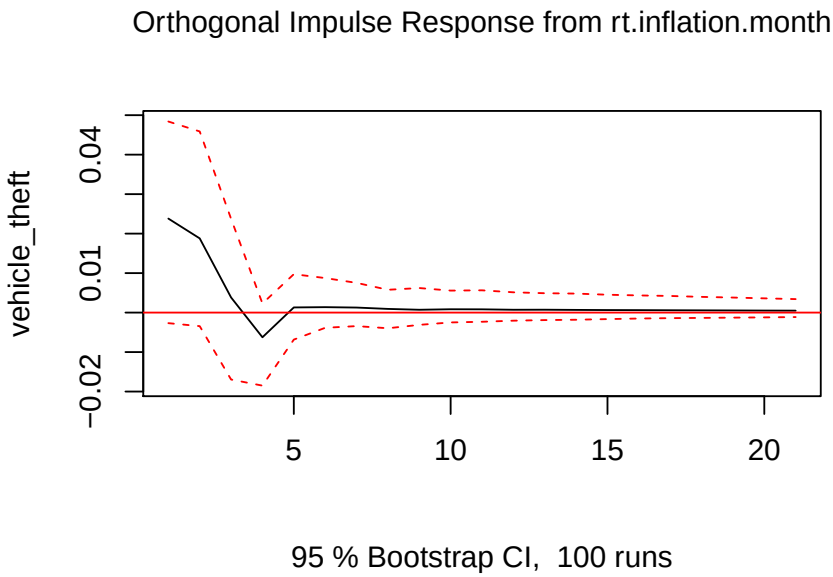
```
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month vehicle_theft
## rt.unem             1.206e-03         -1.456e-07     6.277e-04
## rt.inflation.month -1.456e-07          4.449e-06     4.356e-05
## vehicle_theft       6.277e-04          4.356e-05     1.864e-02
##
## Correlation matrix of residuals:
##                       rt.unem rt.inflation.month vehicle_theft
## rt.unem             1.000000          -0.001988        0.1324
## rt.inflation.month -0.001988           1.000000        0.1513
## vehicle_theft       0.132414           0.151263        1.0000
```

```
## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause vehicle_theft
##
## data:  VAR object m.vehicle_theft.inf.unem
## F-Test = 1.1809, df1 = 2, df2 = 426, p-value = 0.308
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and vehicle_theft
##
## data:  VAR object m.vehicle_theft.inf.unem
## Chi-squared = 5.4897, df = 2, p-value = 0.06426
```

Rate of change of vehicle theft is stationary (omitted table). The model with 1 lag indicate that there is no Granger causality between unemployment and inflation to vehicle theft. And the coefficients are not significant. Next we test VAR(3) model.

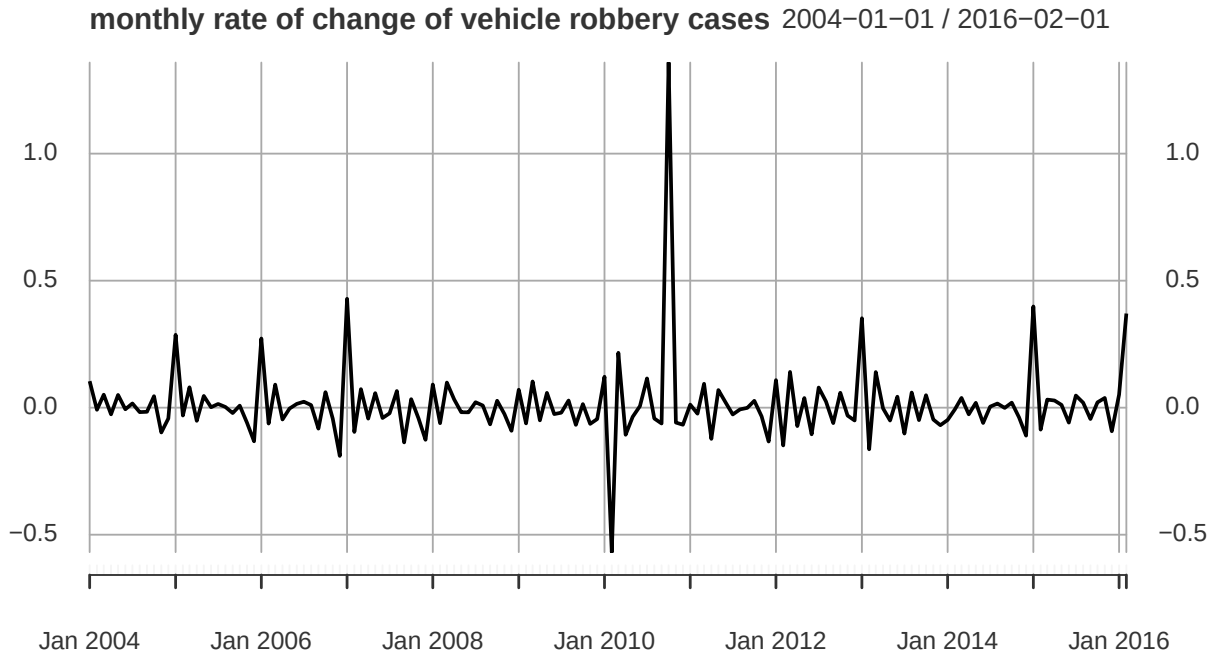
```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, vehicle_theft
## Deterministic variables: none
## Sample size: 143
## Log Likelihood: 1053.526
## Roots of the characteristic polynomial:
## 0.954 0.6792 0.627 0.627 0.4725 0.3912 0.3912 0.3799 0.3799
## Call:
## VAR(y = base.temp2, p = 3, type = "none")
##
##
## Estimation results for equation vehicle_theft:
## ==============================================
## vehicle_theft = rt.unem.l1 + rt.inflation.month.l1 + vehicle_theft.l1 + rt.unem.l2 + rt.inflation.mo
##
##                        Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1             -0.22677    0.34203  -0.663  0.50846
## rt.inflation.month.l1 11.21856    5.52516   2.030  0.04429 *
```

```
## vehicle_theft.l1      -0.23397    0.08817  -2.654  0.00892 **
## rt.unem.l2             0.17370    0.33865   0.513  0.60885
## rt.inflation.month.l2 -6.05522    7.44243  -0.814  0.41731
## vehicle_theft.l2      -0.03835    0.08992  -0.427  0.67042
## rt.unem.l3            -0.01885    0.34164  -0.055  0.95608
## rt.inflation.month.l3 -3.61189    5.63448  -0.641  0.52260
## vehicle_theft.l3      -0.07187    0.08651  -0.831  0.40758
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1377 on 134 degrees of freedom
## Multiple R-Squared: 0.08724, Adjusted R-squared: 0.02594
## F-statistic: 1.423 on 9 and 134 DF,  p-value: 0.1842
##
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month vehicle_theft
## rt.unem             1.145e-03         -9.433e-07     6.771e-04
## rt.inflation.month -9.433e-07          4.618e-06     5.036e-05
## vehicle_theft       6.771e-04          5.036e-05     1.895e-02
##
## Correlation matrix of residuals:
##                     rt.unem rt.inflation.month vehicle_theft
## rt.unem             1.00000           -0.01297        0.1454
## rt.inflation.month -0.01297            1.00000        0.1702
## vehicle_theft       0.14539            0.17025        1.0000

## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause vehicle_theft
##
## data:  VAR object m.vehicle_theft.inf.unem
## F-Test = 0.95336, df1 = 6, df2 = 402, p-value = 0.4567
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and vehicle_theft
##
## data:  VAR object m.vehicle_theft.inf.unem
## Chi-squared = 6.9209, df = 2, p-value = 0.03141
```



We test the model with 3 lags, inflation is significant and positive, but there is no Granger causality from unemployment and inflation to vehicle theft.

Vehicle robbery varialbe



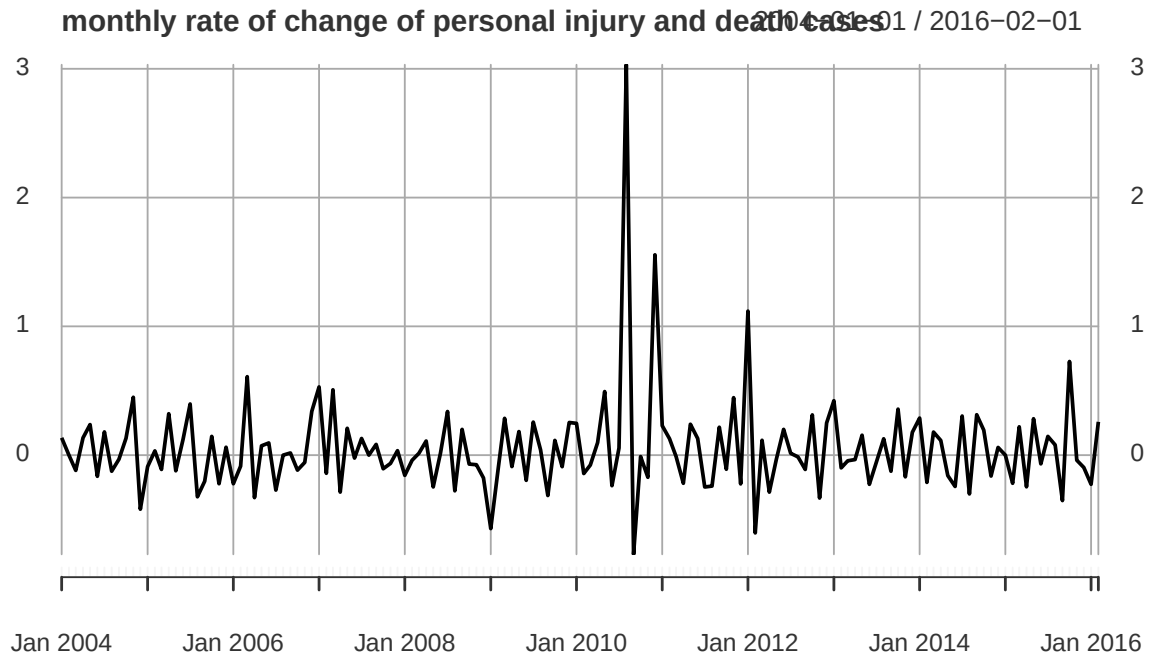

```
##
## VAR Estimation Results:
```

```
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, vehicle_robbery
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 1041.542
## Roots of the characteristic polynomial:
## 0.9285 0.2942 0.07657
## Call:
## VAR(y = base.temp2, p = 1, type = "none")
##
##
## Estimation results for equation vehicle_robbery:
## ================================================
## vehicle_robbery = rt.unem.l1 + rt.inflation.month.l1 + vehicle_robbery.l1
##
##                       Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1            -0.45815    0.36326  -1.261 0.209295
## rt.inflation.month.l1  3.24601    2.23719   1.451 0.149003
## vehicle_robbery.l1    -0.27867    0.08195  -3.401 0.000873 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1503 on 142 degrees of freedom
## Multiple R-Squared: 0.09822, Adjusted R-squared: 0.07917
## F-statistic: 5.155 on 3 and 142 DF,  p-value: 0.002061
##
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month vehicle_robbery
## rt.unem             1.205e-03         -5.738e-08       4.807e-04
## rt.inflation.month -5.738e-08          4.462e-06       3.307e-05
## vehicle_robbery     4.807e-04          3.307e-05       2.258e-02
##
## Correlation matrix of residuals:
##                       rt.unem rt.inflation.month vehicle_robbery
## rt.unem             1.0000000         -0.0007827         0.09217
## rt.inflation.month -0.0007827          1.0000000         0.10420
## vehicle_robbery     0.0921717          0.1041973         1.00000

## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause vehicle_robbery
##
## data:  VAR object m.vehicle_robbery.inf.unem
## F-Test = 1.9264, df1 = 2, df2 = 426, p-value = 0.1469
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and vehicle_robbery
```

```
##
## data:  VAR object m.vehicle_robbery.inf.unem
## Chi-squared = 2.6636, df = 2, p-value = 0.264
```

Vehicle robbery is stationary (omitted table). Unemployment and inflation are not significant and do not Granger cause vehicle robbery.

Personal injury and death



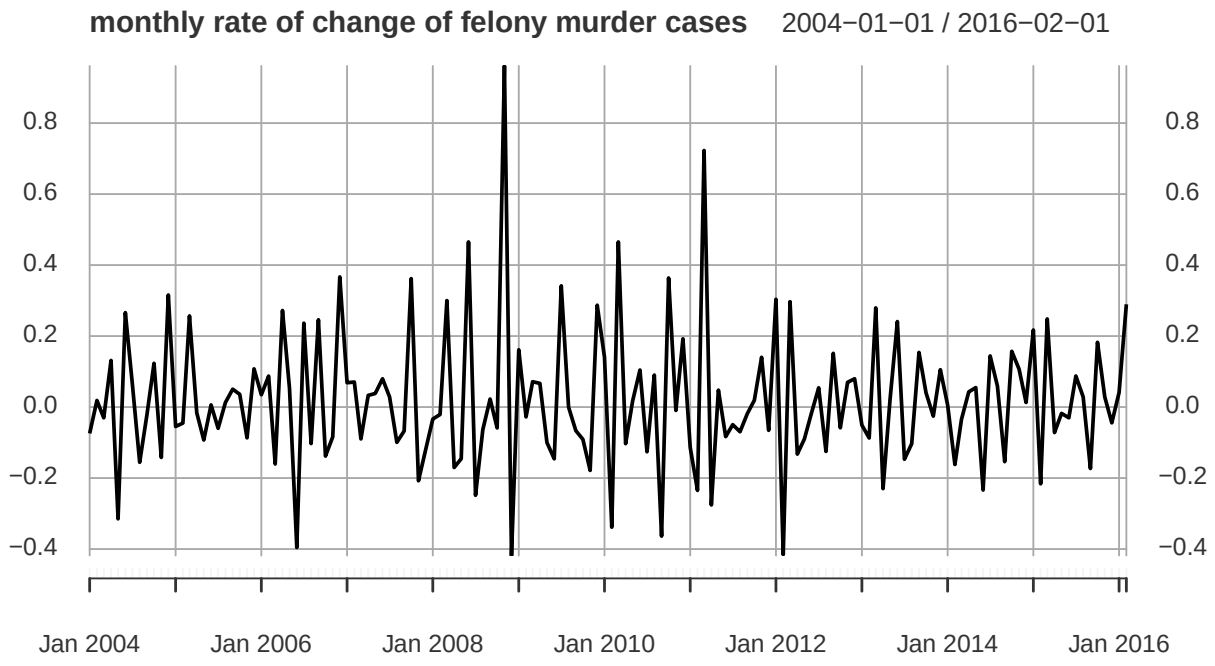

```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, personal_injury_death
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 913.442
## Roots of the characteristic polynomial:
## 0.9292 0.3302 0.0348
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation personal_injury_death:
## ======================================================
## personal_injury_death = rt.unem.l1 + rt.inflation.month.l1 + personal_injury_death.l1
##
##                           Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1                -0.79225    0.88567  -0.895 0.372558
## rt.inflation.month.l1      8.46893    5.47076   1.548 0.123840
## personal_injury_death.l1 -0.27135    0.08049  -3.371 0.000964 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.3681 on 142 degrees of freedom
## Multiple R-Squared: 0.08966, Adjusted R-squared: 0.07043
## F-statistic: 4.662 on 3 and 142 DF,  p-value: 0.003873
##
##
##
## Covariance matrix of residuals:
##                           rt.unem rt.inflation.month personal_injury_death
## rt.unem                 1.167e-03          1.105e-06            -3.525e-04
## rt.inflation.month      1.105e-06          4.427e-06             6.576e-06
## personal_injury_death -3.525e-04          6.576e-06             1.352e-01
##
## Correlation matrix of residuals:
##                         rt.unem rt.inflation.month personal_injury_death
## rt.unem                 1.00000           0.015369            -0.028065
## rt.inflation.month      0.01537           1.000000             0.008501
## personal_injury_death -0.02807           0.008501             1.000000
```

```
## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause personal_injury_death
##
## data:  VAR object m.personal_injury_death.inf.unem
## F-Test = 1.6463, df1 = 2, df2 = 426, p-value = 0.194
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and personal_injury_death
##
## data:  VAR object m.personal_injury_death.inf.unem
## Chi-squared = 0.17274, df = 2, p-value = 0.9173
```

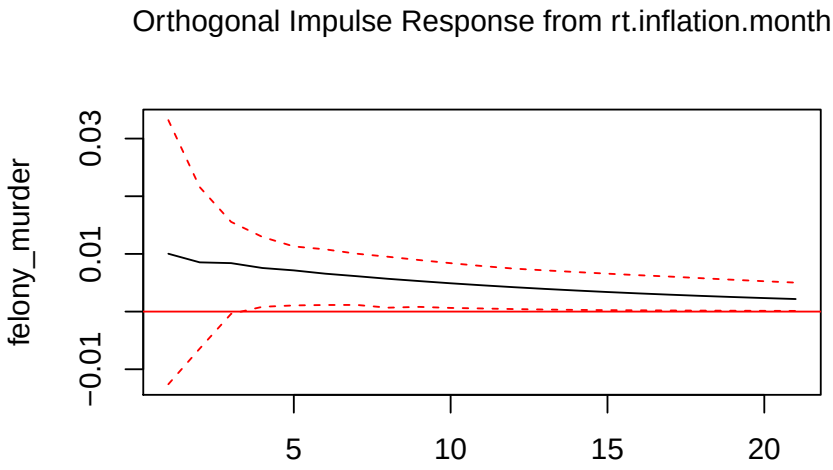
Personal injury and death is stationary (table omitted). Unemployment and inflation are not significant and do not Granger cause personal injury and death.

Felony murder variable




```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: rt.unem, rt.inflation.month, felony_murder
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 1025.321
## Roots of the characteristic polynomial:
## 0.9288  0.51 0.06285
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation felony_murder:
## ==============================================
## felony_murder = rt.unem.l1 + rt.inflation.month.l1 + felony_murder.l1
##
##                       Estimate Std. Error t value Pr(>|t|)
## rt.unem.l1            -0.33995    0.42100  -0.807   0.4207
## rt.inflation.month.l1  6.30386    2.54579   2.476   0.0145 *
## felony_murder.l1      -0.49537    0.07434  -6.664 5.47e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 0.1708 on 142 degrees of freedom
## Multiple R-Squared: 0.2717,  Adjusted R-squared: 0.2563
## F-statistic: 17.66 on 3 and 142 DF,  p-value: 8.471e-10
##
```

```
##
##
## Covariance matrix of residuals:
##                       rt.unem rt.inflation.month felony_murder
## rt.unem            1.197e-03          1.874e-07     1.147e-03
## rt.inflation.month 1.874e-07          4.454e-06     2.136e-05
## felony_murder      1.147e-03          2.136e-05     2.916e-02
##
## Correlation matrix of residuals:
##                       rt.unem rt.inflation.month felony_murder
## rt.unem            1.000000           0.002566       0.19417
## rt.inflation.month 0.002566           1.000000       0.05926
## felony_murder      0.194172           0.059264       1.00000
```




```
## $Granger
##
##  Granger causality H0: rt.unem rt.inflation.month do not
##  Granger-cause felony_murder
##
## data:  VAR object m.felony_murder.inf.unem
## F-Test = 3.5147, df1 = 2, df2 = 426, p-value = 0.03062
##
##
## $Instant
##
##  H0: No instantaneous causality between: rt.unem
##  rt.inflation.month and felony_murder
##
## data:  VAR object m.felony_murder.inf.unem
## Chi-squared = 5.7333, df = 2, p-value = 0.05689
```

Felony murder is stationary (table omitted). Inflation is significant and positive. Inflation and unemployment

Granger cause felony murder.

Analysis on level

Given that there not significant results using rate of change of variables, we test on level. Many of the variables are non-stationary and have significant results.

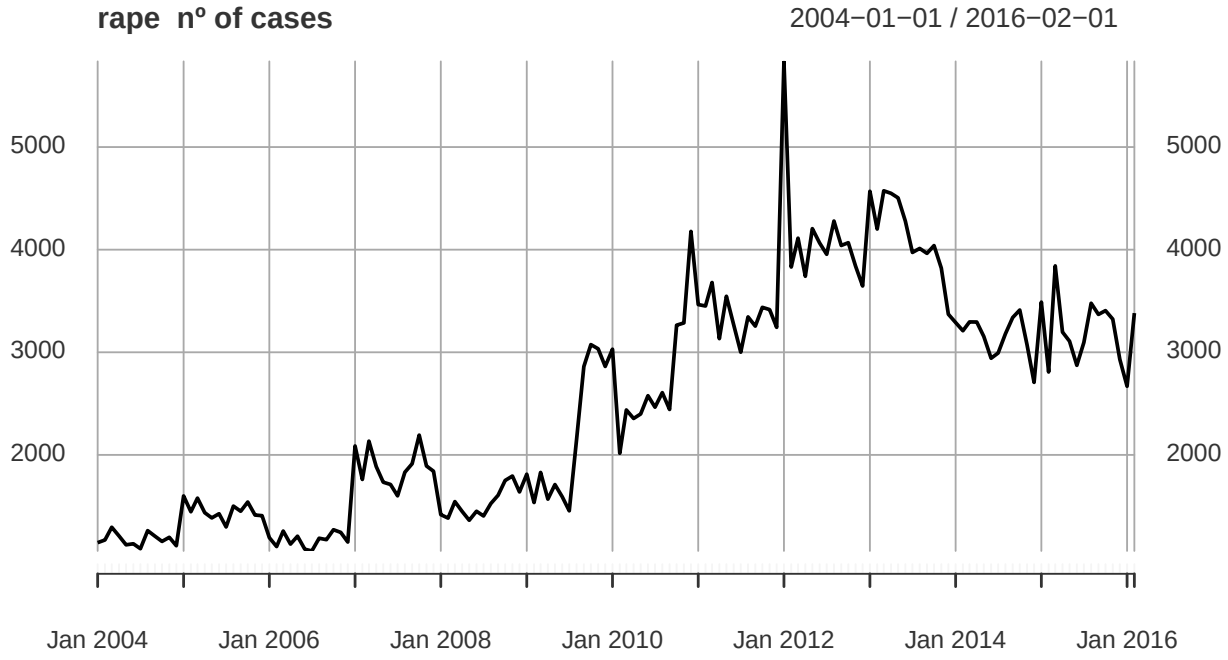
Unemployment


```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag   ADF p.value
## [1,]   0 -1.99  0.0468
## [2,]   1 -1.93  0.0536
## [3,]   2 -1.87  0.0613
## [4,]   3 -1.82  0.0691
## [5,]   4 -1.30  0.2142
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -2.41  0.1678
## [2,]   1 -2.30  0.2118
## [3,]   2 -2.45  0.1542
## [4,]   3 -2.64  0.0922
## [5,]   4 -2.07  0.3021
## Type 3: with drift and trend
##      lag    ADF p.value
```

```
## [1,]   0  0.323   0.990
## [2,]   1  0.787   0.990
## [3,]   2  0.379   0.990
## [4,]   3 -0.266   0.990
## [5,]   4 -0.415   0.984
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

Rate of unemployment is not stationary.

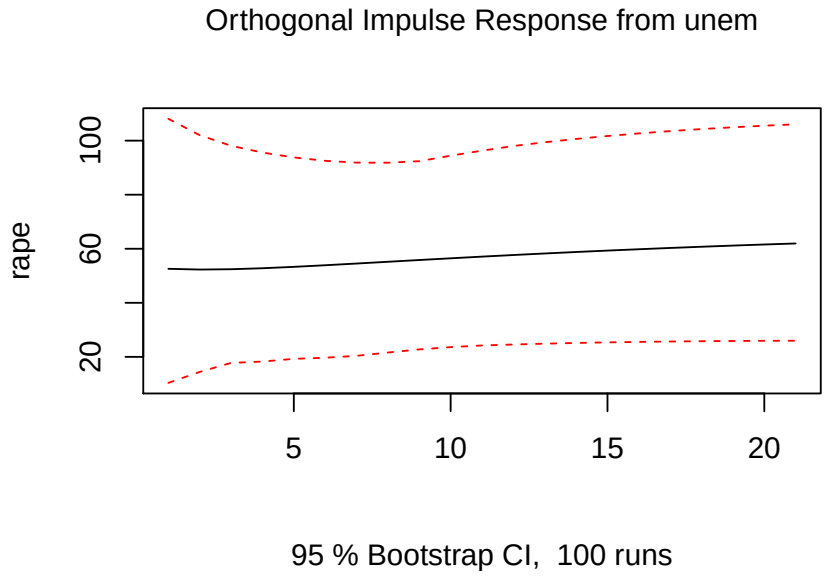
Rape variable

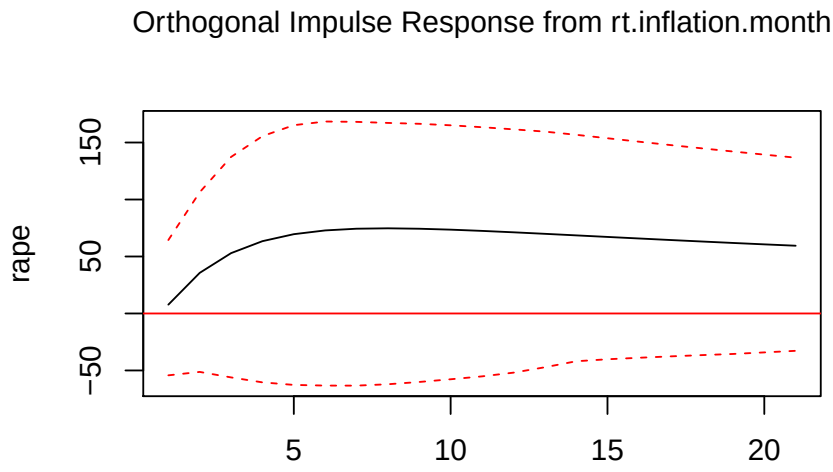



```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag      ADF p.value
## [1,]   0 -0.53771   0.486
## [2,]   1 -0.01536   0.639
## [3,]   2  0.00338   0.644
## [4,]   3  0.06777   0.663
## [5,]   4  0.30554   0.731
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -2.40   0.172
## [2,]   1 -1.60   0.485
## [3,]   2 -1.53   0.510
## [4,]   3 -1.48   0.528
## [5,]   4 -1.34   0.577
## Type 3: with drift and trend
```

```
##      lag   ADF p.value
## [1,]   0 -4.14   0.010
## [2,]   1 -2.32   0.439
## [3,]   2 -2.27   0.459
## [4,]   3 -2.14   0.515
## [5,]   4 -1.65   0.719
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
## ========================
## Endogenous variables: unem, rt.inflation.month, rape
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: -380.623
## Roots of the characteristic polynomial:
## 0.9968 0.9653 0.6472
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation rape:
## =====================================
## rape = unem.l1 + rt.inflation.month.l1 + rape.l1
##
##                        Estimate Std. Error t value Pr(>|t|)
## unem.l1               5.824e+00  8.229e+00   0.708    0.480
## rt.inflation.month.l1 1.417e+04  1.302e+04   1.088    0.278
## rape.l1               9.555e-01  2.435e-02  39.245   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 413.4 on 142 degrees of freedom
## Multiple R-Squared: 0.978,   Adjusted R-squared: 0.9775
## F-statistic:  2100 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                         unem rt.inflation.month      rape
## unem                6.101e-02          1.087e-05 1.294e+01
## rt.inflation.month 1.087e-05          3.973e-06 1.763e-02
## rape                1.294e+01          1.763e-02 1.707e+05
##
## Correlation matrix of residuals:
##                        unem rt.inflation.month   rape
## unem                1.00000            0.02207 0.1268
## rt.inflation.month 0.02207            1.00000 0.0214
## rape                0.12683            0.02140 1.0000
## $JB
##
##  JB-Test (multivariate)
```

```
##
## data:  Residuals of VAR object rape.ml
## Chi-squared = 1076.6, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object rape.ml
## Chi-squared = 47.331, df = 3, p-value = 2.955e-10
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object rape.ml
## Chi-squared = 1029.3, df = 3, p-value < 2.2e-16
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object rape.ml
## Chi-squared = 178.52, df = 135, p-value = 0.00719
```

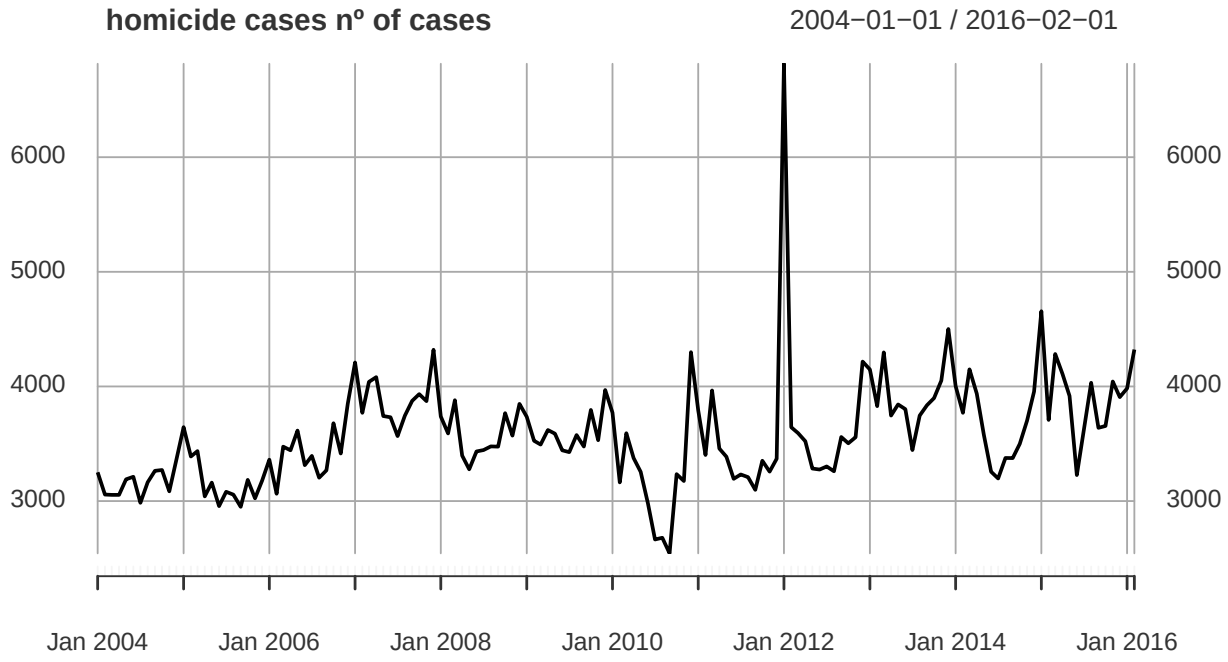





```
## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause rape
##
## data:  VAR object rape.ml
## F-Test = 1.6335, df1 = 2, df2 = 426, p-value = 0.1965
##
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and rape
##
## data:  VAR object rape.ml
## Chi-squared = 2.3577, df = 2, p-value = 0.3076
```

Rape is non-stationary. The estimates for unemployment and inflation are not significant. There is no Granger causality of unemployment and inflation to rape. The residuals are non-Gaussian and have serial correlation. But the graph of IRF shows a positive shock in inflation and unemployment increase the cases of rape. The impact of unemployment increases with time and is persistent. The impact of inflation increases and then diminishes but still is persistent.

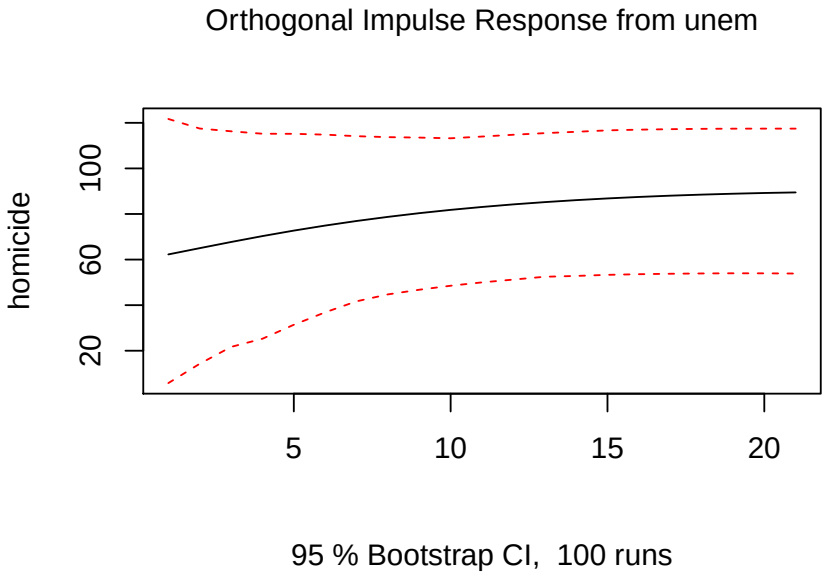
Homicide variable

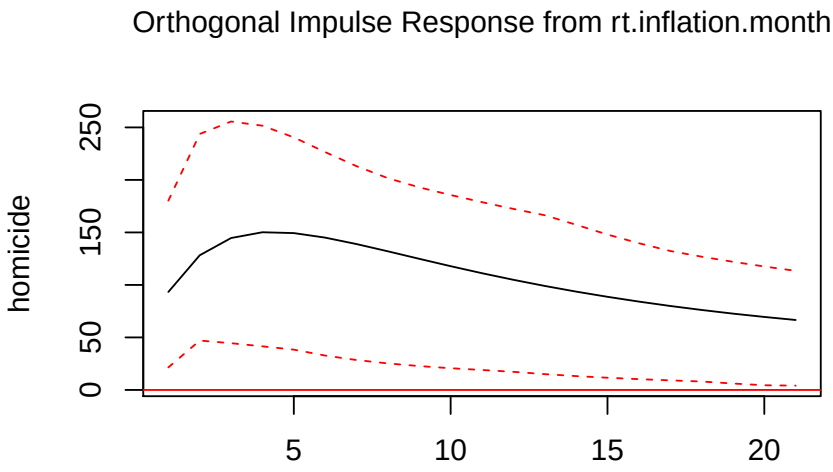



```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag      ADF p.value
## [1,]   0 -0.63248   0.452
## [2,]   1 -0.21997   0.580
## [3,]   2 -0.02512   0.636
## [4,]   3 -0.01107   0.640
## [5,]   4  0.00901   0.646
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -7.38    0.01
## [2,]   1 -5.07    0.01
## [3,]   2 -4.14    0.01
## [4,]   3 -4.41    0.01
## [5,]   4 -4.35    0.01
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 -8.27    0.01
## [2,]   1 -5.79    0.01
## [3,]   2 -4.79    0.01
## [4,]   3 -5.17    0.01
## [5,]   4 -5.24    0.01
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
```

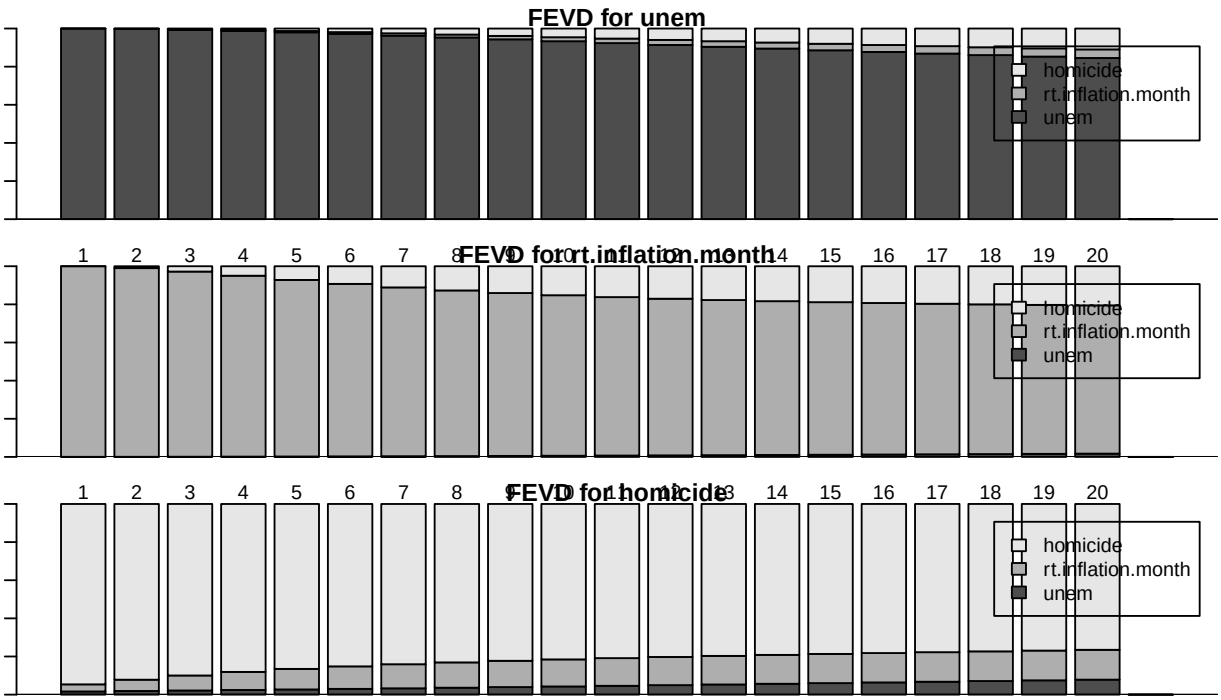
```
## ========================
## Endogenous variables: unem, rt.inflation.month, homicide
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: -400.625
## Roots of the characteristic polynomial:
## 0.9959 0.9083 0.6153
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation homicide:
## =========================================
## homicide = unem.l1 + rt.inflation.month.l1 + homicide.l1
##
##                        Estimate Std. Error t value Pr(>|t|)
## unem.l1               3.956e+01  1.582e+01   2.500   0.0136 *
## rt.inflation.month.l1 2.314e+04  1.578e+04   1.467   0.1447
## homicide.l1           8.780e-01  4.259e-02  20.612   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 483.3 on 142 degrees of freedom
## Multiple R-Squared: 0.9824,  Adjusted R-squared: 0.982
## F-statistic:  2637 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                         unem rt.inflation.month  homicide
## unem                6.062e-02          6.367e-06 1.529e+01
## rt.inflation.month 6.367e-06          4.006e-06 1.879e-01
## homicide           1.529e+01          1.879e-01 2.329e+05
##
## Correlation matrix of residuals:
##                        unem rt.inflation.month homicide
## unem                1.00000            0.01292   0.1287
## rt.inflation.month 0.01292            1.00000   0.1945
## homicide           0.12868            0.19453   1.0000

## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object hom.ml
## Chi-squared = 3771.8, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object hom.ml
```

```
## Chi-squared = 66.028, df = 3, p-value = 3.02e-14
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object hom.ml
## Chi-squared = 3705.7, df = 3, p-value < 2.2e-16
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object hom.ml
## Chi-squared = 154.03, df = 135, p-value = 0.1255
```





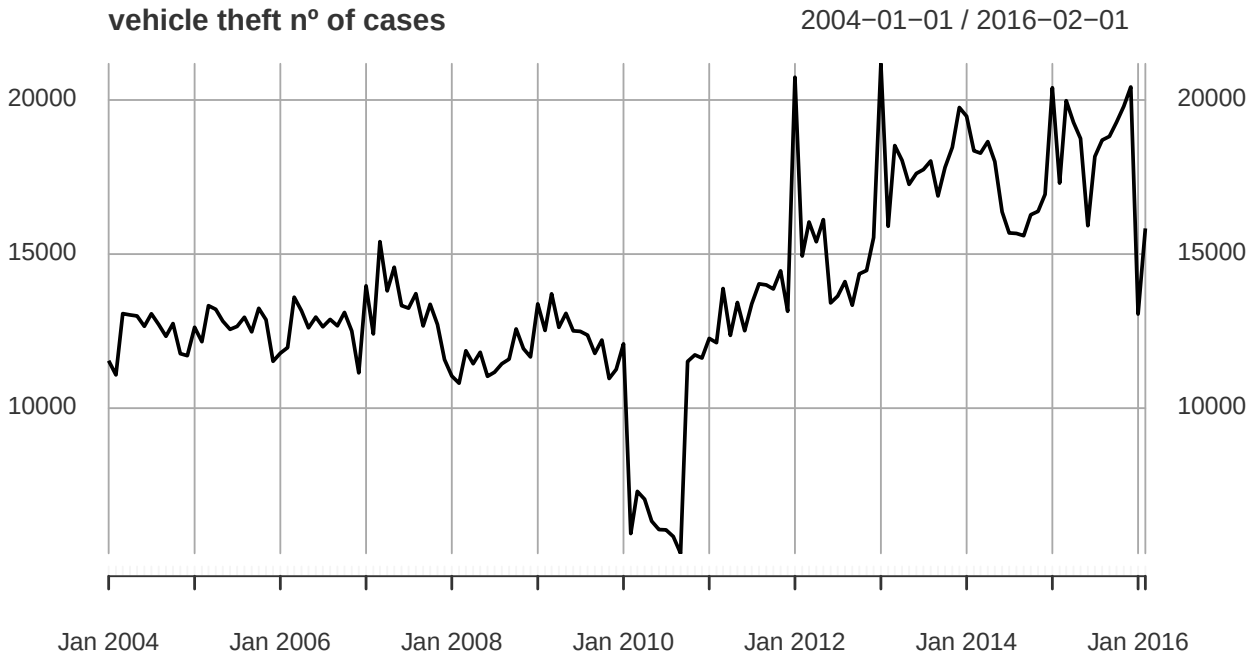

```
## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause homicide
##
## data:  VAR object hom.ml
## F-Test = 3.9346, df1 = 2, df2 = 426, p-value = 0.02027
##
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and homicide
##
## data:  VAR object hom.ml
## Chi-squared = 7.4119, df = 2, p-value = 0.02458
```



Homicide is stationary when including constant or trend.

The coefficient of unemployment on homicide is significant and positive, which means that an increase in the rate of unemployment increases cases of homicides. Inflation is not significant. Unemployment and inflation Granger cause homicides with 0.0203 p-value. The residuals are non-Gaussian, but have no serial correlation. The IRF graph shows that unemployment have a permanent and increasing impact on homicide. The impact of inflation incraeses peaking in 4 to 5 months and fades with time but still is persistent.

Vehicle theft variable



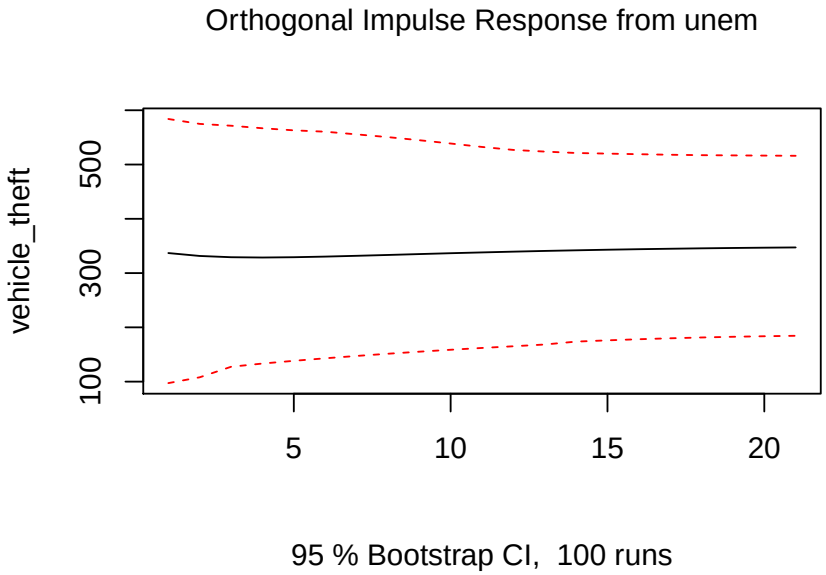

```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -0.537   0.487
## [2,]   1 -0.170   0.594
## [3,]   2 -0.179   0.592
## [4,]   3 -0.230   0.577
## [5,]   4 -0.259   0.569
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -3.41  0.0136
## [2,]   1 -2.14  0.2749
## [3,]   2 -1.94  0.3511
## [4,]   3 -1.95  0.3470
## [5,]   4 -2.03  0.3185
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 -4.29   0.010
## [2,]   1 -2.57   0.337
## [3,]   2 -2.48   0.375
## [4,]   3 -2.57   0.338
## [5,]   4 -2.67   0.296
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
```

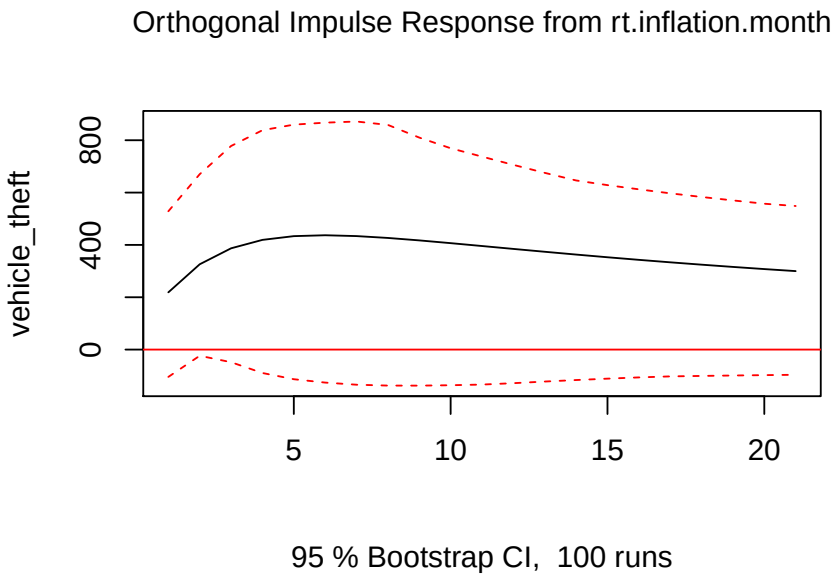
```
## ========================
## Endogenous variables: unem, rt.inflation.month, vehicle_theft
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: -583.741
## Roots of the characteristic polynomial:
## 0.9966 0.9481  0.63
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation vehicle_theft:
## ==============================================
## vehicle_theft = unem.l1 + rt.inflation.month.l1 + vehicle_theft.l1
##
##                        Estimate Std. Error t value Pr(>|t|)
## unem.l1               6.043e+01  4.559e+01   1.325    0.187
## rt.inflation.month.l1 6.024e+04  5.636e+04   1.069    0.287
## vehicle_theft.l1      9.423e-01  3.102e-02  30.373   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 1732 on 142 degrees of freedom
## Multiple R-Squared: 0.9854,  Adjusted R-squared: 0.9851
## F-statistic:  3198 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                          unem rt.inflation.month vehicle_theft
## unem                 5.964e-02         -2.643e-06     8.232e+01
## rt.inflation.month -2.643e-06          3.964e-06     4.305e-01
## vehicle_theft       8.232e+01          4.305e-01     2.994e+06
##
## Correlation matrix of residuals:
##                          unem rt.inflation.month vehicle_theft
## unem                 1.000000          -0.005435        0.1948
## rt.inflation.month -0.005435           1.000000        0.1250
## vehicle_theft       0.194799           0.124956        1.0000

## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause vehicle_theft
##
## data:  VAR object veh.t.ml
## F-Test = 1.5887, df1 = 2, df2 = 426, p-value = 0.2054
##
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and vehicle_theft
```

```
##
## data:  VAR object veh.t.ml
## Chi-squared = 7.4036, df = 2, p-value = 0.02468
```

```
## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object veh.t.ml
## Chi-squared = 264.94, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object veh.t.ml
## Chi-squared = 2.5021, df = 3, p-value = 0.4749
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object veh.t.ml
## Chi-squared = 262.44, df = 3, p-value < 2.2e-16
```

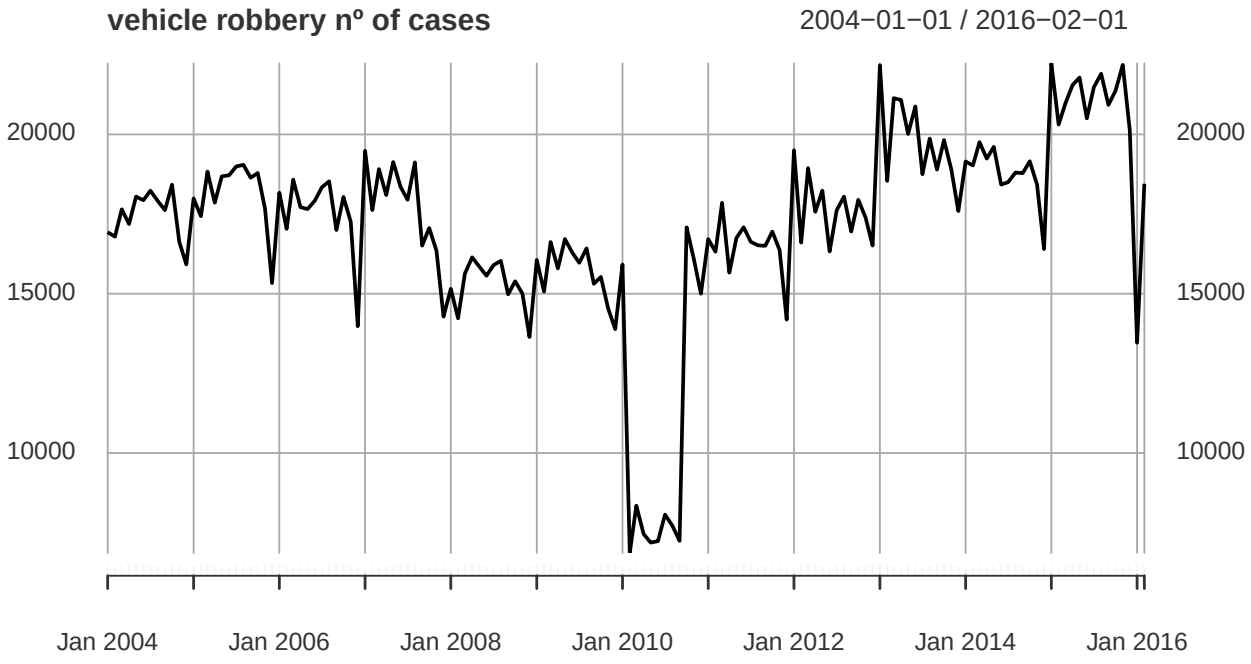
```
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object veh.t.ml
## Chi-squared = 179.27, df = 135, p-value = 0.006475
```





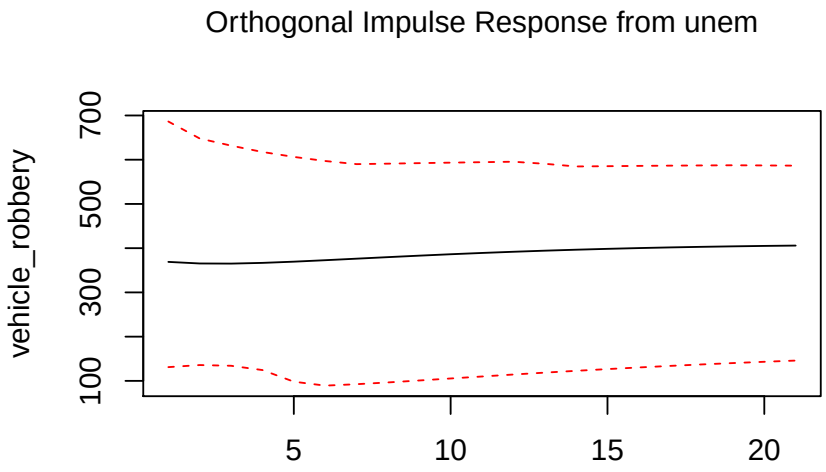
Vehicle theft is non-stationary. Unemployment and inflation are not statistically significant to explain vehicle theft. Unemployment and inflation do not Granger cause vehicle theft. The residuals are non-Gaussian and have serial correlation. The IRF shows that the impact of unemployment is positive and persistent and inflation increases in the first four months and decreases.

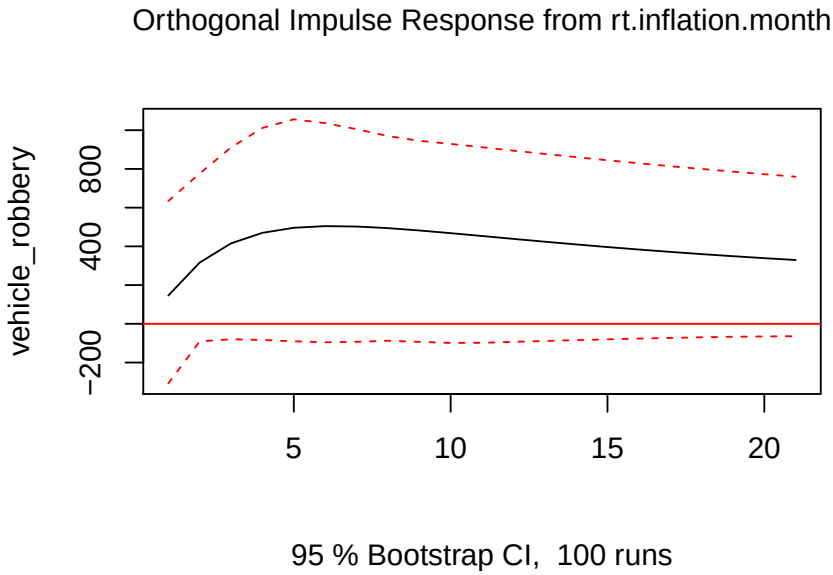
Vehicle robbery variable



```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -0.620   0.457
## [2,]   1 -0.411   0.525
## [3,]   2 -0.388   0.532
## [4,]   3 -0.454   0.513
## [5,]   4 -0.513   0.495
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -4.18  0.0100
## [2,]   1 -2.57  0.1051
## [3,]   2 -2.30  0.2124
## [4,]   3 -2.58  0.1021
## [5,]   4 -2.74  0.0754
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 -4.30   0.010
## [2,]   1 -2.63   0.313
## [3,]   2 -2.37   0.420
## [4,]   3 -2.65   0.305
## [5,]   4 -2.82   0.235
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
## ========================
## Endogenous variables: unem, rt.inflation.month, vehicle_robbery
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: -603.786
## Roots of the characteristic polynomial:
## 0.9962 0.9333 0.6401
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation vehicle_robbery:
## ================================================
## vehicle_robbery = unem.l1 + rt.inflation.month.l1 + vehicle_robbery.l1
##
##                         Estimate Std. Error t value Pr(>|t|)
## unem.l1                1.099e+02  6.519e+01   1.686    0.094 .
## rt.inflation.month.l1 9.089e+04  6.185e+04   1.470    0.144
## vehicle_robbery.l1    9.208e-01  3.492e-02  26.369   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 1970 on 142 degrees of freedom
## Multiple R-Squared: 0.9875,  Adjusted R-squared: 0.9872
```

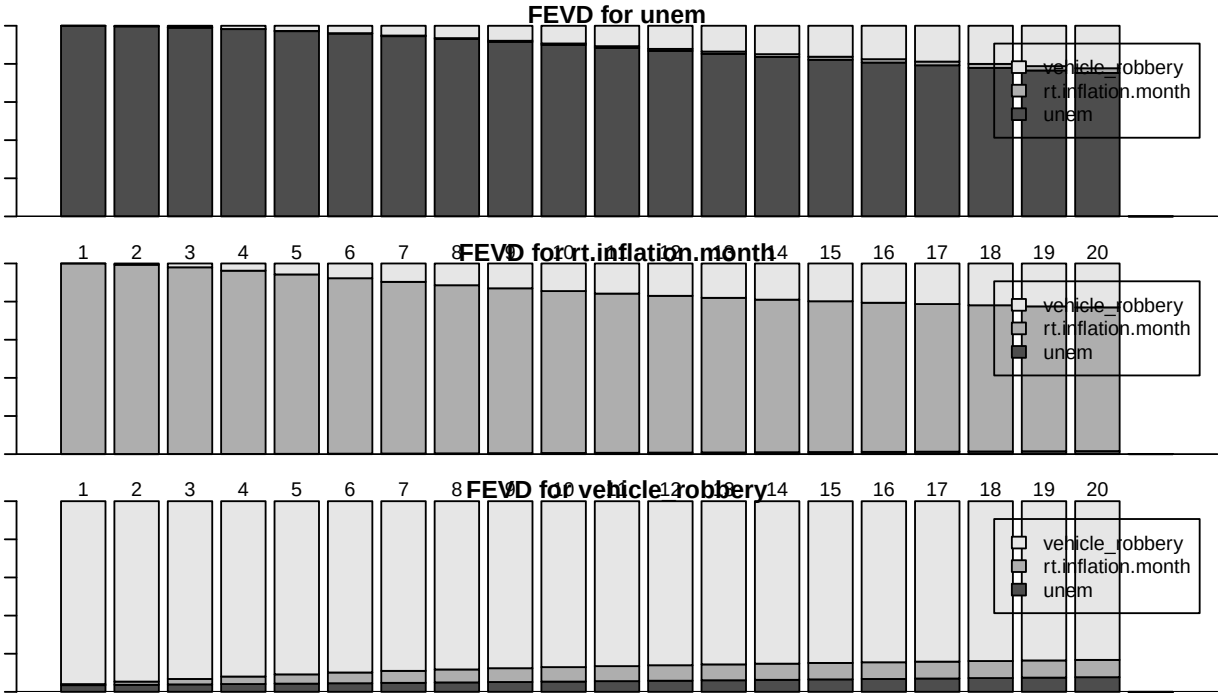
```
## F-statistic:  3734 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                           unem rt.inflation.month vehicle_robbery
## unem                 5.926e-02         -3.020e-06       8.993e+01
## rt.inflation.month -3.020e-06          4.008e-06       2.854e-01
## vehicle_robbery     8.993e+01          2.854e-01       3.874e+06
##
## Correlation matrix of residuals:
##                           unem rt.inflation.month vehicle_robbery
## unem                  1.000000          -0.006196         0.18769
## rt.inflation.month -0.006196           1.000000         0.07244
## vehicle_robbery     0.187686           0.072438         1.00000

## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object veh.r.ml
## Chi-squared = 283.94, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object veh.r.ml
## Chi-squared = 1.5321, df = 3, p-value = 0.6749
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object veh.r.ml
## Chi-squared = 282.41, df = 3, p-value < 2.2e-16

##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object veh.r.ml
## Chi-squared = 192.17, df = 135, p-value = 0.0008991
```






```
## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause vehicle_robbery
##
## data:  VAR object veh.r.ml
## F-Test = 2.4281, df1 = 2, df2 = 426, p-value = 0.08943
##
```

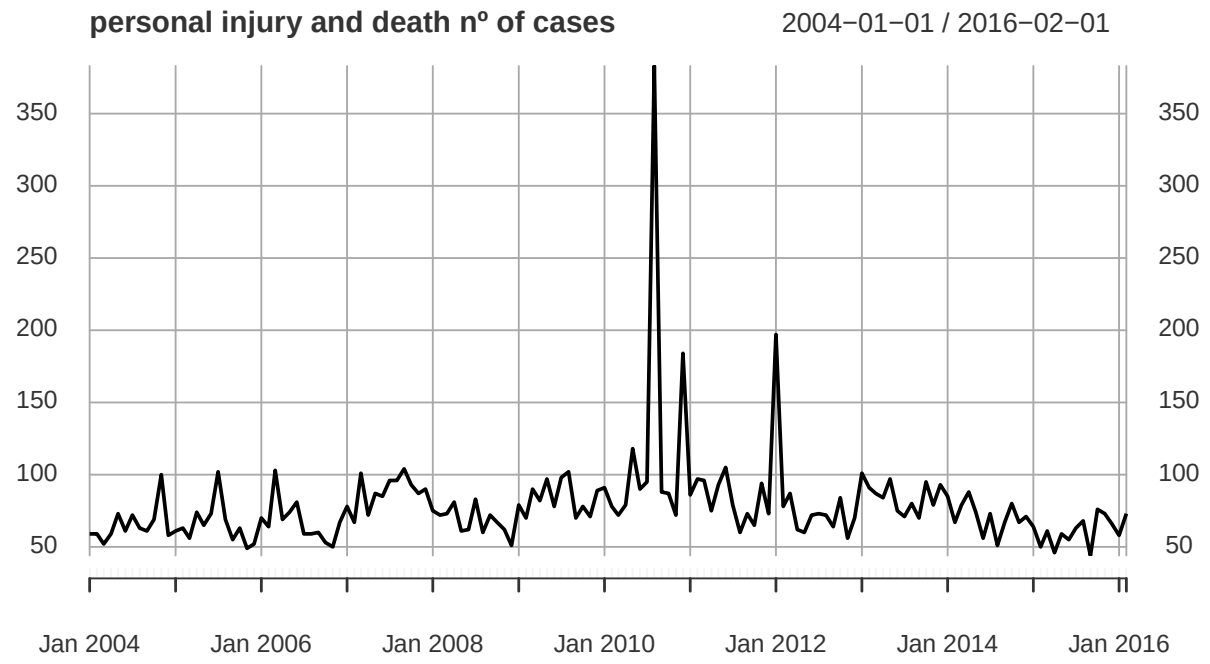
```
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and vehicle_robbery
##
## data:  VAR object veh.r.ml
## Chi-squared = 5.6562, df = 2, p-value = 0.05912
```



Vehicle robbery is non-stationary. In 2010 and january 2016 there are unusual falls of number of cases,this happens with vehicle theft too.

Unemployment have 0.094 p-value and is positive, inflation have 0.144 p-value and is positive. Granger causility test shows that unemployment and inflation cause vehicle robbery. The IRF graph shows that unemployment and inflation have permanent effect on the number of cases of vehicle robbery. The residuals are non-Gaussian and there is serial correlation.

Personal injury and death



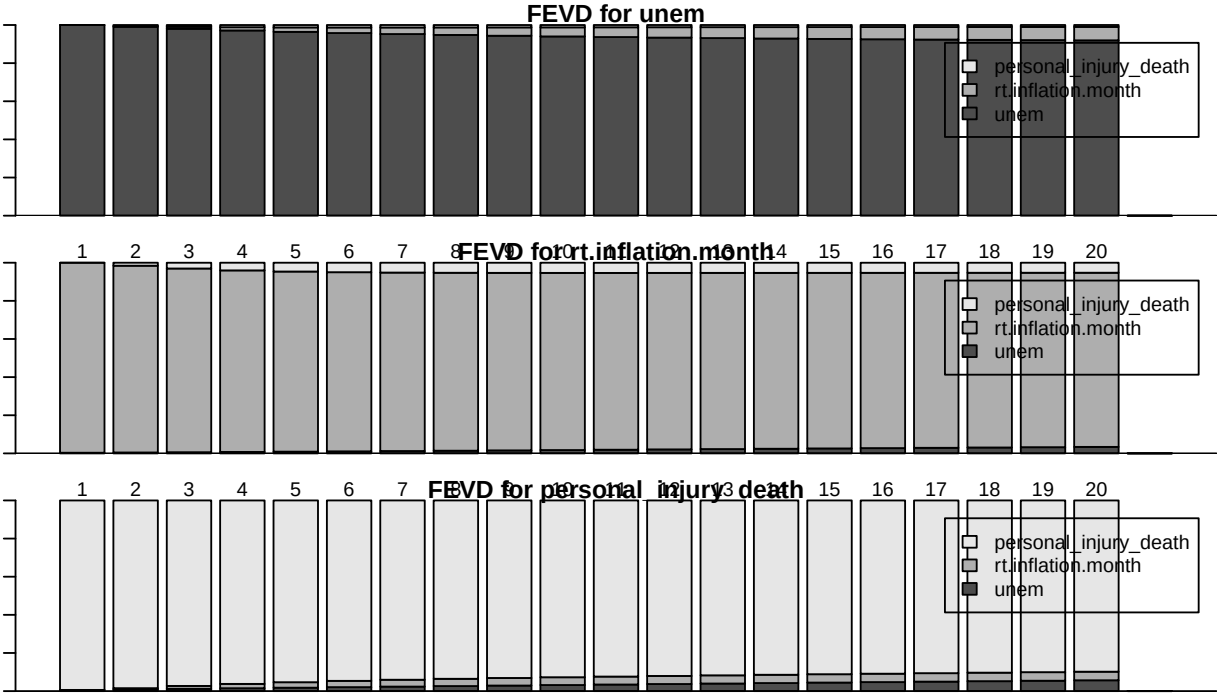

```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -3.065  0.0100
## [2,]   1 -1.742  0.0808
## [3,]   2 -1.228  0.2382
## [4,]   3 -0.837  0.3790
## [5,]   4 -0.798  0.3930
## Type 2: with drift no trend
##      lag    ADF p.value
## [1,]   0 -10.30    0.01
## [2,]   1  -6.70    0.01
## [3,]   2  -5.27    0.01
## [4,]   3  -3.91    0.01
## [5,]   4  -3.77    0.01
## Type 3: with drift and trend
##      lag    ADF p.value
## [1,]   0 -10.28  0.0100
## [2,]   1  -6.68  0.0100
## [3,]   2  -5.24  0.0100
## [4,]   3  -3.87  0.0176
## [5,]   4  -3.74  0.0242
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
```

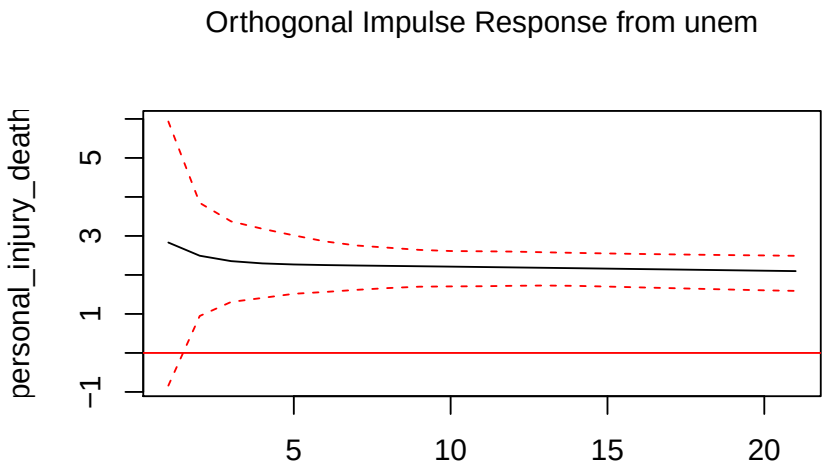
```
## ========================
## Endogenous variables: unem, rt.inflation.month, personal_injury_death
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: -29.201
## Roots of the characteristic polynomial:
## 0.9949 0.7803 0.4036
## Call:
## VAR(y = base.temp2, type = "none", lag.max = 5, ic = "SC")
##
##
## Estimation results for equation personal_injury_death:
## ======================================================
## personal_injury_death = unem.l1 + rt.inflation.month.l1 + personal_injury_death.l1
##
##                            Estimate Std. Error t value Pr(>|t|)
## unem.l1                   4.347e+00  8.948e-01   4.859 3.09e-06 ***
## rt.inflation.month.l1     1.579e+03  9.809e+02   1.610     0.11
## personal_injury_death.l1 4.377e-01  7.478e-02   5.853 3.21e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 36.02 on 142 degrees of freedom
## Multiple R-Squared: 0.8226,  Adjusted R-squared: 0.8189
## F-statistic: 219.5 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                            unem rt.inflation.month personal_injury_death
## unem                   6.033e-02          2.807e-05             6.646e-01
## rt.inflation.month     2.807e-05          4.113e-06            -3.370e-04
## personal_injury_death 6.646e-01         -3.370e-04             1.288e+03
##
## Correlation matrix of residuals:
##                            unem rt.inflation.month personal_injury_death
## unem                   1.00000            0.05636               0.07539
## rt.inflation.month     0.05636            1.00000              -0.00463
## personal_injury_death 0.07539           -0.00463               1.00000

## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause personal_injury_death
##
## data:  VAR object pers.ml
## F-Test = 22.201, df1 = 2, df2 = 426, p-value = 6.734e-10
##
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and personal_injury_death
```

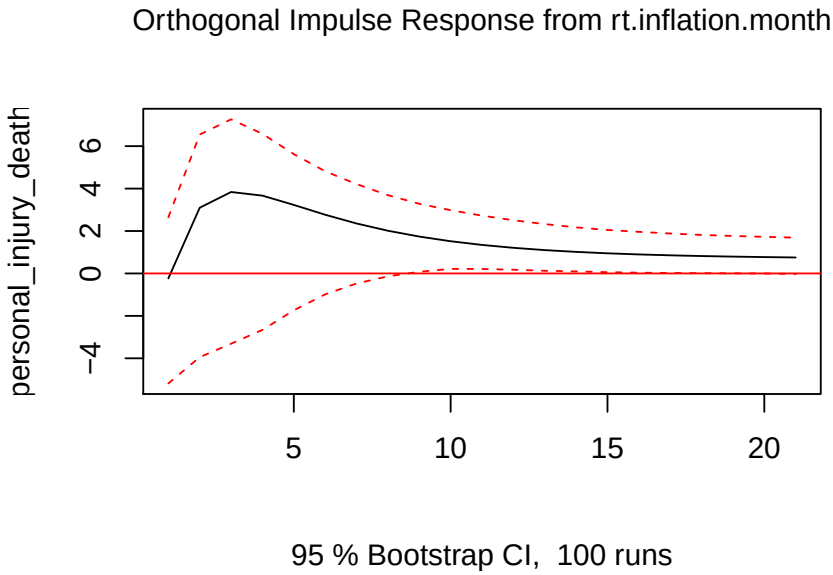
```
##
## data:  VAR object pers.ml
## Chi-squared = 0.89633, df = 2, p-value = 0.6388
```

```
## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object pers.ml
## Chi-squared = 10260, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object pers.ml
## Chi-squared = 572.96, df = 3, p-value < 2.2e-16
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object pers.ml
## Chi-squared = 9687.4, df = 3, p-value < 2.2e-16
```

```
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object pers.ml
## Chi-squared = 159.12, df = 135, p-value = 0.07656
```





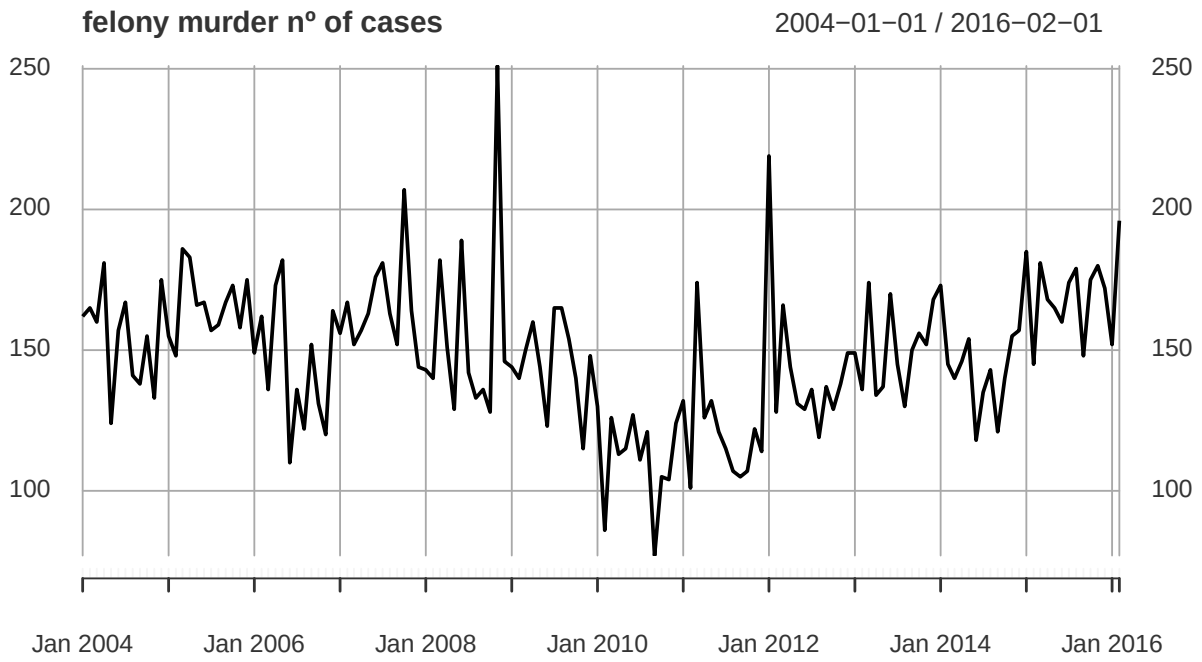


Personal injury and death is stationary, when using a constant deterministic coefficient.

The estimate of unemploymet is significant and positive, inflation have 0.11 p-value and is positive. Unemployment and inflation Granger cause personal injury and death. The IRF graph and shows that shocks of unemployment and inflation increase the cases of personal injury and death.

The crime of personal injury and death do not necessarily have an economic motivation. An example of this case is a personal motivation to attack someone but without intetion to kill the person, the victim is not killed on the spot, but dies some days later.

Felony murder variable




```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag    ADF p.value
## [1,]   0 -1.075   0.293
## [2,]   1 -0.558   0.479
## [3,]   2 -0.329   0.549
## [4,]   3 -0.318   0.552
## [5,]   4 -0.049   0.629
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 -8.52  0.0100
## [2,]   1 -5.08  0.0100
## [3,]   2 -3.60  0.0100
## [4,]   3 -3.20  0.0233
## [5,]   4 -2.46  0.1481
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 -8.52  0.0100
## [2,]   1 -5.05  0.0100
## [3,]   2 -3.55  0.0406
## [4,]   3 -3.10  0.1194
## [5,]   4 -2.37  0.4181
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
##
## VAR Estimation Results:
```

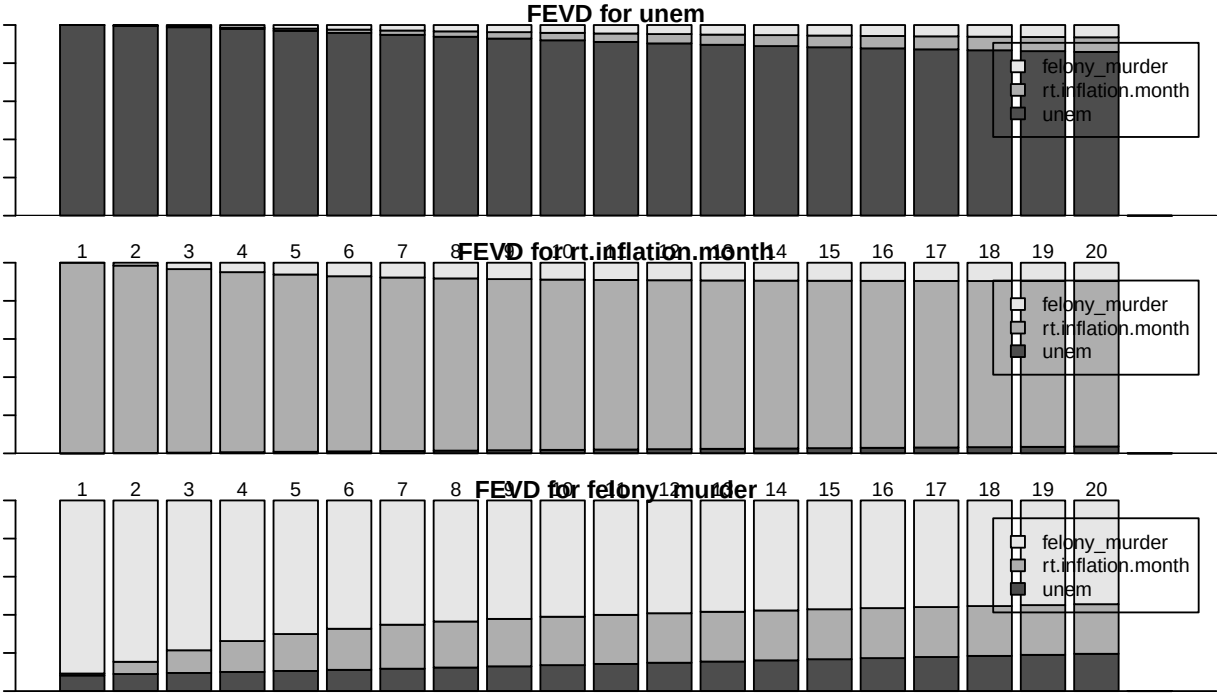
```
## ========================
## Endogenous variables: unem, rt.inflation.month, felony_murder
## Deterministic variables: none
## Sample size: 145
## Log Likelihood: 19.92
## Roots of the characteristic polynomial:
## 0.9953 0.8405 0.4652
## Call:
## VAR(y = base.temp2, p = 1, type = "none")
##
##
## Estimation results for equation felony_murder:
## ==============================================
## felony_murder = unem.l1 + rt.inflation.month.l1 + felony_murder.l1
##
##                        Estimate Std. Error t value Pr(>|t|)
## unem.l1               4.917e+00  1.062e+00   4.628 8.26e-06 ***
## rt.inflation.month.l1 3.064e+03  8.366e+02   3.662 0.000352 ***
## felony_murder.l1      6.310e-01  6.509e-02   9.694  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 26.93 on 142 degrees of freedom
## Multiple R-Squared: 0.9685,  Adjusted R-squared: 0.9678
## F-statistic:  1455 on 3 and 142 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                         unem rt.inflation.month felony_murder
## unem                6.050e-02          7.354e-06     1.893e+00
## rt.inflation.month 7.354e-06          4.074e-06     5.612e-03
## felony_murder      1.893e+00          5.612e-03     7.211e+02
##
## Correlation matrix of residuals:
##                        unem rt.inflation.month felony_murder
## unem                1.00000            0.01481        0.2866
## rt.inflation.month 0.01481            1.00000        0.1035
## felony_murder      0.28657            0.10354        1.0000
```

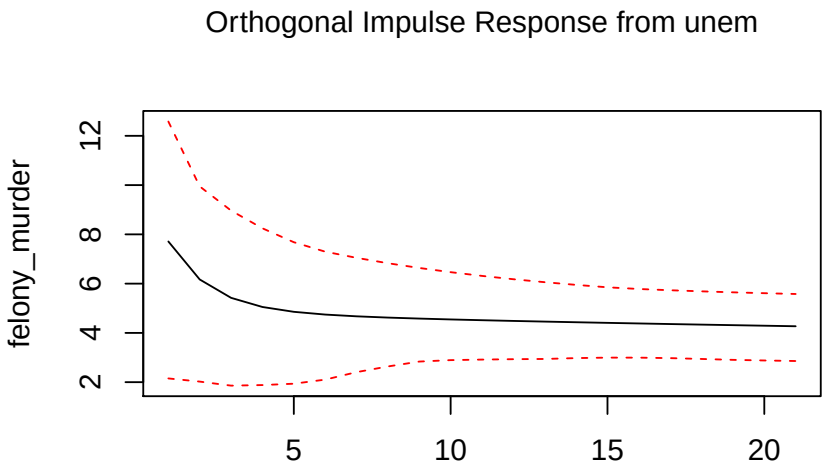
```
## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause felony_murder
##
## data:  VAR object felo.ml
## F-Test = 15.761, df1 = 2, df2 = 426, p-value = 2.492e-07
##
##
## $Instant
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and felony_murder
```

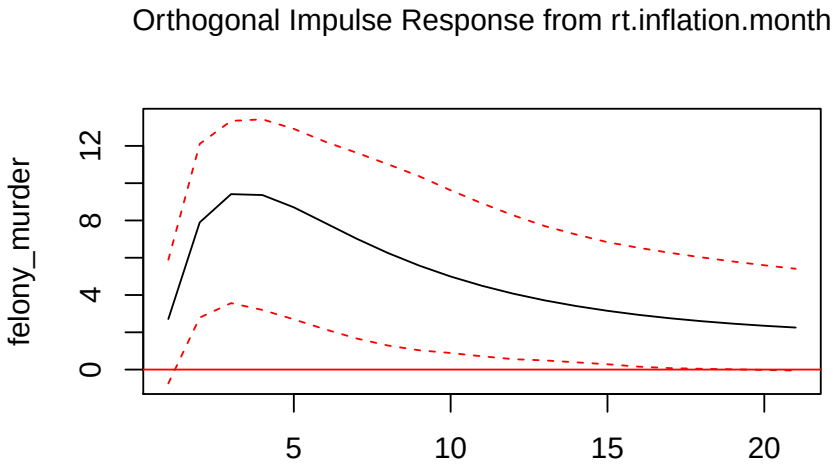
```
##
## data:  VAR object felo.ml
## Chi-squared = 12.236, df = 2, p-value = 0.002202
```

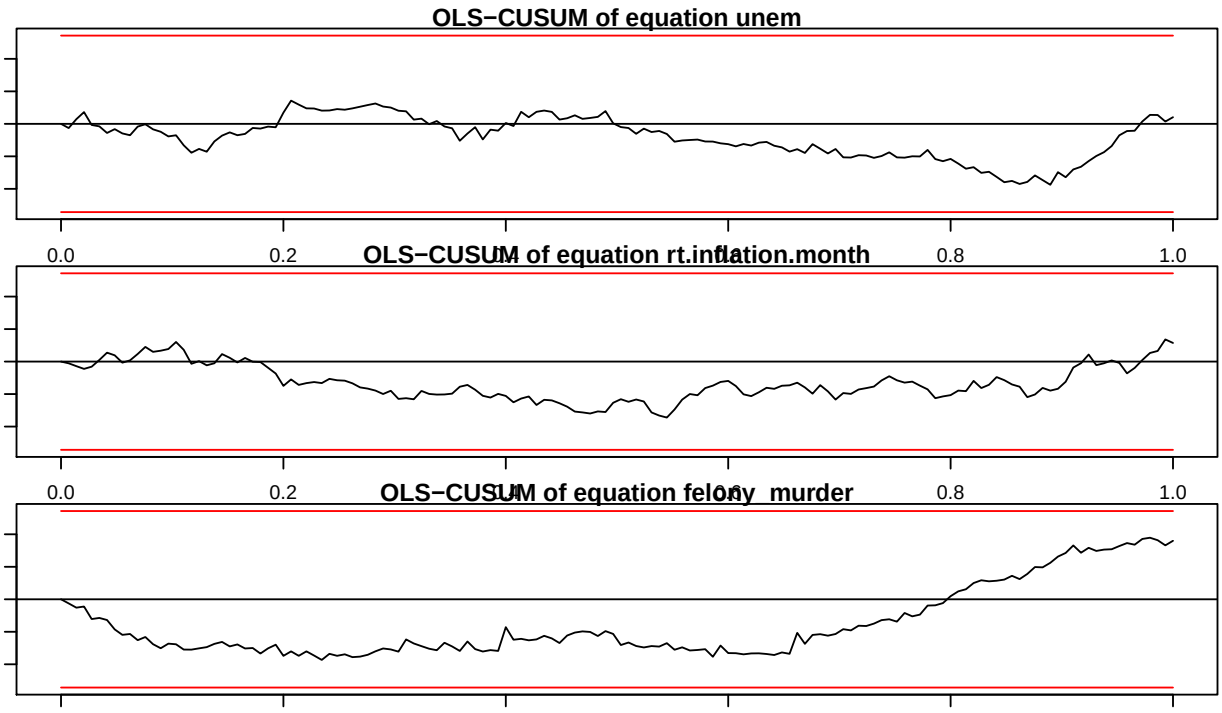
```
## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object felo.ml
## Chi-squared = 62.422, df = 6, p-value = 1.447e-11
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object felo.ml
## Chi-squared = 9.1252, df = 3, p-value = 0.02767
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object felo.ml
## Chi-squared = 53.297, df = 3, p-value = 1.585e-11
```

```
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object felo.ml
## Chi-squared = 175.61, df = 135, p-value = 0.01074
```




Orthogonal Impulse Response from unem
felony_murder
2
4
6
8
12
5
10
15
20
95 % Bootstrap CI, 100 runs


Orthogonal Impulse Response from rt.inflation.month
felony_murder
0
4
8
12
5
10
15
20
95 % Bootstrap CI, 100 runs



With few lags in the ADF test, felony murder is stationary. With more lags felony murder is non-stationary.

Compared to the other violence variable, felony murder respond more to shocks of unemployment and inflation. Maybe a reason for this is that felony murder have an economic motivation, rape or homicide e.g. do not have economic motivation. The signs of coefficients of unemployment and inflation are positive and significant, this means that an increase in inflation and unemployment increase the cases of felony murder. Unemployment and inflation Granger cause felony murder.

Compared to the other violence variables, the FEVD of felony murder shows greater impact of uneployment and inflation. The IRF graph shows that shocks in unemployment and inflation increase the number of cases in felony murder. The shocks have permanent effect on felony murder. Inflation shock increases till three months and then decreases. Unemployment shock have an initial impact and then falls. Unemployment and inflation do not respond to felony murder.

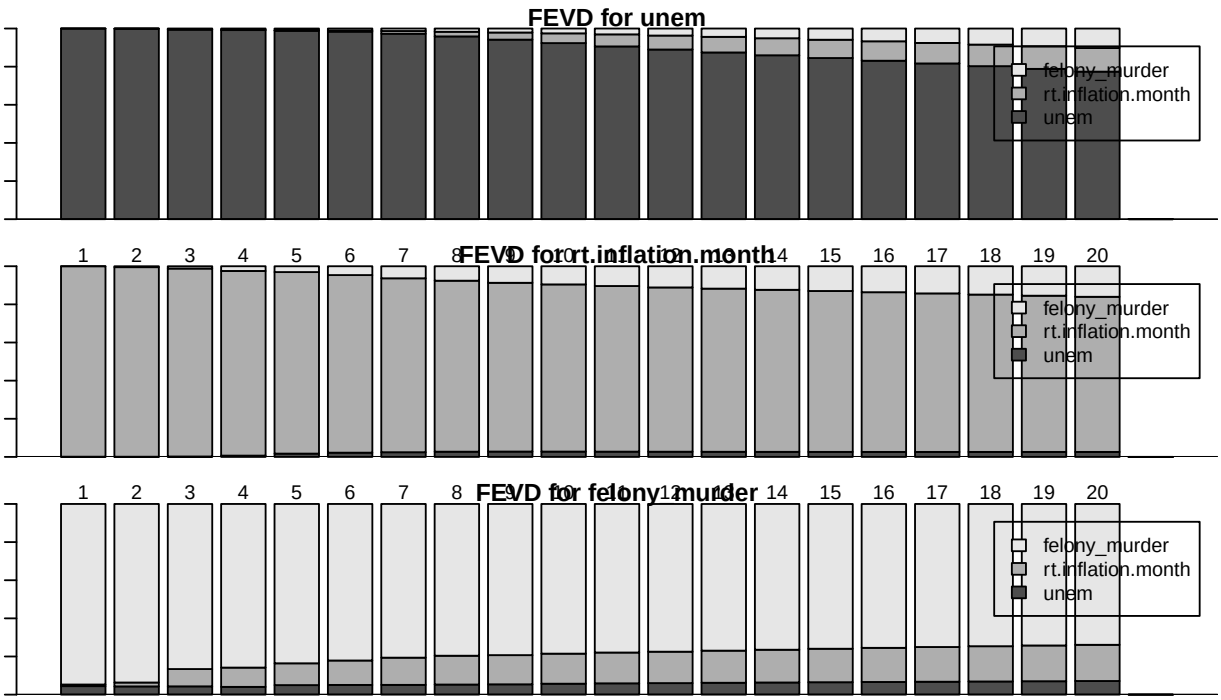
The residuals are non-Gaussian. In a perfect situation the OLS CUSUM graph should revolve around zero, but it is not the case. Also there is serial correlation in the residuals. Those are signs that the VAR(1) model is too simple, there is still information that can be used in the variables, hence in the next section we use a VAR(5) model.

Felony Murder more lags

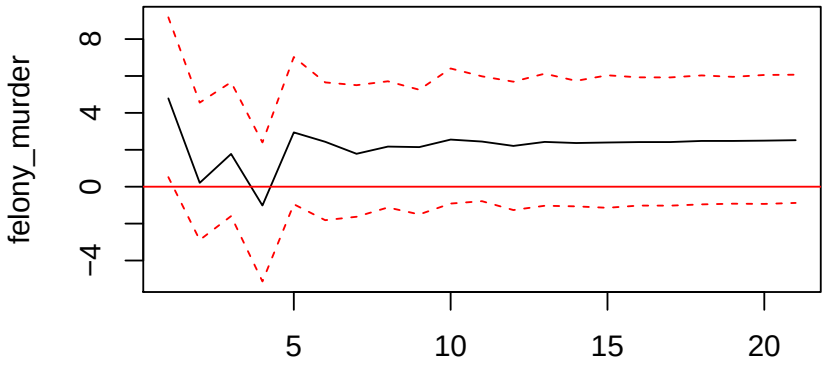
```
##
## VAR Estimation Results:
## ========================
## Endogenous variables: unem, rt.inflation.month, felony_murder
## Deterministic variables: none
## Sample size: 141
## Log Likelihood: 63.39
## Roots of the characteristic polynomial:
## 0.9995 0.9512 0.8008 0.8008 0.7768 0.7306 0.7306 0.7019 0.7019 0.6452 0.6452 0.6053 0.5956 0.5956 0.4
## Call:
## VAR(y = base.temp2, p = 5, type = "none")
```

```
##
##
## Estimation results for equation felony_murder:
## ==============================================
## felony_murder = unem.l1 + rt.inflation.month.l1 + felony_murder.l1 + unem.l2 + rt.inflation.month.l2
##
##                          Estimate Std. Error t value Pr(>|t|)
## unem.l1                -2.680e+00  8.510e+00  -0.315  0.75337
## rt.inflation.month.l1   1.087e+03  9.750e+02   1.115  0.26683
## felony_murder.l1        1.608e-01  8.826e-02   1.822  0.07087 .
## unem.l2                 5.421e+00  1.127e+01   0.481  0.63148
## rt.inflation.month.l2   2.009e+03  1.240e+03   1.620  0.10781
## felony_murder.l2        1.761e-01  8.870e-02   1.985  0.04931 *
## unem.l3                -1.231e+01  1.133e+01  -1.086  0.27937
## rt.inflation.month.l3 -1.215e+03  1.254e+03  -0.969  0.33460
## felony_murder.l3        2.434e-01  8.755e-02   2.780  0.00628 **
## unem.l4                 1.872e+01  1.126e+01   1.663  0.09888 .
## rt.inflation.month.l4   1.225e+02  1.257e+03   0.097  0.92249
## felony_murder.l4        6.622e-02  8.848e-02   0.748  0.45560
## unem.l5                -8.033e+00  8.200e+00  -0.980  0.32918
## rt.inflation.month.l5   4.355e+02  1.031e+03   0.422  0.67349
## felony_murder.l5        2.150e-01  8.495e-02   2.531  0.01259 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 22.67 on 126 degrees of freedom
## Multiple R-Squared: 0.9795,  Adjusted R-squared: 0.9771
## F-statistic: 402.3 on 15 and 126 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##                          unem rt.inflation.month felony_murder
## unem                5.558e-02          1.561e-05     1.129e+00
## rt.inflation.month 1.561e-05          4.232e-06     4.555e-03
## felony_murder      1.129e+00          4.555e-03     5.139e+02
##
## Correlation matrix of residuals:
##                       unem rt.inflation.month felony_murder
## unem                1.00000            0.03219       0.21123
## rt.inflation.month 0.03219            1.00000       0.09767
## felony_murder      0.21123            0.09767       1.00000

## $Granger
##
##  Granger causality H0: unem rt.inflation.month do not
##  Granger-cause felony_murder
##
## data:  VAR object felo.mlv3
## F-Test = 1.3895, df1 = 10, df2 = 378, p-value = 0.1828
##
##
## $Instant
```

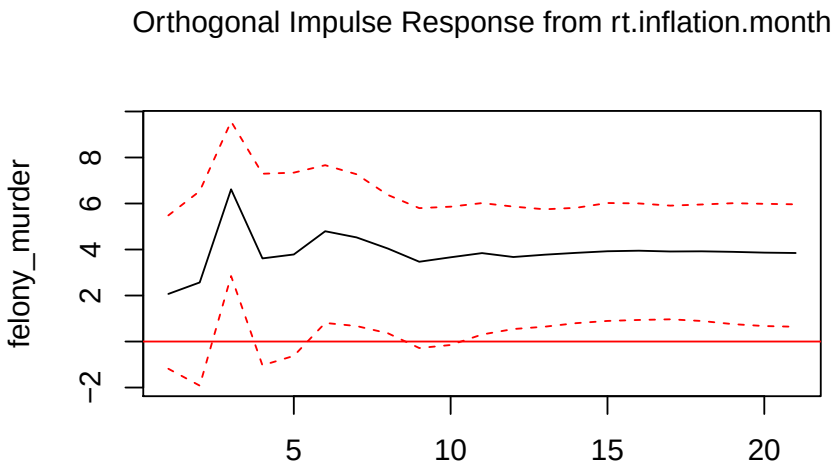
```
##
##  H0: No instantaneous causality between: unem rt.inflation.month
##  and felony_murder
##
## data:  VAR object felo.mlv3
## Chi-squared = 7.0815, df = 2, p-value = 0.02899

## $JB
##
##  JB-Test (multivariate)
##
## data:  Residuals of VAR object felo.mlv3
## Chi-squared = 143.8, df = 6, p-value < 2.2e-16
##
##
## $Skewness
##
##  Skewness only (multivariate)
##
## data:  Residuals of VAR object felo.mlv3
## Chi-squared = 29.137, df = 3, p-value = 2.096e-06
##
##
## $Kurtosis
##
##  Kurtosis only (multivariate)
##
## data:  Residuals of VAR object felo.mlv3
## Chi-squared = 114.67, df = 3, p-value < 2.2e-16

##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object felo.mlv3
## Chi-squared = 101.2, df = 99, p-value = 0.4197
```

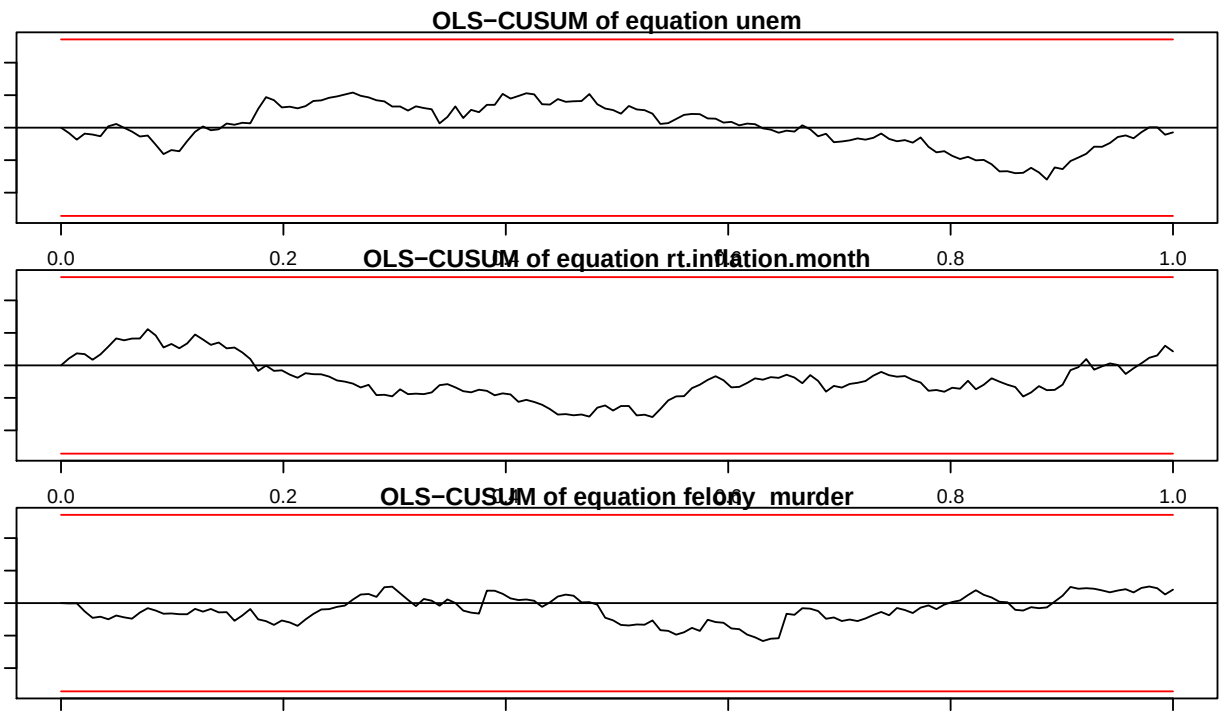


Orthogonal Impulse Response from unem



95 % Bootstrap CI, 100 runs





The VAR(5) model does not have serial correlation in the residuals. The residuals are non-Gaussian. Unemployment and inflation are not significant at 1% in the felony murder equation, the inclusion of 5 lags made them non significant. Results with lower lags do not change much. And unemployment and inflation does not Granger cause felony murder. There is significant correlation in the innovations of those variables according to the instantaneous causality test and the correlation matrix of residuals.

The second lag of inflation have 0.108 p-value, and is positive. The forth lag of unemployment have 0.099 p-value and is positive. The IRF graphs shows that shocks in inflation and unemployment have the expected effect of increasing cases of violence.

In the analysis of rate of change, felony murder is the variable the most respond to shocks of unemployment and inflation.

Given that there is indication that felony murder is non-stationary, we apply a cointegration test and VECM.

Felony murder VECM

```
##
## ######################
## # Johansen-Procedure #
## ######################
##
## Test type: trace statistic , with linear trend
##
## Eigenvalues (lambda):
## [1] 0.19202698 0.07379322 0.02657072
##
## Values of teststatistic and critical values of test:
##
##           test 10pct  5pct  1pct
## r <= 2 |  3.80  6.50  8.18 11.65
## r <= 1 | 14.61 15.66 17.95 23.52
## r = 0  | 44.67 28.71 31.52 37.22
##
## Eigenvectors, normalised to first column:
## (These are the cointegration relations)
##
##                       felony_murder.l1      unem.l1 rt.inflation.month.l1
## felony_murder.l1               1.00000     1.000000               1.00000
## unem.l1                      -10.00195    -6.754776              18.74287
## rt.inflation.month.l1    -106019.22183 -1792.763760            1261.07677
##
## Weights W:
## (This is the loading matrix)
##
##                      felony_murder.l1       unem.l1 rt.inflation.month.l1
## felony_murder.d         -1.535136e-02 -2.884491e-01         -4.945530e-02
## unem.d                  -1.876887e-04  2.301643e-03         -6.231972e-04
## rt.inflation.month.d     4.692766e-06 -1.324556e-06         -2.954899e-06

##                                ect1
## felony_murder.l1            1.00000
## unem.l1                   -10.00195
## rt.inflation.month.l1 -106019.22183

## Response felony_murder.d :
##
## Call:
## lm(formula = felony_murder.d ~ ect1 + constant + felony_murder.dl1 +
##     unem.dl1 + rt.inflation.month.dl1 + felony_murder.dl2 + unem.dl2 +
##     rt.inflation.month.dl2 + felony_murder.dl3 + unem.dl3 + rt.inflation.month.dl3 +
##     felony_murder.dl4 + unem.dl4 + rt.inflation.month.dl4 - 1,
##     data = data.mat)
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -53.996 -13.343  -2.073  12.333 102.872
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## ect1                      -0.01535    0.01073  -1.430  0.15505
## constant                  -6.63545    5.20661  -1.274  0.20484
## felony_murder.dl1         -0.79820    0.08722  -9.151 1.19e-15 ***
## unem.dl1                  -4.43479    8.27174  -0.536  0.59280
## rt.inflation.month.dl1 -745.12794 1197.81631  -0.622  0.53501
## felony_murder.dl2         -0.59637    0.10822  -5.511 1.91e-07 ***
## unem.dl2                   0.68247    8.10194   0.084  0.93300
## rt.inflation.month.dl2 1179.09572 1146.87826   1.028  0.30586
## felony_murder.dl3         -0.32437    0.10730  -3.023  0.00303 **
## unem.dl3                 -11.60451    8.02138  -1.447  0.15045
## rt.inflation.month.dl3 -170.67770 1069.99123  -0.160  0.87352
## felony_murder.dl4         -0.23440    0.08470  -2.767  0.00650 **
## unem.dl4                   7.62925    8.24527   0.925  0.35657
## rt.inflation.month.dl4 -154.05126 1037.46567  -0.148  0.88219
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 22.82 on 127 degrees of freedom
## Multiple R-squared:  0.4629, Adjusted R-squared:  0.4037
## F-statistic: 7.818 on 14 and 127 DF,  p-value: 9.952e-12
##
##
## Response unem.d :
##
## Call:
## lm(formula = unem.d ~ ect1 + constant + felony_murder.dl1 + unem.dl1 +
##     rt.inflation.month.dl1 + felony_murder.dl2 + unem.dl2 + rt.inflation.month.dl2 +
##     felony_murder.dl3 + unem.dl3 + rt.inflation.month.dl3 + felony_murder.dl4 +
##     unem.dl4 + rt.inflation.month.dl4 - 1, data = data.mat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.61103 -0.13918 -0.00843  0.16180  0.60085
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## ect1                     -1.877e-04  1.124e-04  -1.670   0.0974 .
## constant                 -1.002e-01  5.454e-02  -1.837   0.0686 .
## felony_murder.dl1         1.635e-06  9.136e-04   0.002   0.9986
## unem.dl1                 -7.319e-02  8.664e-02  -0.845   0.3998
## rt.inflation.month.dl1 -2.365e+01  1.255e+01  -1.885   0.0617 .
## felony_murder.dl2         1.061e-03  1.134e-03   0.936   0.3511
## unem.dl2                  1.038e-01  8.486e-02   1.224   0.2234
## rt.inflation.month.dl2 -1.158e+01  1.201e+01  -0.964   0.3368
## felony_murder.dl3         9.973e-04  1.124e-03   0.887   0.3766
## unem.dl3                  1.303e-01  8.402e-02   1.551   0.1235
## rt.inflation.month.dl3 -2.482e+01  1.121e+01  -2.214   0.0286 *
## felony_murder.dl4         8.470e-04  8.872e-04   0.955   0.3416
## unem.dl4                  1.249e-01  8.637e-02   1.446   0.1506
```

```
## rt.inflation.month.dl4 -1.283e+01  1.087e+01  -1.181   0.2399
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.239 on 127 degrees of freedom
## Multiple R-squared:  0.1311, Adjusted R-squared:  0.03531
## F-statistic: 1.369 on 14 and 127 DF,  p-value: 0.1779
##
##
## Response rt.inflation.month.d :
##
## Call:
## lm(formula = rt.inflation.month.d ~ ect1 + constant + felony_murder.dl1 +
##     unem.dl1 + rt.inflation.month.dl1 + felony_murder.dl2 + unem.dl2 +
##     rt.inflation.month.dl2 + felony_murder.dl3 + unem.dl3 + rt.inflation.month.dl3 +
##     felony_murder.dl4 + unem.dl4 + rt.inflation.month.dl4 - 1,
##     data = data.mat)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -0.0045032 -0.0013442 -0.0000775  0.0013857  0.0054589
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## ect1                    4.693e-06  9.512e-07   4.934 2.48e-06 ***
## constant                2.177e-03  4.615e-04   4.718 6.17e-06 ***
## felony_murder.dl1       3.632e-07  7.730e-06   0.047   0.9626
## unem.dl1                8.589e-05  7.331e-04   0.117   0.9069
## rt.inflation.month.dl1  2.199e-01  1.062e-01   2.071   0.0404 *
## felony_murder.dl2       1.472e-06  9.592e-06   0.153   0.8783
## unem.dl2               -3.086e-04  7.181e-04  -0.430   0.6681
## rt.inflation.month.dl2  1.252e-01  1.016e-01   1.232   0.2202
## felony_murder.dl3       3.866e-06  9.510e-06   0.407   0.6850
## unem.dl3                1.262e-03  7.109e-04   1.775   0.0783 .
## rt.inflation.month.dl3  1.274e-01  9.483e-02   1.343   0.1816
## felony_murder.dl4      -2.334e-06  7.507e-06  -0.311   0.7564
## unem.dl4                1.120e-03  7.308e-04   1.533   0.1278
## rt.inflation.month.dl4  1.119e-01  9.195e-02   1.217   0.2260
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.002022 on 127 degrees of freedom
## Multiple R-squared:  0.2249, Adjusted R-squared:  0.1395
## F-statistic: 2.632 on 14 and 127 DF,  p-value: 0.002177
```

There is one cointegration vector. The long run relation is:

$$felony = 10 \cdot unem + 106019 \cdot inf$$

Which means that high unemployment and inflation are related to high level of felony murder. `ect1` is the adjustment coefficient α. For felony murder's equation α is not significant, which means that felony murder do not adjust to deviations in the long-run relationship. Which disagree with our hypothesis that violence change according to movements of unemployment and inflation.

The adjustment coefficients of unemployment is significant and negative. The adjustment coefficient of inflation is significant and positive. These adjustment coefficients maybe capturing the Phillips curve relation.

In the short-run unemployment is affected by inflation, the coefficients are negative and significant. This means that increasing inflation lowers unemployment. In the short-run coefficient, inflation is affected by unemployment and past inflation.

The cointegration vector shows the long-run relationship between felony murder, unemployment and inflation. This result agrees with the persisntent impact of unemployment and inflation found in the IRF graphs.

Santos and Kassouf (2014) found in the adjustment coefficients that violence adjust to deviations in the long-run relationship, differently from the result found here. Saridakis (2004) did not found cointegrating vector. And he found that economic variables have a stronger relationship with his murder variable.

Data

The variable os unemployment is obtained through the site of the Brazilian Institute of Geography and Statistics (IBGE). The variable was built using the surveys of PNAD asking if the person was employed or looking for job in the last week.

Inflation data is the IPCA (Índice de Preços ao Consumidor Amplo) it captures the price levels of a bundle of goods, giving enphasis in metropolitan regions of Brazil, this is found in the site of IBGE.

Violence variables are available in the site of Ministry of Justice of Brazil. The data have monthly information on the number of occurances of violent crimes in each municipality. This is a dataset built using reports of the civil police. There are other institutions of public security, for example, the state police that a strong presence in each state. So the data does not capture all cases of reported crimes. And many of the violent crimes are under reported.

All the cited variables are published in number of cases. The difference between vehicle theft and robbery is that theft does not involve the presence of the victim robbery is assault. Personal injury and death occurs when the victim is injured but do not die on the spot, he dies some hours or days later, hence the objective of the offender was not to kill. Felony murder is robbery followed by assassination.

Concluding Remarks

The objective of this work is to study the relationship of violent crimes and economic variables using VAR/VEC models. We analyze the variables in level and rate of change. The violent crimes studied are: i) rape; ii) homicides; iii) vehicle theft; iv) vehicle robbery; v) personal injury and death; vi) felony murder.

In the rate of change analysis we do find for most of the variables significant estimates, hence there is no Granger causality from inflation and unemployment to violent crime. The exception is felony murder, the variable shows a significant relationship, and there is Granger causality. The problem is the variance of the estimates, because their sign is positive as we expect. That is increasing unemployment and inflation increase violence. The IRF graphs show for all variables that unemployment and inflation have positive and permanent impact on violence. The analysis is with the rate of change which are I(0) next we study with the variables in level.

The analysis on level with VAR show that all variable behave as expected the sign of shocks in unemployment and inflation increase violence. But for rape and vehicle theft we do not find statistically significant Granger causality estimates. For homicide, vehicle robbery, personal injury and death, and felony murder there is Granger causality. The IRF shows that the shock of unemployment is positive and persistent in time, it does not diminish with time. Inflation shock increase in the first 3~4 months and then slowly decreases.

For felony murder we test a VAR with five lags given that the speciafication with one lag showed serial correlation in residuals. The estimates show that inflation and unemployment are slightly significant. And there is no Granger causality.

We apply a cointegration test on felony murder. We find a long-run relationship between felony murder, inflation and unemployment. The signs of in the cointegrating vector are as expected. However, it is unexpected that the adjustment coefficient of violence is not significant, which means that violence does not adjust to match the long-run relation. The adjustment coefficients of unemployment and inflation are significant, which means that they move to the long-run relation. This indication that the cointegration test is capturing the Phillips curve relation of unemployment and inflation and that violence is irrelevant in the long-run relation.

Further studies: i) study the relationship between inflation, unemployment and crime in states or regions of Brazil; iii) study misdemeanor crimes such as: petty theft, prostitution, public intoxication, simple assault, disorderly conduct, trespass, vandalism, reckless driving, discharging a firearm within city limits, possession of cannabis; iv) use data with other frequencies, annual or quarterly frequency; v) use variables of violence measured by population size, one hundred thousand inhabitants; v) study structural breaks or change in regime in the VAR/VEC models.

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