Life Expectancy Time Series Project

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#Loading in necessary libraries

```
library(tswge)
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
##
## Attaching package: 'tswge'
```

```
## The following object is masked from 'package:datasets':
##
##     uspop
```

```
library(tseries)
library(nnfor)
```

```
## Loading required package: generics
```

```
##
## Attaching package: 'generics'
```

```
## The following objects are masked from 'package:base':
##
##     as.difftime, as.factor, as.ordered, intersect, is.element, setdiff,
##     setequal, union
```

```
library(forecast)
library(vars)
```

```
## Loading required package: MASS
```

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

```
## The following object is masked from 'package:tswge':
##
##     cement
```

```
## Loading required package: strucchange
```

```
## Loading required package: zoo
```

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

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

```
## Loading required package: sandwich
```

```
##
## Attaching package: 'sandwich'
```

```
## The following object is masked from 'package:generics':
##
##     estfun
```

```
## Loading required package: urca
```

```
## Loading required package: lmtest
```

```
##
## Attaching package: 'lmtest'
```

```
## The following object is masked from 'package:tswge':
##
##     wages
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

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

```
## The following object is masked from 'package:generics':
##
##     explain
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(tidyverse)
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✔ forcats   1.0.0     ✔ readr     2.1.4
## ✔ ggplot2   3.4.3     ✔ stringr   1.5.0
## ✔ lubridate 1.9.2     ✔ tibble    3.2.1
## ✔ purrr     1.0.2     ✔ tidyr     1.3.0
```

```
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ stringr::boundary() masks strucchange::boundary()
## ✖ dplyr::filter()     masks stats::filter()
## ✖ dplyr::lag()        masks stats::lag()
## ✖ dplyr::select()     masks MASS::select()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(tswge)
library(tidyr)
library(tswge)
library(tseries)
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

Loading in data & checking for any missing values, and splitting into Mexico & US

```
# LifeExpectancy=read.csv(file.choose())
setwd("~/Desktop")
LifeExpectancy<-read.csv("/Users/tmc/Desktop/MS_SMU_Admin/04_2024_Spring/Time_Series_DS6373/12_Project_Assigned/r
enu_files/LifeExpectancy Updated Dataset.csv",header=T)
LifeExpectancy=subset(LifeExpectancy[1:8])
head(LifeExpectancy)
```

```
##   Country Country.Code                   Region        Income.Group Year
## 1  Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2  Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3  Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4  Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5  Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6  Mexico          MEX Latin America & Caribbean Upper middle income 1965
##   Life.Expectancy       GDP Population
## 1        57.06563 1.304e+10   36268055
## 2        57.65615 1.416e+10   37439317
## 3        58.18024 1.520e+10   38683283
## 4        58.64290 1.696e+10   39982118
## 5        59.05559 2.008e+10   41333878
## 6        59.43371 2.184e+10   42737991
```

```
is.na(LifeExpectancy$Life.Expectancy)
```

```
##   [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [13] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [25] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [37] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [49] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [61] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [73] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [85] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [97] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
## [109] FALSE FALSE FALSE FALSE
```

```
is.na(LifeExpectancy$GDP)
```

```
##   [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [13] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [25] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [37] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [49] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [61] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [73] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [85] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [97] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
## [109] FALSE FALSE FALSE FALSE
```

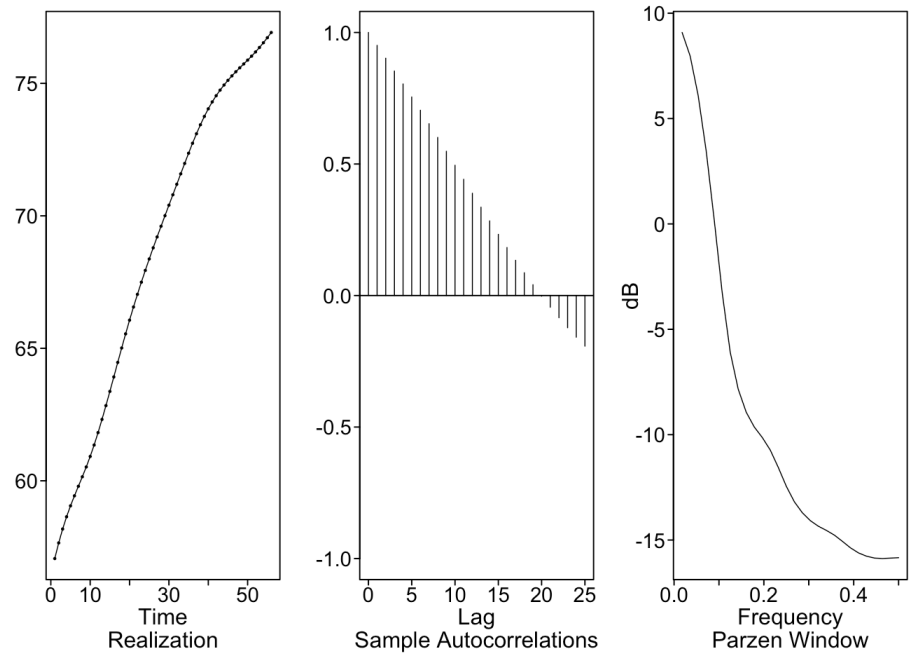
```
is.na(LifeExpectancy$Population)
```

```
##   [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [13] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [25] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [37] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [49] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [61] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [73] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [85] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
##  [97] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
## [109] FALSE FALSE FALSE FALSE
```

```
Mexico=subset(LifeExpectancy,Country=="Mexico")
UnitedStates=subset(LifeExpectancy,Country=="United States")
```

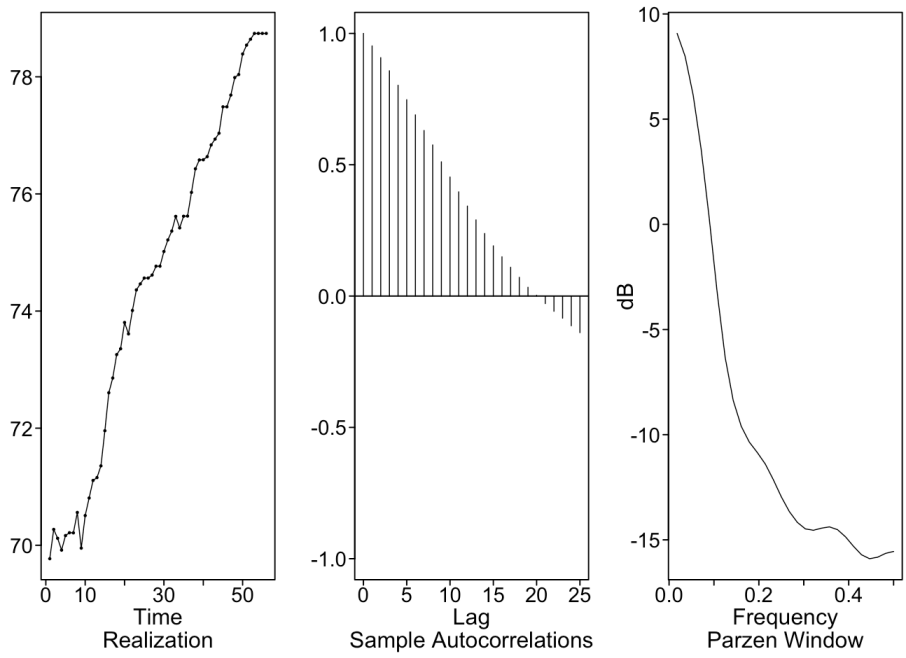
Looking at life expectancy, GDP, Population for Mexico & US

```
plotts.sample.wge(Mexico$Life.Expectancy)
```



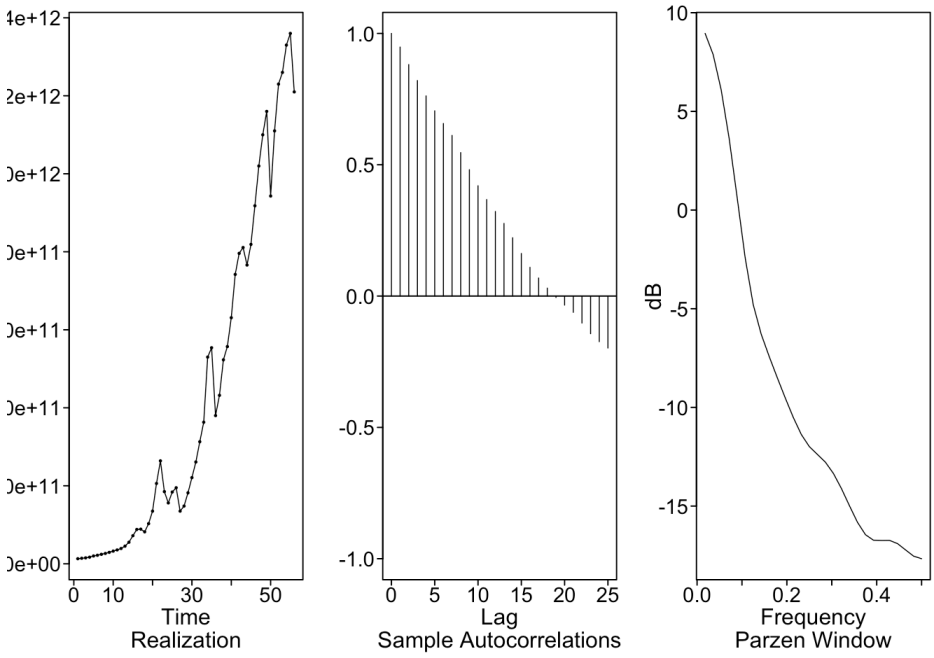

```
## $xbar
## [1] 68.72894
##
## $autplt
##  [1]  1.000000000  0.950981835  0.902239822  0.853464781  0.804360676
##  [6]  0.754686060  0.704277285  0.653051406  0.601036602  0.548354876
## [11]  0.495212754  0.441887833  0.388693450  0.335909008  0.283789964
## [16]  0.232581461  0.182512256  0.133794351  0.086608515  0.041096860
## [21] -0.002633546 -0.044509183 -0.084475922 -0.122493850 -0.158519088
## [26] -0.192519874
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   9.0856443   7.9732188   6.1019548   3.4758687   0.2081674  -3.2607993
##  [7]  -6.0824129  -7.8441048  -8.9361698  -9.6352289 -10.1344941 -10.7333423
## [13] -11.5581658 -12.4519050 -13.1857586 -13.7075066 -14.0829997 -14.3463089
## [19] -14.5441385 -14.7694551 -15.0645992 -15.3713836 -15.6113311 -15.7674828
## [25] -15.8557577 -15.8793354 -15.8566349 -15.8389167
```

```
plotts.sample.wge(UnitedStates$Life.Expectancy)
```



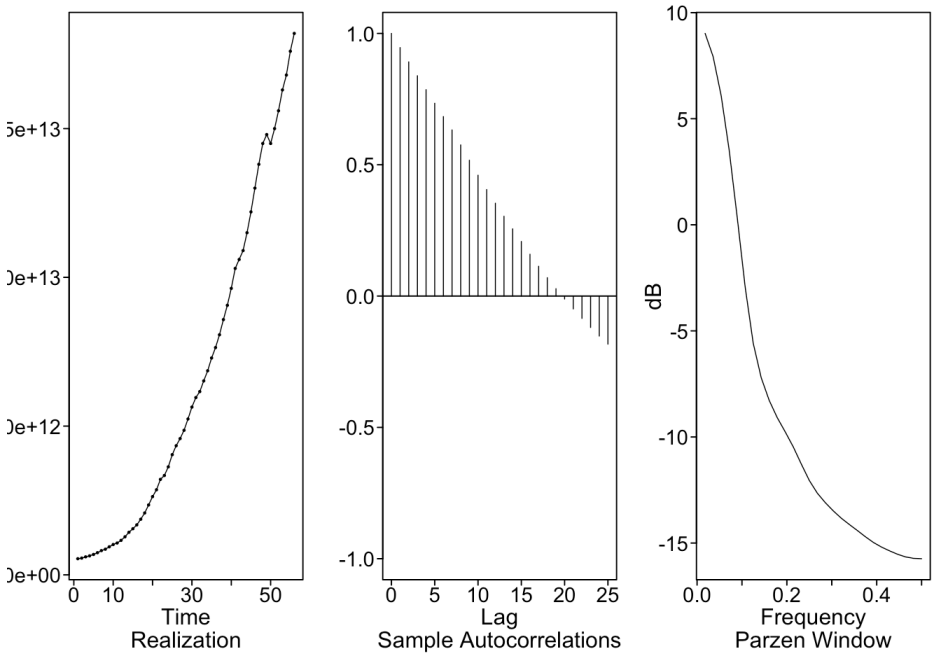

```
## $xbar
## [1] 74.53284
##
## $autplt
##  [1]  1.000000000  0.952409492  0.907676625  0.857772203  0.802433526
##  [6]  0.747544650  0.689888762  0.630372094  0.575503964  0.511044451
## [11]  0.453138107  0.396807413  0.342621121  0.290132906  0.238162449
## [16]  0.191199966  0.149482508  0.109453004  0.071288392  0.033473814
## [21]  0.002874331 -0.028623198 -0.057905600 -0.084106028 -0.113131434
## [26] -0.139320421
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   9.0764254   7.9862137   6.1511187   3.5678509   0.3178162  -3.2460547
##  [7]  -6.3401396  -8.3753251  -9.6019638 -10.3502588 -10.8470936 -11.3962870
## [13] -12.1396745 -12.9563437 -13.6568389 -14.1711217 -14.4791216 -14.5444329
## [19] -14.4450186 -14.3834081 -14.5143796 -14.8546308 -15.3073035 -15.7092666
## [25] -15.8962925 -15.8258492 -15.6427952 -15.5518723
```

```
plotts.sample.wge(Mexico$GDP)
```



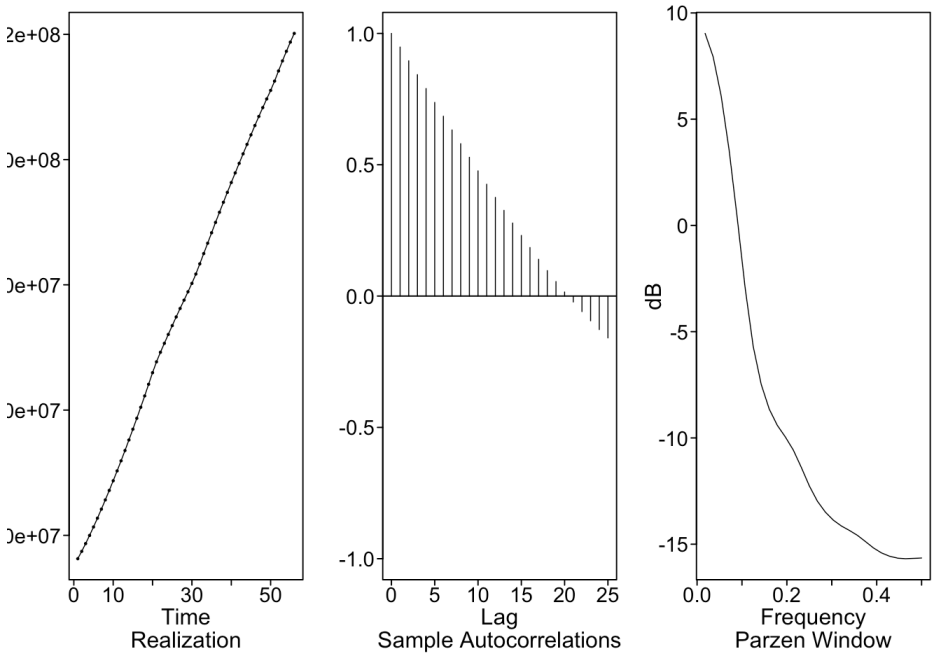

```
## $xbar
## [1] 427731927546
##
## $autplt
##  [1]  1.000000000  0.948128798  0.881401543  0.820541267  0.762123075
##  [6]  0.705192459  0.656905591  0.611582710  0.546147738  0.481091792
## [11]  0.419951185  0.367470772  0.322004023  0.276550745  0.221955039
## [16]  0.162080212  0.109432033  0.068824278  0.030213618 -0.005586215
## [21] -0.034418378 -0.062034281 -0.102722861 -0.143383007 -0.173707168
## [26] -0.198011729
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   8.9516083   7.8846416   6.1009262   3.6287043   0.6266393  -2.4258403
##  [7]  -4.7911388  -6.2946614  -7.4271815  -8.4924019  -9.5241673 -10.5095931
## [13] -11.3733747 -11.9871717 -12.3805522 -12.7737489 -13.3446787 -14.1101304
## [19] -14.9800563 -15.8192622 -16.4497688 -16.7303309 -16.7407872 -16.7378780
## [25] -16.9023625 -17.2210812 -17.5359609 -17.6667678
```

```
plotts.sample.wge(UnitedStates$GDP)
```



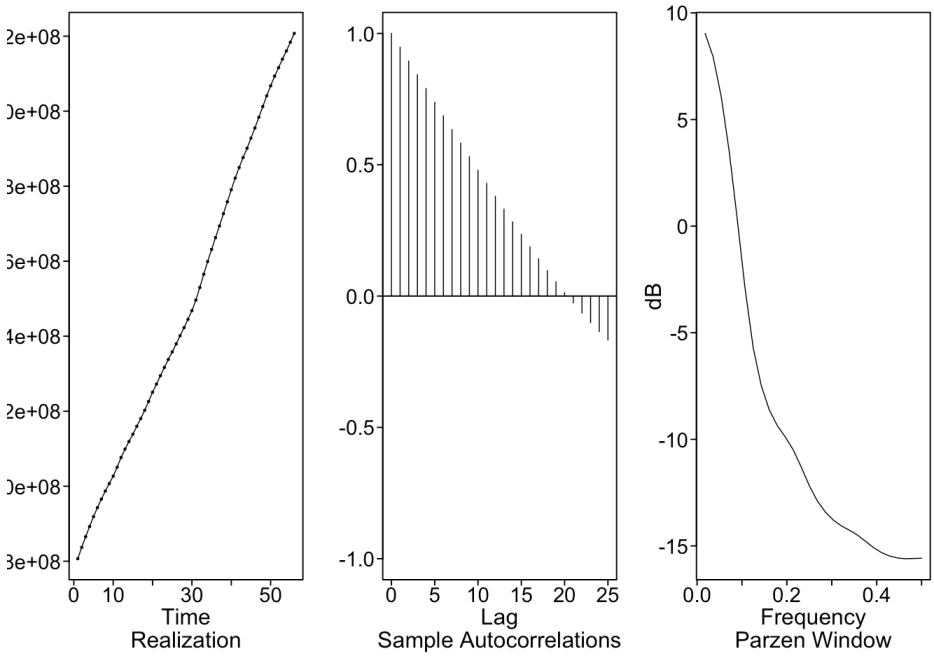

```
## $xbar
## [1] 6.564821e+12
##
## $autplt
##  [1]  1.00000000  0.94593286  0.89151691  0.83877086  0.78580240  0.73413411
##  [7]  0.68324827  0.63239960  0.57554134  0.51706304  0.46011624  0.40549176
## [13]  0.35349418  0.30378676  0.25593405  0.20772534  0.15923630  0.11340734
## [19]  0.06978959  0.02805525 -0.01136486 -0.04904875 -0.08503019 -0.11950270
## [25] -0.15239123 -0.18297812
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   9.0213111   7.9282502   6.0935109   3.5295972   0.3655145  -2.9428501
##  [7]  -5.5782811  -7.2101509  -8.2806863  -9.0915950  -9.7642109 -10.4709843
## [13] -11.2784145 -12.0528336 -12.6507563 -13.0996903 -13.4888761 -13.8334685
## [19] -14.1290047 -14.4121107 -14.7047831 -14.9740605 -15.1890592 -15.3668051
## [25] -15.5276694 -15.6531106 -15.7199299 -15.7377107
```

```
plotts.sample.wge(Mexico$Population)
```




```
## $xbar
## [1] 78177627
##
## $autplt
##  [1]  1.00000000  0.94812178  0.89567993  0.84290494  0.79000958  0.73720994
##  [7]  0.68465380  0.63229148  0.58008516  0.52816295  0.47666906  0.42574086
## [13]  0.37554904  0.32623151  0.27790027  0.23067922  0.18467270  0.13999327
## [19]  0.09681066  0.05528474  0.01549359 -0.02260177 -0.05912705 -0.09412600
## [25] -0.12754214 -0.15934166
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   9.0370169   7.9407433   6.1021411   3.5360356   0.3709826  -2.9594164
##  [7]  -5.6939473  -7.4830205  -8.6431483  -9.4040371  -9.9498745 -10.5695068
## [13] -11.3870670 -12.2581902 -12.9744701 -13.4921177 -13.8722790 -14.1452167
## [19] -14.3539435 -14.5849542 -14.8774447 -15.1771267 -15.4117671 -15.5665081
## [25] -15.6562736 -15.6837760 -15.6659857 -15.6505920
```

```
plotts.sample.wge(UnitedStates$Population)
```




```
## $xbar
## [1] 248641189
##
## $autplt
##  [1]  1.00000000  0.94743601  0.89504099  0.84276027  0.79046513  0.73827402
##  [7]  0.68606113  0.63400437  0.58218574  0.53069867  0.47958639  0.42922165
## [13]  0.37973700  0.33092677  0.28252871  0.23467937  0.18767840  0.14179520
## [19]  0.09725796  0.05425907  0.01302231 -0.02670003 -0.06475560 -0.10105593
## [25] -0.13542277 -0.16775041
##
## $freq
##  [1] 0.01785714 0.03571429 0.05357143 0.07142857 0.08928571 0.10714286
##  [7] 0.12500000 0.14285714 0.16071429 0.17857143 0.19642857 0.21428571
## [13] 0.23214286 0.25000000 0.26785714 0.28571429 0.30357143 0.32142857
## [19] 0.33928571 0.35714286 0.37500000 0.39285714 0.41071429 0.42857143
## [25] 0.44642857 0.46428571 0.48214286 0.50000000
##
## $dbz
##  [1]   9.0375857   7.9392696   6.0970355   3.5255514   0.3541688  -2.9790700
##  [7]  -5.7051703  -7.4758694  -8.6149275  -9.3561119  -9.8878147 -10.4987226
## [13] -11.3098685 -12.1762777 -12.8912699 -13.4102491 -13.7905910 -14.0605544
## [19] -14.2645648 -14.4911610 -14.7802640 -15.0778866 -15.3125559 -15.4700921
## [25] -15.5652043 -15.5991798 -15.5866630 -15.5732838
```

Both countries seem to show slight wandering upward trending Life Expectancy realizations. ACFs are slowly dampening and the Parzen spectral densities have peaks at 0 indicating that the realization is wandering

Both countries seem to have upward trending GDP, it looks like the right half of a parabolic curve (may possibly indicate a quadratic root). The ACFs are slowly dampening, and there is a peak at 0.0 Frequency implying that it is wandering

The realization for Population seems to be linear for both Mexico and the United States. Like the ACFs and Spectral density for GDP & Life Expectancy, population follows the same pattern of slowly dampening ACFs and peaks near 0 for Spectral Density.

Identifying and Fitting Univariate ARMA models for Mexico & US

```
#did AR Models initially, but thought ARMA would be better
aic5.ar.wge(Mexico$Life.Expectancy,p=0:10,type="bic",method="burg")
```

```
## ---------WORKING... PLEASE WAIT...
##
##
## Five Smallest Values of  bic
## Method= burg
##     p        bic
##     5  -11.73802
##     6  -11.69466
##     4  -11.68973
##     7  -11.67363
##     8  -11.62559
```

```
aic5.ar.wge(UnitedStates$Life.Expectancy,p=0:10,type="aic",method="burg")
```

```
## ---------WORKING... PLEASE WAIT...
##
##
## Five Smallest Values of  aic
## Method= burg
##     p        aic
##     9  -2.864321
##    10  -2.856113
##     7  -2.806725
##     8  -2.801305
##     6  -2.800696
```

```
aic5.wge(Mexico$Life.Expectancy,p=0:10,q=0:5,type="bic") #top suggestion is an ARMA(5,2), ARMA (5,4)
```

```
## ---------WORKING... PLEASE WAIT...
##
##
## Error in aic calculation at 3 4
## Error in aic calculation at 4 2
## Error in aic calculation at 4 4
## Error in aic calculation at 4 5
## Error in aic calculation at 5 1
## Error in aic calculation at 5 3
## Error in aic calculation at 5 5
## Error in aic calculation at 6 2
## Error in aic calculation at 6 5
## Error in aic calculation at 7 2
## Error in aic calculation at 7 5
## Error in aic calculation at 8 1
## Error in aic calculation at 8 5
## Error in aic calculation at 9 0
## Error in aic calculation at 9 1
## Error in aic calculation at 9 3
## Error in aic calculation at 10 3
## Error in aic calculation at 10 4
## Five Smallest Values of  bic
##     p    q        bic
##     5    2  -11.61208
##     5    4  -11.59794
##     7    3  -11.51222
##     7    0  -11.32805
##     8    0  -11.25970
```

```
aic5.wge(UnitedStates$Life.Expectancy,p=0:10,q=0:5,type="bic") #top suggestion is an ARMA(7,1), ARMA(4,0)
```

```
## ---------WORKING... PLEASE WAIT...
##
##
## Error in aic calculation at 2 1
## Error in aic calculation at 2 5
## Error in aic calculation at 3 1
## Five Smallest Values of  bic
##     p    q        bic
##     7    1  -2.599075
##     4    0  -2.557799
##     8    1  -2.552661
##     3    0  -2.546903
##     6    0  -2.545434
```

```
M_ARMA1=est.arma.wge(Mexico$Life.Expectancy,p=5,q=2)
```

```
##
##
## Coefficients of AR polynomial:
## 2.9010 -1.9122 -1.8749 2.8820 -0.9961
##
##                             AR Factor Table
## Factor                 Roots                Abs Recip    System Freq
## 1-1.8976B+1.0000B^2    0.9488+-0.3159i      1.0000       0.0511
## 1-1.9995B+0.9999B^2    0.9998+-0.0202i      1.0000       0.0032
## 1+0.9961B             -1.0039               0.9961       0.5000
##
##
##
##
## Coefficients of MA polynomial:
## -1.2447 -0.2647
##
##                                MA FACTOR TABLE
## Factor                 Roots                Abs Recip    System Freq
## 1+0.9725B             -1.0282               0.9725       0.5000
## 1+0.2721B             -3.6745               0.2721       0.5000
##
##
```

```
M_ARMA2=est.arma.wge(Mexico$Life.Expectancy,p=5,q=4)
```

```
##
##
## Coefficients of AR polynomial:
## 3.5213 -4.3562 1.8117 0.3592 -0.3361
##
##                             AR Factor Table
## Factor                 Roots                Abs Recip    System Freq
## 1-1.9966B+0.9970B^2    1.0013+-0.0208i      0.9985       0.0033
## 1-1.8732B+0.9676B^2    0.9680+-0.3107i      0.9837       0.0494
## 1+0.3484B             -2.8699               0.3484       0.5000
##
##
##
##
## Coefficients of MA polynomial:
## -0.3353 0.0276 -0.0519 0.0449
##
##                                MA FACTOR TABLE
## Factor                 Roots                Abs Recip    System Freq
## 1+0.6564B             -1.5235               0.6564       0.5000
## 1+0.0311B+0.1941B^2   -0.0801+-2.2683i      0.4406       0.2556
## 1-0.3522B              2.8397               0.3522       0.0000
##
##
```

```
US_ARMA1=est.arma.wge(UnitedStates$Life.Expectancy,p=7,q=1)
```

```
##
##
## Coefficients of AR polynomial:
## 0.1646 0.9860 0.1398 -0.1198 0.2276 0.0579 -0.4788
##
##                            AR Factor Table
## Factor                 Roots                Abs Recip    System Freq
## 1-1.9566B+0.9598B^2    1.0192+-0.0548i      0.9797       0.0086
## 1+0.9670B             -1.0342               0.9670       0.5000
## 1+1.3356B+0.7982B^2   -0.8367+-0.7435i      0.8934       0.3844
## 1-0.5106B+0.6463B^2    0.3950+-1.1795i      0.8040       0.1986
##
##
##
##
## Coefficients of MA polynomial:
## -0.7825
##
##                               MA FACTOR TABLE
## Factor                 Roots                Abs Recip    System Freq
## 1+0.7825B             -1.2779               0.7825       0.5000
##
##
```

```
US_ARMA2=est.arma.wge(UnitedStates$Life.Expectancy,p=4)
```

```
##
##
## Coefficients of AR polynomial:
## 1.0261 0.3066 -0.0457 -0.2923
##
##                            AR Factor Table
## Factor                 Roots                Abs Recip    System Freq
## 1-0.9827B              1.0176               0.9827       0.0000
## 1-0.8565B              1.1675               0.8565       0.0000
## 1+0.8131B+0.3473B^2   -1.1708+-1.2284i      0.5893       0.3712
##
##
```

Mexico Model's respective factor table observations:

- Model 1 and 2 have 2 imaginary roots in the AR side. 2 roots on AR side with absolute reciprocals of 1, system frequency has peaks close to 0.
- Model 2 has an imaginary root in the MA side. 2 roots on AR side with absolute reciprocals close to 1, system frequency has peaks closer to 0, indicating wandering behavior

US Model's respective factor table observations:

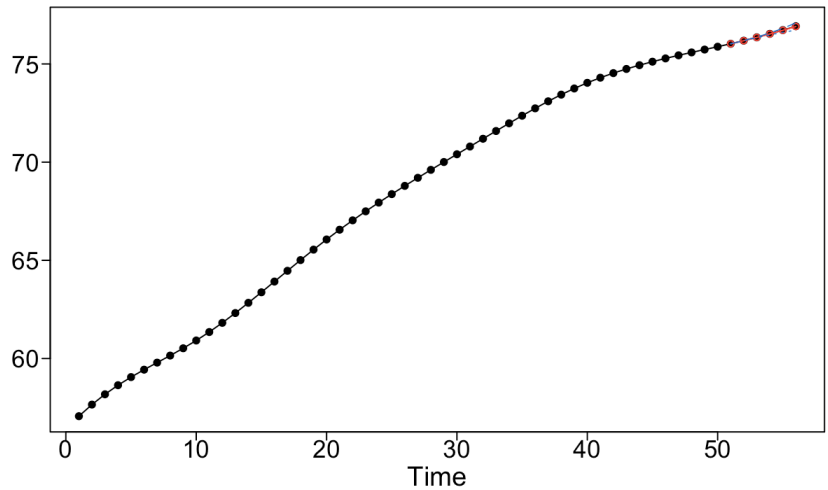
- Model 1 has 3 imaginary roots in the AR side. Model 1 AR side has 2 roots with absolute reciprocals closer to 1, indicating possible wandering behavior
- Model 2 has an imaginary root in the AR side. Model 2's AR side, has 2 roots that have roots closer to 1, indicating possible wandering behavior; there are also peaks at the spectral density at 0.

Forecasting with the fitted ARMA models for each respective country

Choosing short horizon of 5 and long horizon of 10 for Forecasting

Mexico

```
#Short & Long term Forecast with ASE & RMSE Model 1
SF_M1=fore.arma.wge(Mexico$Life.Expectancy,phi=M_ARMA1$phi,theta=M_ARMA1$theta,n.ahead = 5,lastn=T,limits=T)
```

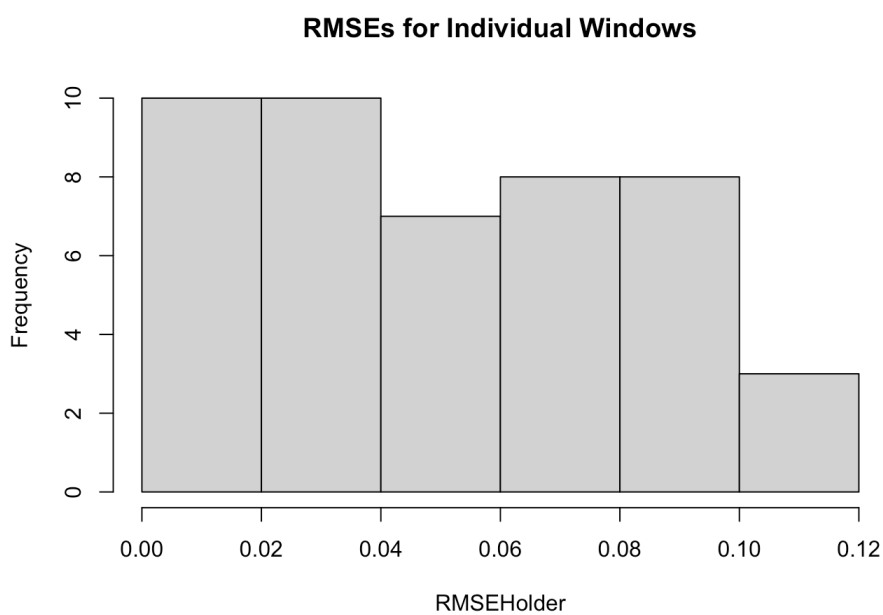



```
ASE=mean((Mexico$Life.Expectancy[52:56]-SF_M1$f)^2)
ASE #7.811939e^-5
```

```
## [1] 7.811939e-05
```

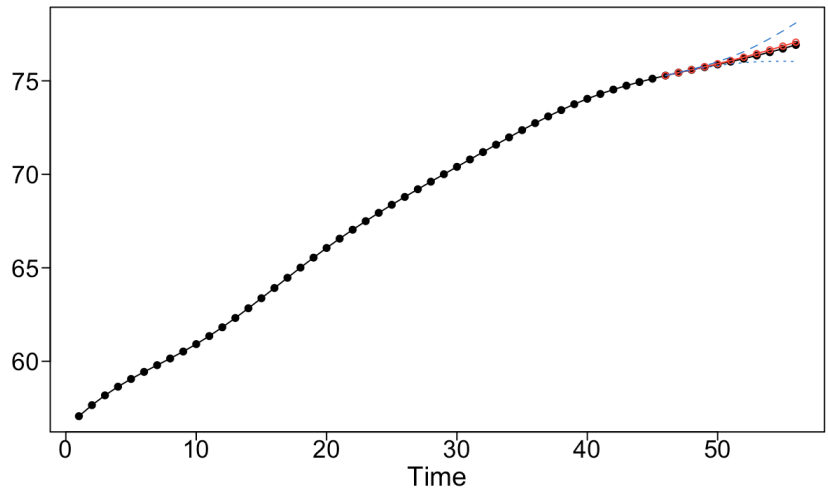
```
roll.win.rmse.wge(Mexico$Life.Expectancy,horizon=5,phi=M_ARMA1$phi,theta=M_ARMA1$theta) #.05
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 46 windows."
```




```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## 0.001106 0.026647 0.045366 0.049686 0.074311 0.114891
## [1] "The Rolling Window RMSE is:  0.05"
```

```
LF_M1=fore.arma.wge(Mexico$Life.Expectancy,phi=M_ARMA1$phi,theta=M_ARMA1$theta,n.ahead = 10,lastn=T,limits=T)
```

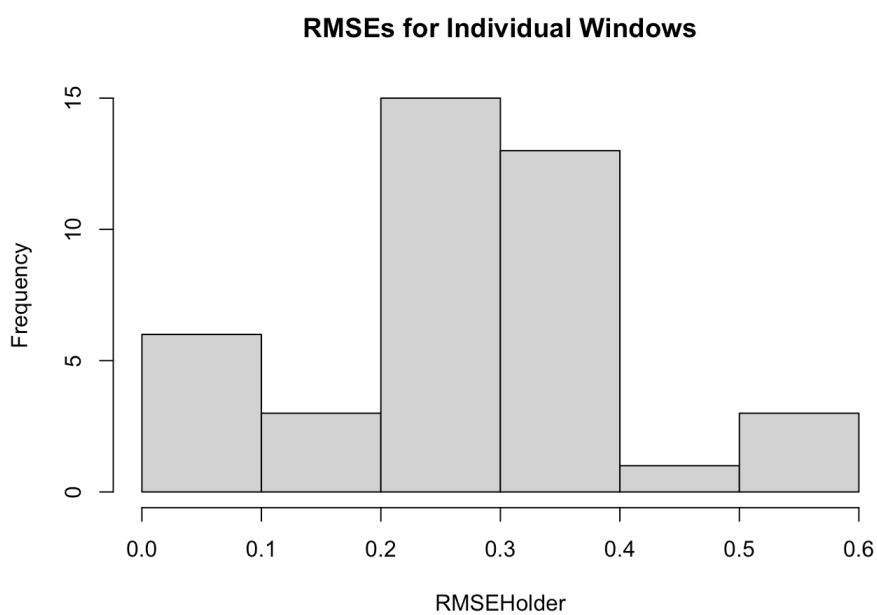



```
ASE=mean((Mexico$Life.Expectancy[47:56]-LF_M1$f)^2)
ASE #0.007747863
```

```
## [1] 0.007747863
```

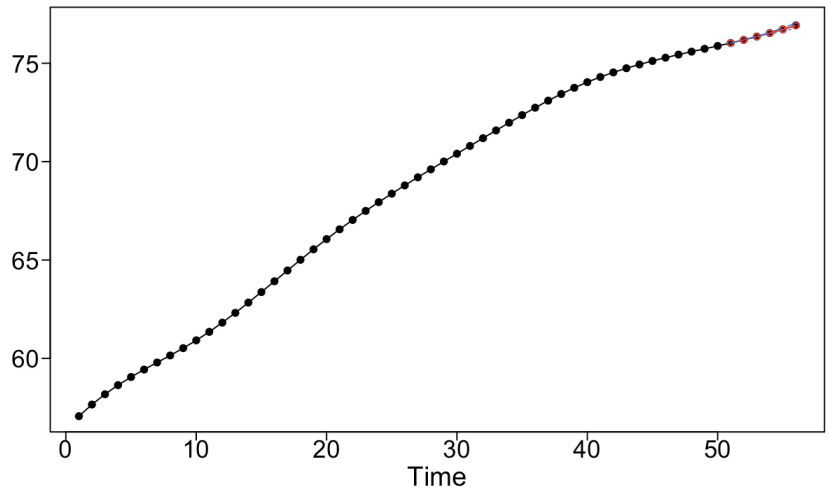
```
roll.win.rmse.wge(Mexico$Life.Expectancy,horizon=10,phi=M_ARMA1$phi,theta=M_ARMA1$theta) #.269
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 41 windows."
```




```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.0113  0.2162  0.2721  0.2688  0.3439  0.5412
## [1] "The Rolling Window RMSE is:  0.269"
```

```
#Short & Long term Forecast with ASE & RMSE Model 2

SF_M2=fore.arma.wge(Mexico$Life.Expectancy,phi=M_ARMA2$phi,theta=M_ARMA2$theta,n.ahead=5,lastn=T,limits=T)
```

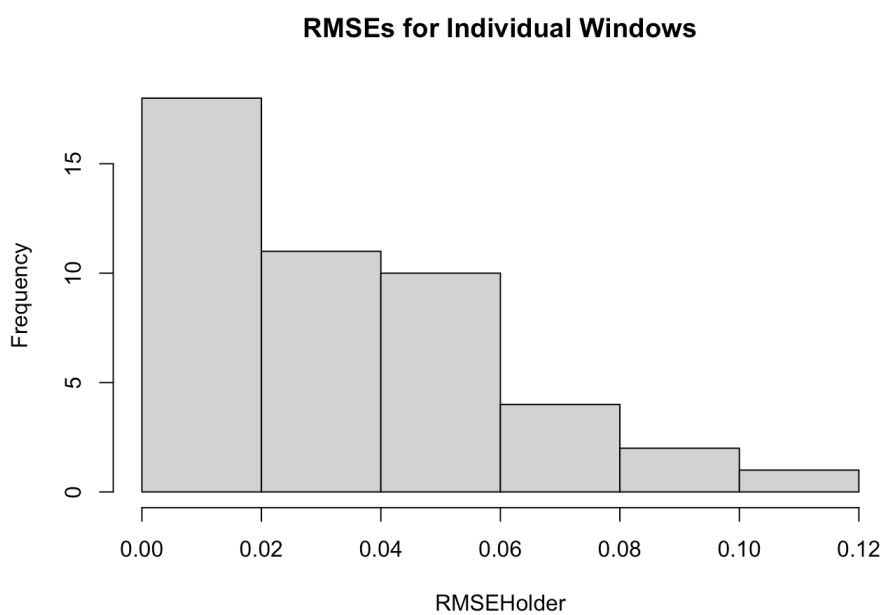



```
ASE=mean((Mexico$Life.Expectancy[52:56]-SF_M2$f)^2)
ASE #0.00011528
```

```
## [1] 0.00011528
```

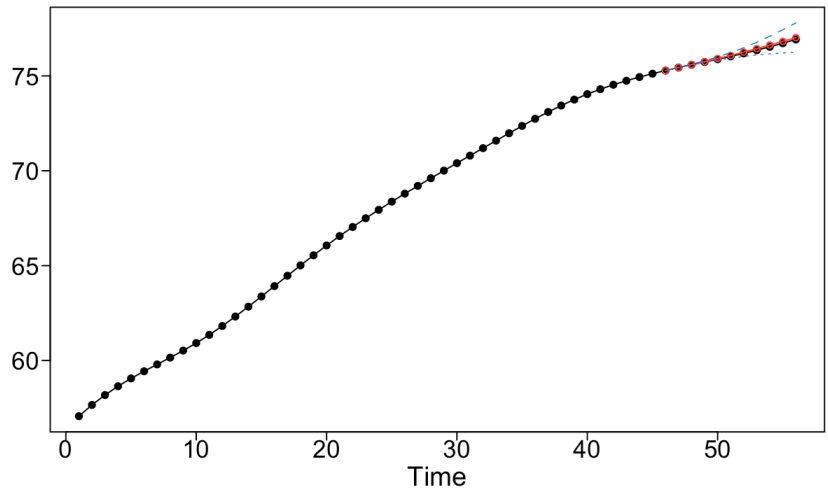
```
roll.win.rmse.wge(Mexico$Life.Expectancy,horizon=5,phi=M_ARMA2$phi,theta=M_ARMA2$theta) #.033
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 46 windows."
```




```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##      Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
## 0.0007278 0.0095549 0.0317057 0.0325199 0.0483059 0.1048077
## [1] "The Rolling Window RMSE is:  0.033"
```

```
LF_M2=fore.arma.wge(Mexico$Life.Expectancy,phi=M_ARMA2$phi,theta=M_ARMA2$theta,n.ahead=10,lastn=T,limits=T)
```

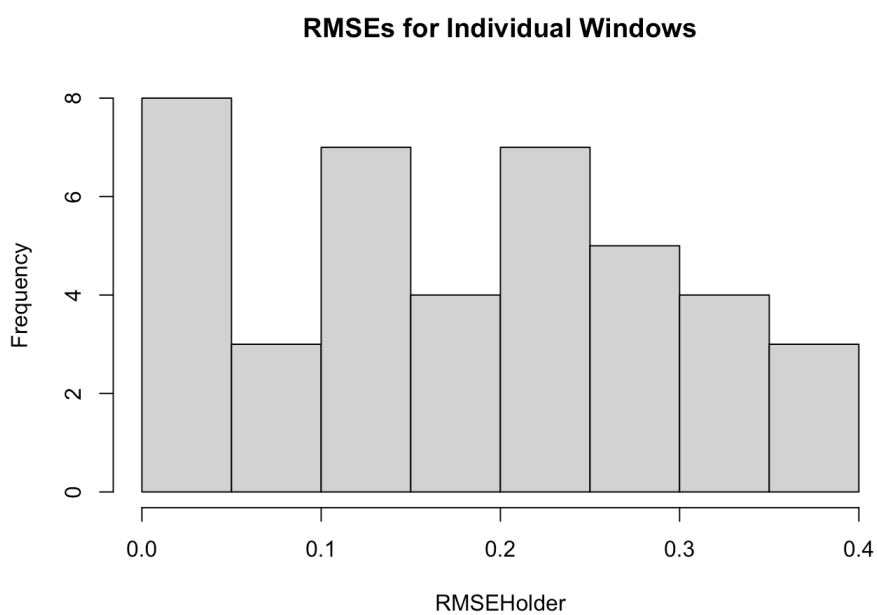



```
ASE=mean((Mexico$Life.Expectancy[47:56]-LF_M2$f)^2)
ASE #0.004462134
```

```
## [1] 0.004462134
```

```
roll.win.rmse.wge(Mexico$Life.Expectancy,horizon=10,phi=M_ARMA2$phi,theta=M_ARMA2$theta) #.181
```

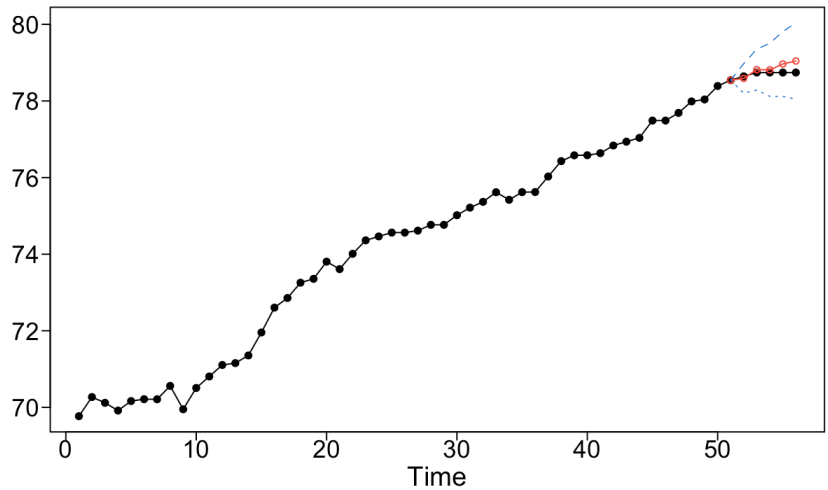
```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 41 windows."
```




```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.00643 0.08255 0.17699 0.18081 0.26508 0.36790
## [1] "The Rolling Window RMSE is:  0.181"
```

United States

```
#Short & long term Forecast with ASE & RMSE Model 1
SF_U1=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_ARMA1$phi,theta=US_ARMA1$theta,n.ahead = 5,lastn=T,limits
=T)
```

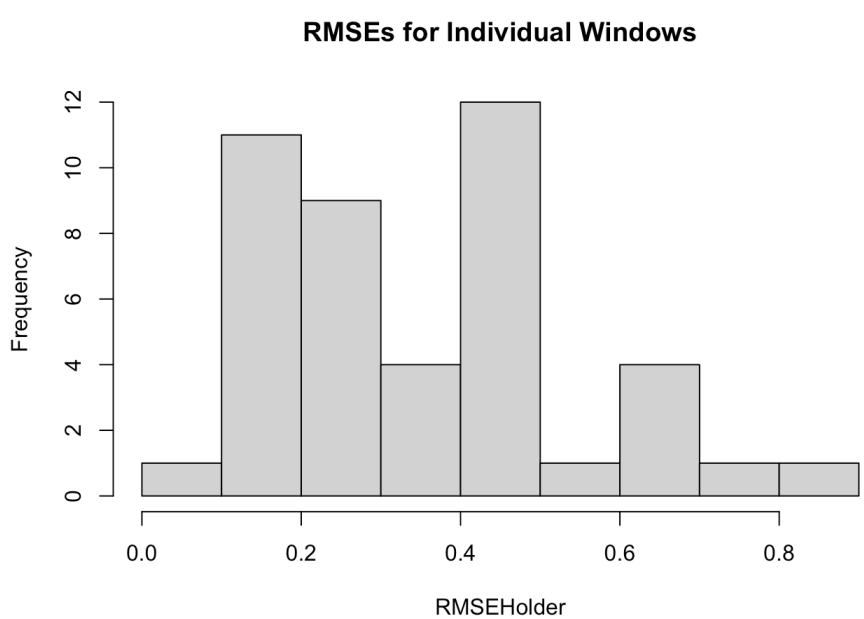



```
ASE=mean((UnitedStates$Life.Expectancy[52:56]-SF_U1$f)^2)
ASE #0.03084328
```

```
## [1] 0.03084328
```

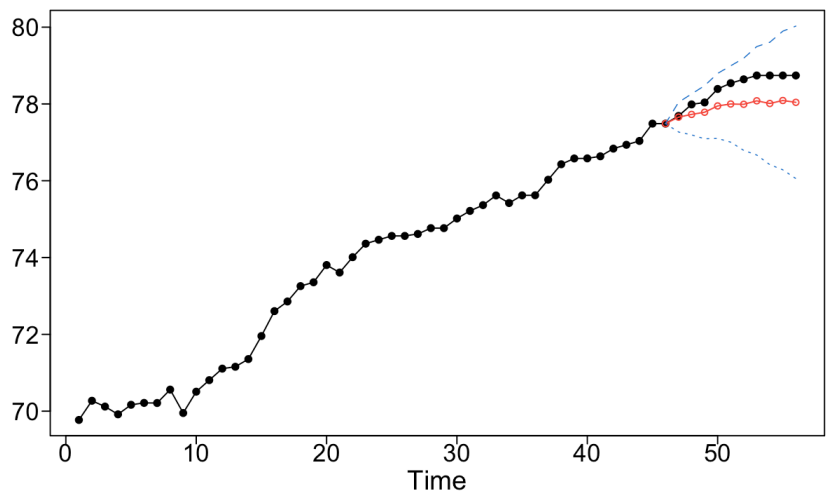
```
roll.win.rmse.wge(UnitedStates$Life.Expectancy,horizon=5,phi=US_ARMA1$phi,theta=US_ARMA1$theta) #.355
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 44 windows."
```



```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.09265 0.19385 0.30711 0.35461 0.46886 0.88990
## [1] "The Rolling Window RMSE is:  0.355"
```

```
LF_U1=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_ARMA1$phi,theta=US_ARMA1$theta,n.ahead = 10,lastn=T,limit
s=T)
```

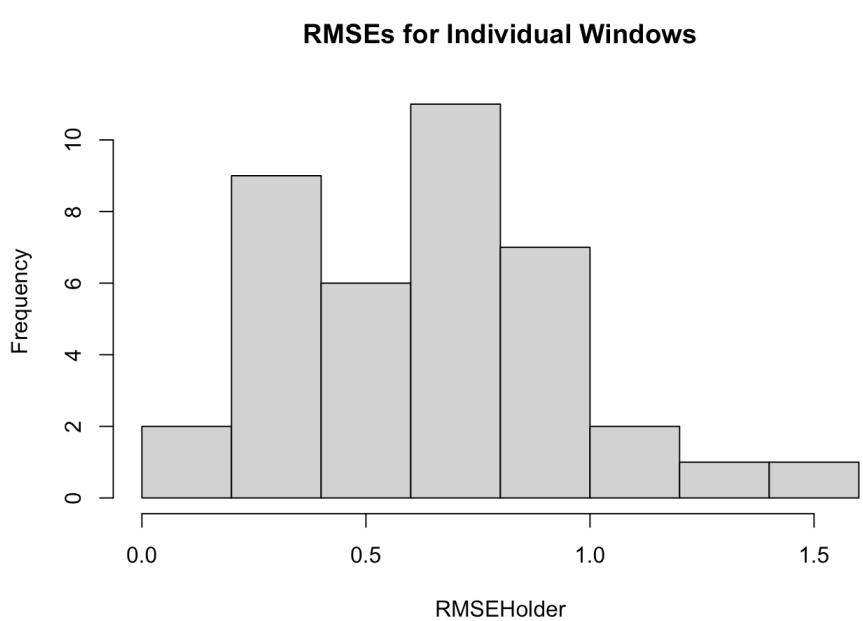



```
ASE=mean((UnitedStates$Life.Expectancy[47:56]-LF_U1$f)^2)
ASE #0.2926274
```

```
## [1] 0.2926274
```

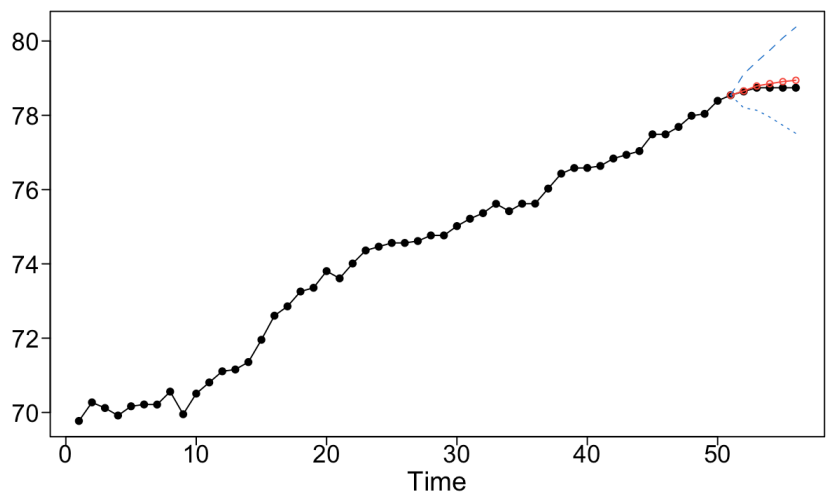
```
roll.win.rmse.wge(UnitedStates$Life.Expectancy,horizon=10,phi=US_ARMA1$phi,theta=US_ARMA1$theta) #.633
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 39 windows."
```



```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.1576  0.3433  0.6227  0.6327  0.9096  1.5564
## [1] "The Rolling Window RMSE is:  0.633"
```

```
#Short & long term Forecast with ASE & RMSE Model 2

SF_U2=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_ARMA2$phi,theta=US_ARMA2$theta,n.ahead=5,lastn=T,limits=
T)
```

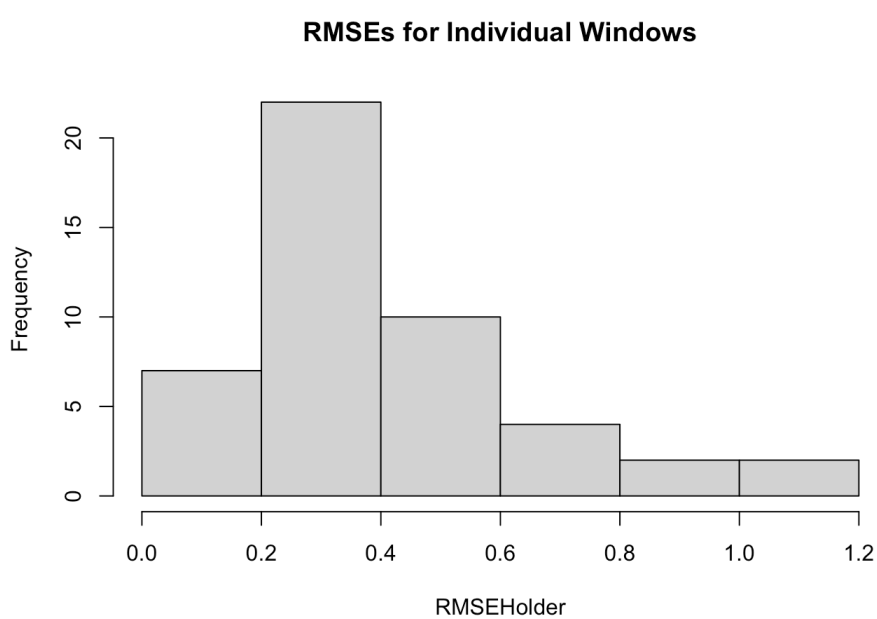



```
ASE=mean((UnitedStates$Life.Expectancy[52:56]-SF_U2$f)^2)
ASE # 0.01653549
```

```
## [1] 0.01653549
```

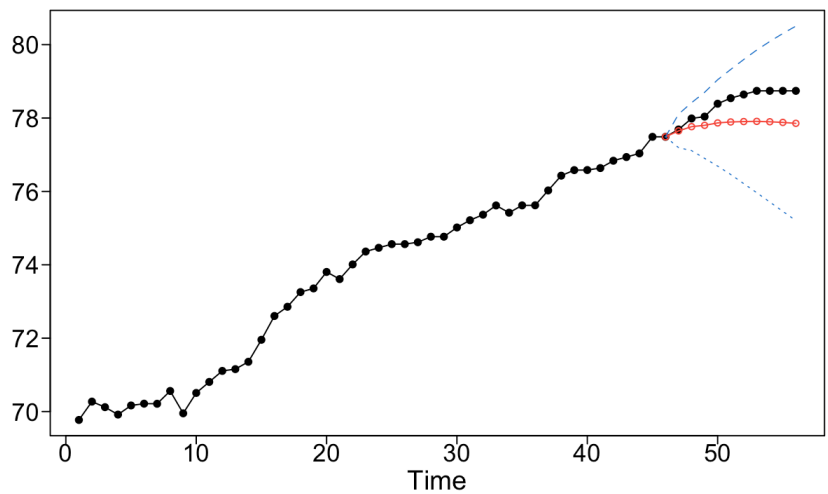
```
roll.win.rmse.wge(UnitedStates$Life.Expectancy,horizon=5,phi=US_ARMA2$phi,theta=US_ARMA2$theta) #.399
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 47 windows."
```



```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.04862 0.24221 0.30798 0.39874 0.50183 1.17277
## [1] "The Rolling Window RMSE is:  0.399"
```

```
LF_U2=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_ARMA2$phi,theta=US_ARMA2$theta,n.ahead=10,lastn=T,limits=
T)
```

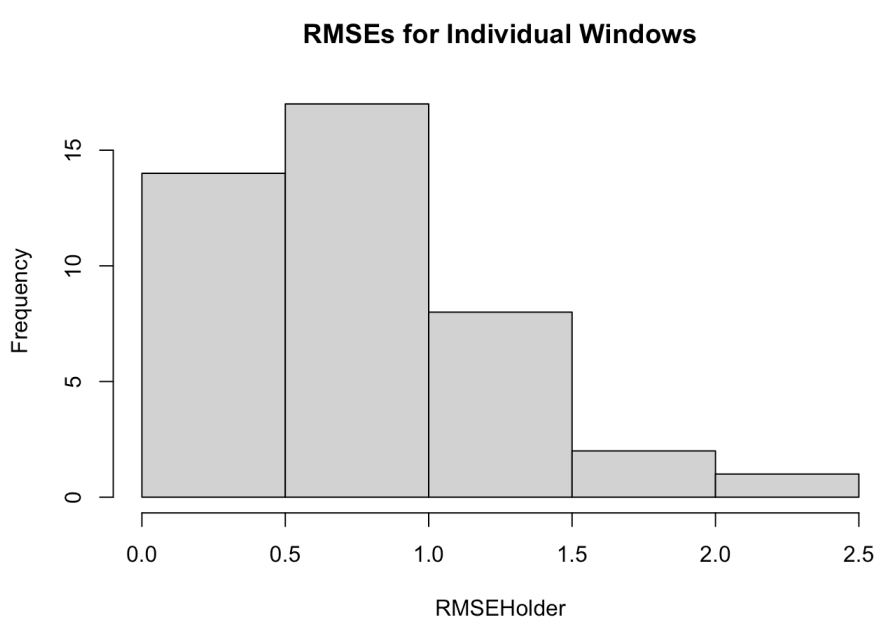



```
ASE=mean((UnitedStates$Life.Expectancy[47:56]-LF_U2$f)^2)
ASE #0.4274855
```

```
## [1] 0.4274855
```

```
roll.win.rmse.wge(UnitedStates$Life.Expectancy,horizon=10,phi=US_ARMA2$phi,theta=US_ARMA2$theta) #.745
```

```
## [1] "Please Hold For a Moment, TSWGE is processing the Rolling Window RMSE with 42 windows."
```



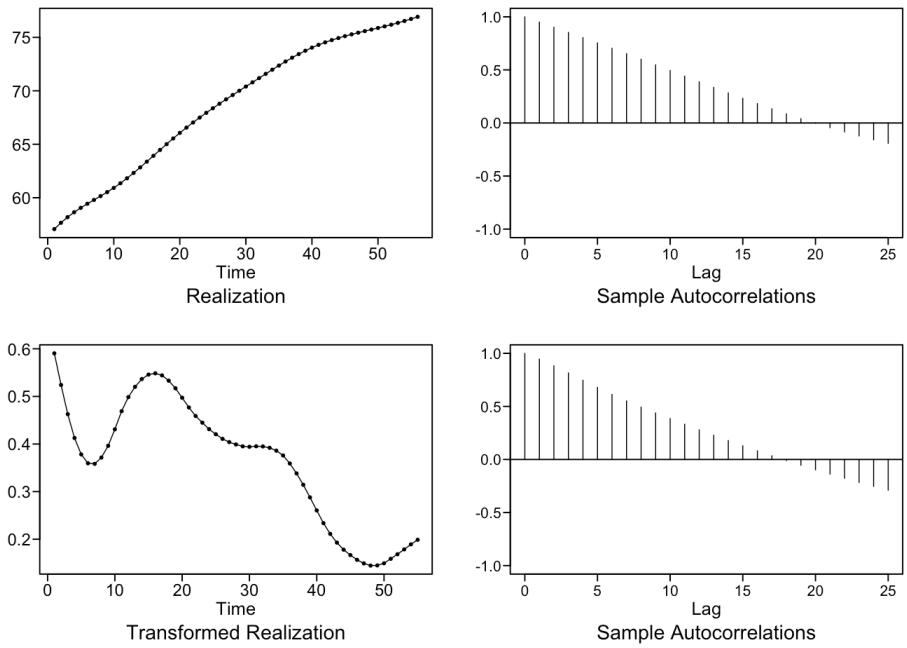
```
## [1] "The Summary Statistics for the Rolling Window RMSE Are:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.1545  0.3775  0.6787  0.7447  1.0027  2.2055
## [1] "The Rolling Window RMSE is:  0.745"
```

Differencing data to see if there is a noticeable change

Domain knowledge tells us that Life expectancy does not drastically change year over year. It changes when looking at a 5 year period, so on and so forth. Visually inspecting the plotts.sample.wge output above, there is no indication of seasonality.

Mexico Differenced data, the ACF does not seem to show white noise. However, United States, the ACF shows white noise. Both differenced data models do not seem to forecast as well as the above ARMA models.

```
#MEXICO
MexicoD1=artrans.wge(Mexico$Life.Expectancy,phi.tr=1)
```



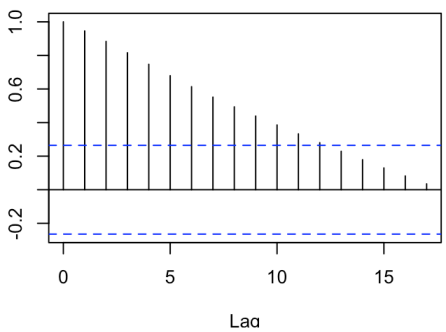

```
acf(MexicoD1) #doesnt look to be white noise
aic5.wge(MexicoD1,p=0:5,q=0:2,type="bic") # top suggestion is an AR(3) according to AIC & BIC
```

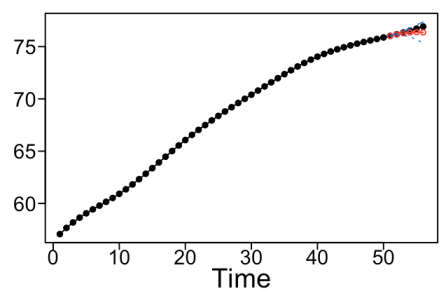
```
## ---------WORKING... PLEASE WAIT...
##
##
## Error in aic calculation at 3 1
## Error in aic calculation at 4 1
## Error in aic calculation at 4 2
## Five Smallest Values of  bic
##     p    q        bic
##     3    0  -12.03770
##     4    0  -11.96779
##     5    0  -11.89424
##     3    2  -11.85524
##     2    2  -11.33943
```

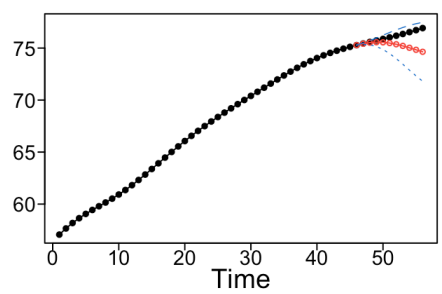
```
M_Diff_AR=est.ar.wge(MexicoD1,p=3)
```

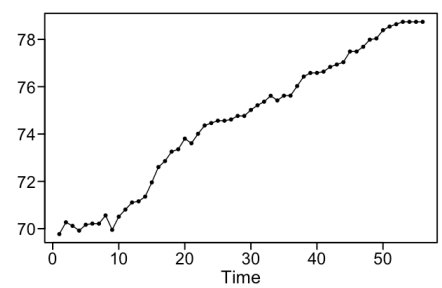
```
##
##
## Coefficients of AR polynomial:
## 2.8644 -2.8185 0.9538
##
##                              AR Factor Table
## Factor                  Roots                Abs Recip    System Freq
## 1-0.9963B               1.0038               0.9963       0.0000
## 1-1.8681B+0.9574B^2     0.9756+-0.3044i      0.9785       0.0481
##
##
```

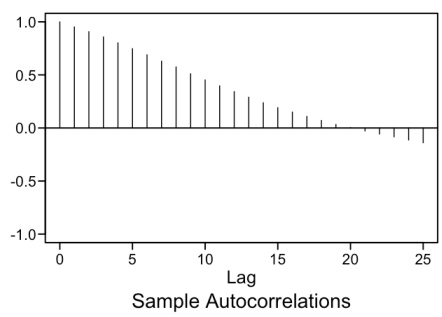
```
#getting: Warning: possible convergence problem: optim gave code = 1
M_Diff_F_Short=fore.arma.wge(Mexico$Life.Expectancy,phi=M_Diff_AR$phi,n.ahead=5,lastn=T,limits=T)
M_Diff_F_Long=fore.arma.wge(Mexico$Life.Expectancy,phi=M_Diff_AR$phi,n.ahead=10,lastn=T,limits=T)

#UNITED STATES
USD1=artrans.wge(UnitedStates$Life.Expectancy,phi.tr=1)
```

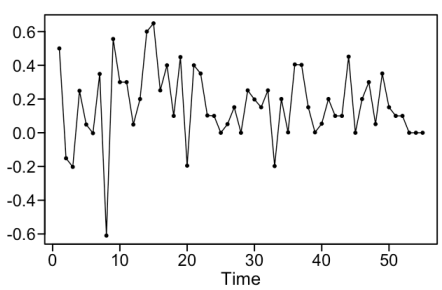


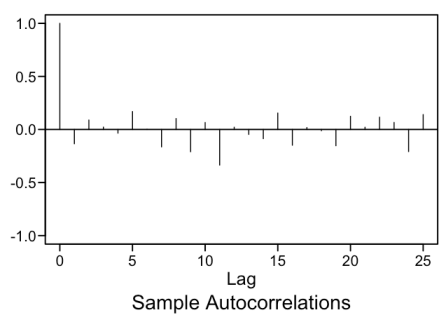












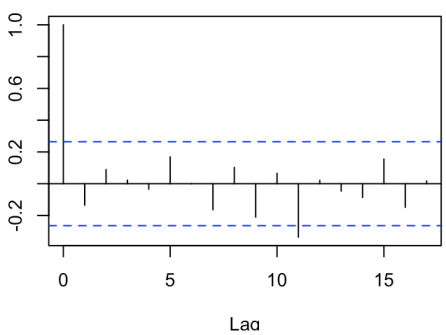
```
acf(USD1) #doesnt look to be white noise
aic5.wge(USD1,p=0:5,q=0:2,type="bic") # top suggestion is an AR(1) according to AIC & BIC
```

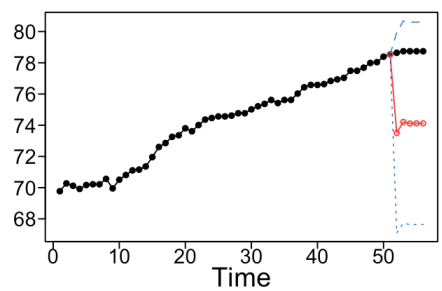
```
## ---------WORKING... PLEASE WAIT...
##
##
## Five Smallest Values of  bic
##     p    q        bic
##     0    0  -2.939697
##     1    0  -2.887042
##     0    1  -2.883641
##     2    0  -2.821713
##     1    1  -2.817517
```

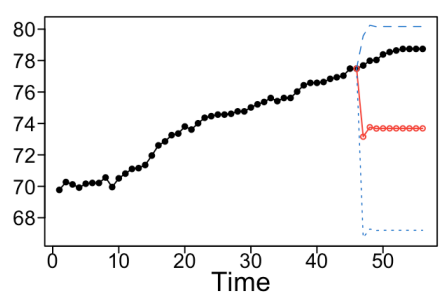
```
US_Diff_AR=est.ar.wge(USD1,p=1)
```

```
##
##
## Coefficients of AR polynomial:
## -0.1397
##
##                            AR Factor Table
## Factor                 Roots                Abs Recip    System Freq
## 1+0.1397B             -7.1593               0.1397       0.5000
##
##
```

```
#getting: Warning: possible convergence problem: optim gave code = 1
US_Diff_F_Short=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_Diff_AR$phi,n.ahead=5,lastn=T,limits=T)
US_Diff_F_Long=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_Diff_AR$phi,n.ahead=10,lastn=T,limits=T)
```





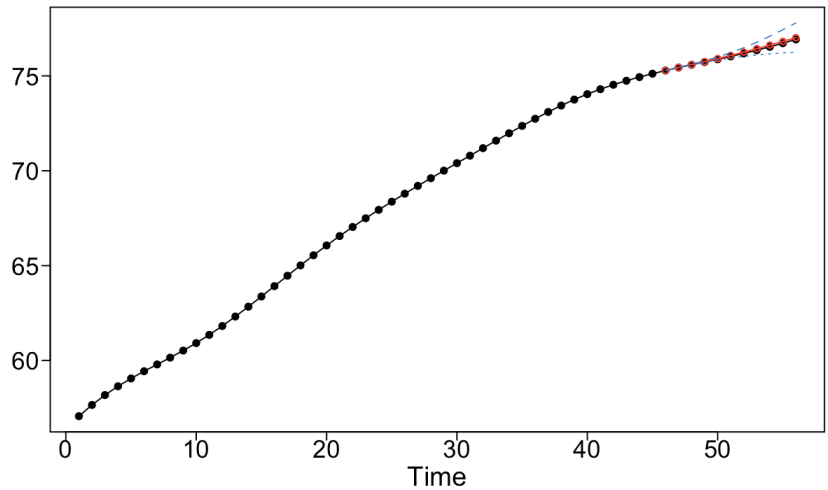


Of the Univariate ARMA Models, the second model is better for Mexico - ARMA (5,4). For the United States, the first model, ARMA(7,1) is better. The optimal most useful models were selected using ASE.

10 iteration Spectral Densities of the most useful ARMA models

Mexico:

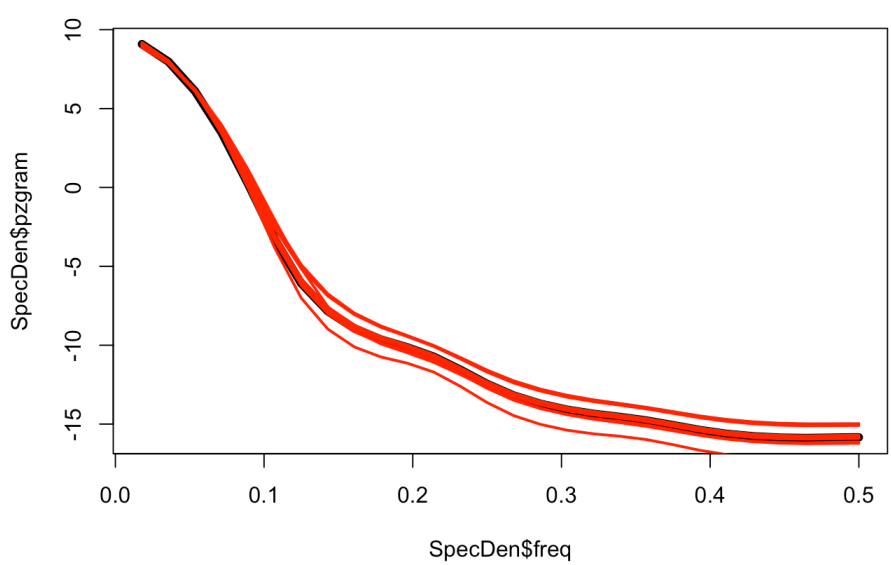
```
LF_M2=fore.arma.wge(Mexico$Life.Expectancy,phi=M_ARMA2$phi,theta=M_ARMA2$theta,n.ahead=10,lastn=T,limits=T)
```




```
ASE=mean((Mexico$Life.Expectancy[47:56]-LF_M2$f)^2)
ASE #0.004462134
```

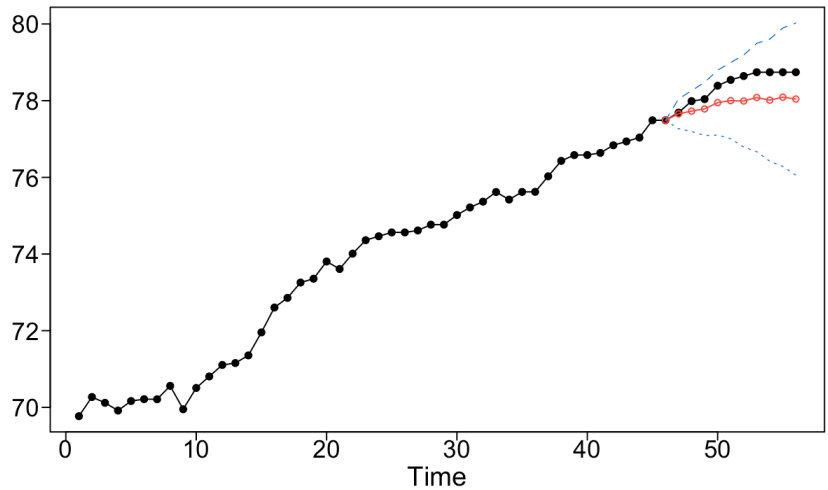
```
## [1] 0.004462134
```

```
#Compare Spectral Densities
sims = 10
SpecDen = parzen.wge(Mexico$Life.Expectancy, plot = "FALSE")
plot(SpecDen$freq,SpecDen$pzgram, type = "l", lwd = 6)

for( i in 1: sims)
{
   SpecDen2 = parzen.wge(gen.arma.wge(length(Mexico$Life.Expectancy),phi=M_ARMA2$phi,theta=M_ARMA2$theta,plot=F),
plot = FALSE)
   lines(SpecDen2$freq,SpecDen2$pzgram, lwd = 2, col = "red")
}
```



United States:

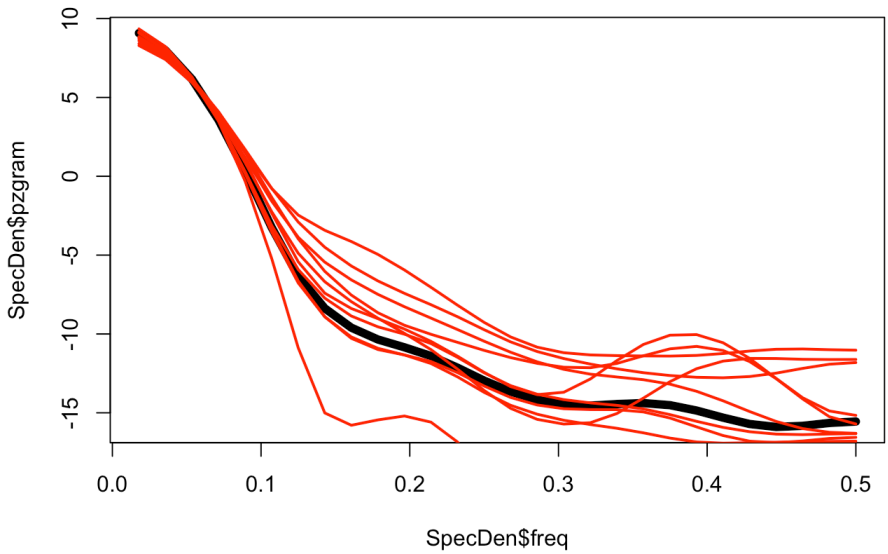
```
LF_U1=fore.arma.wge(UnitedStates$Life.Expectancy,phi=US_ARMA1$phi,theta=US_ARMA1$theta,n.ahead = 10,lastn=T,limit
s=T)
```




```
ASE=mean((UnitedStates$Life.Expectancy[47:56]-LF_U1$f)^2)
ASE #0.2926274
```

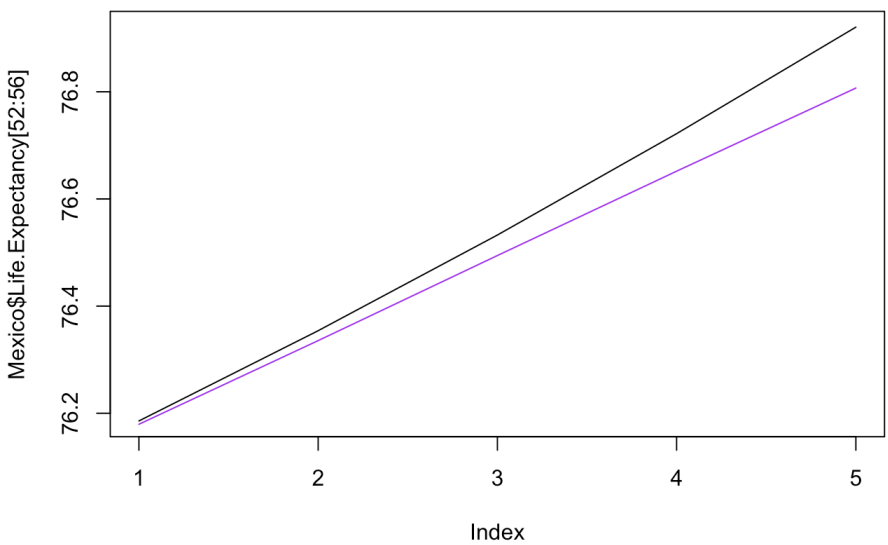
```
## [1] 0.2926274
```

```
#Compare Spectral Densities
sims = 10
SpecDen = parzen.wge(UnitedStates$Life.Expectancy, plot = "FALSE")
plot(SpecDen$freq,SpecDen$pzgram, type = "l", lwd = 6)

for( i in 1: sims)
{
   SpecDen2 = parzen.wge(gen.arma.wge(length(Mexico$Life.Expectancy),phi=US_ARMA1$phi,theta=US_ARMA1$theta,plot=
F),plot = FALSE)
   lines(SpecDen2$freq,SpecDen2$pzgram, lwd = 2, col = "red")
}
```



MLP model for Mexico (not used, as set.seed was not used)

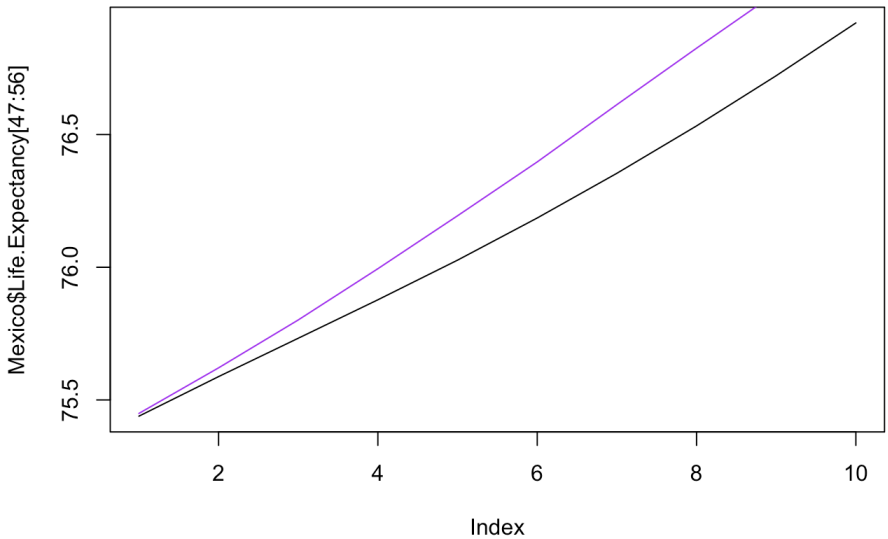
```
#short term fcst
MexicoTrain=ts(Mexico$Life.Expectancy[1:51])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=5,xreg=MexicoVar)
plot(Mexico$Life.Expectancy[52:56],type="l")
lines(seq(1,5),f$mean,col="purple")
```




```
ASE=mean((Mexico$Life.Expectancy[52:56]-f$mean)^2)
ASE #0.0003446278
```

```
## [1] 0.003937045
```

```
#long term fcst
MexicoTrain=ts(Mexico$Life.Expectancy[1:46])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=10,xreg=MexicoVar)
plot(Mexico$Life.Expectancy[47:56],type="l")
lines(seq(1,10),f$mean,col="purple")
```

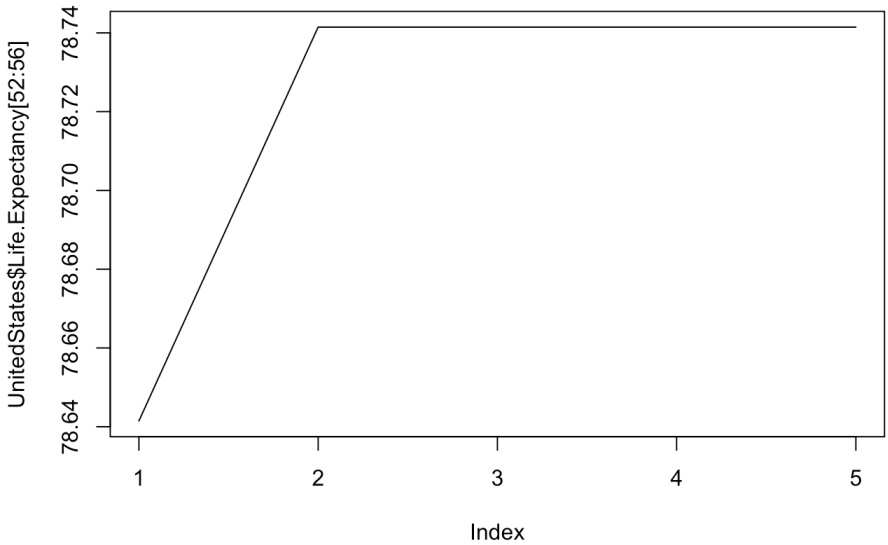



```
ASE=mean((Mexico$Life.Expectancy[47:56]-f$mean)^2)
ASE #0.02413821
```

```
## [1] 0.04423285
```

MLP model for United States (not used, as set.seed was not used)

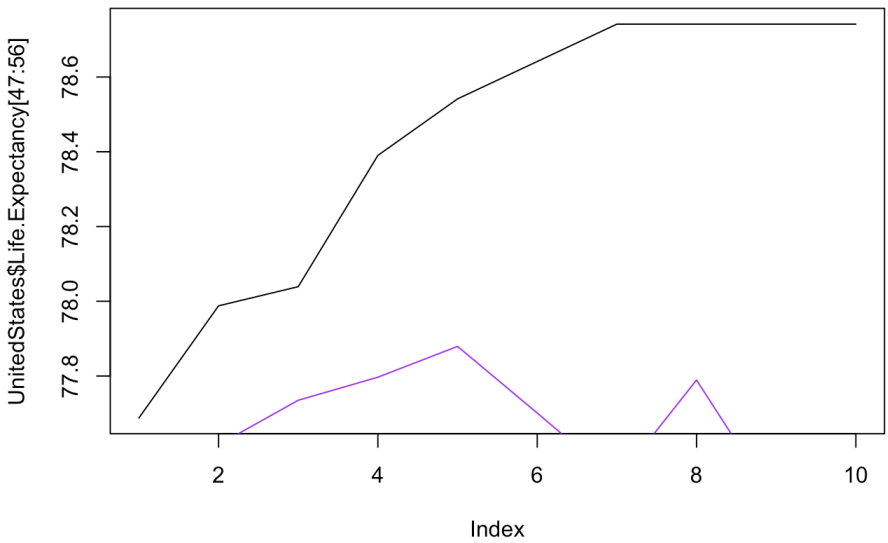
```
#short term fcst
USTrain=ts(UnitedStates$Life.Expectancy[1:51])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=5,xreg=USVar)
plot(UnitedStates$Life.Expectancy[52:56],type="l")
lines(seq(1,5),f$mean,col="purple")
```



```
ASE=mean((UnitedStates$Life.Expectancy[52:56]-f$mean)^2)
ASE #0.5191963
```

```
## [1] 0.3722898
```

```
#long term fcst
USTrain=ts(UnitedStates$Life.Expectancy[1:46])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=10,xreg=USVar)
plot(UnitedStates$Life.Expectancy[47:56],type="l")
lines(seq(1,10),f$mean,col="purple")
```




```
ASE=mean((UnitedStates$Life.Expectancy[47:56]-f$mean)^2)
ASE #0.1066129
```

```
## [1] 0.7721241
```

VAR Mexico Short-Term 5 year

```
# Short Term
Mexico
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
## 52  Mexico          MEX Latin America & Caribbean Upper middle income 2011
## 53  Mexico          MEX Latin America & Caribbean Upper middle income 2012
## 54  Mexico          MEX Latin America & Caribbean Upper middle income 2013
## 55  Mexico          MEX Latin America & Caribbean Upper middle income 2014
## 56  Mexico          MEX Latin America & Caribbean Upper middle income 2015
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
```

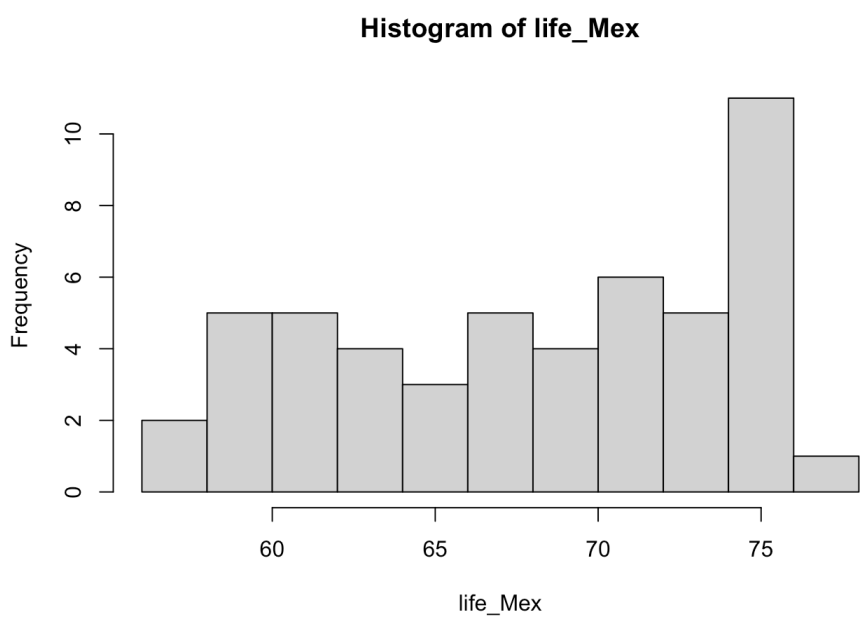
```
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
## 52        76.18566 1.230000e+12  114150481
## 53        76.35410 1.260000e+12  115755909
## 54        76.53266 1.330000e+12  117290686
## 55        76.72185 1.360000e+12  118755887
## 56        76.92068 1.210000e+12  120149897
```

```
Mex_small = Mexico[1:51,] # first 47, predict next 10 years for forecast
Mex_small
```

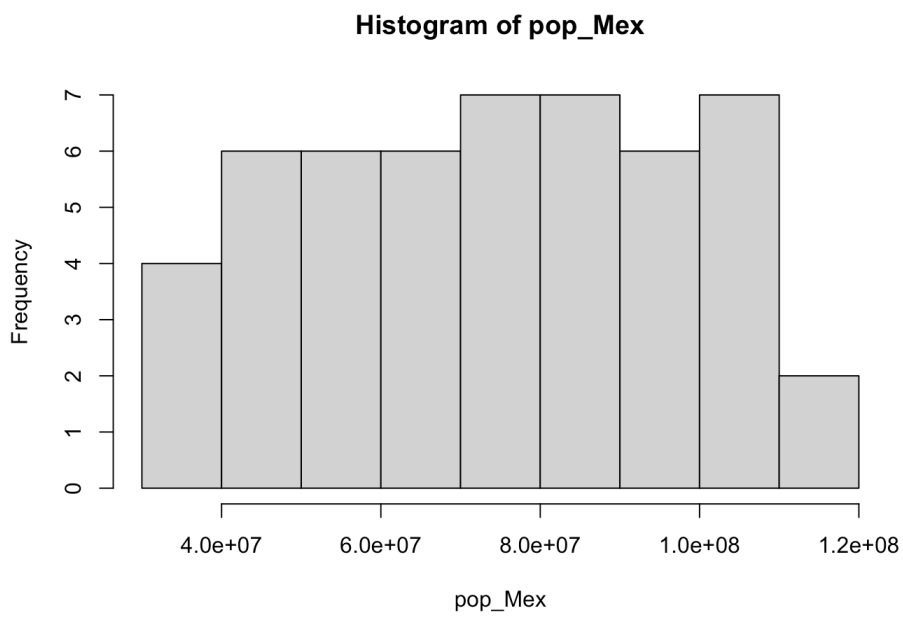
```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
```

```
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
```

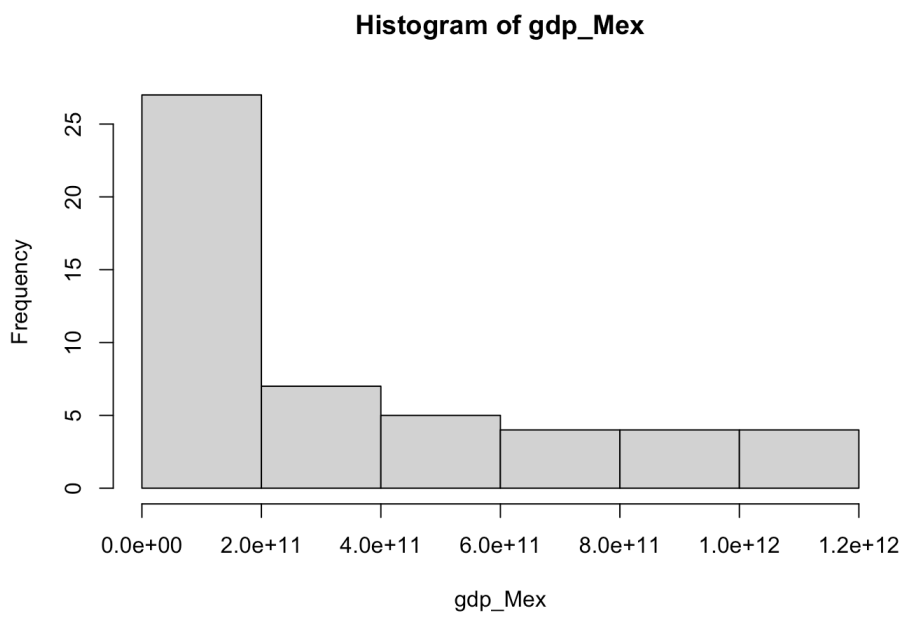
```
pop_Mex = Mex_small$Population
gdp_Mex = Mex_small$GDP
life_Mex = Mex_small$Life.Expectancy
hist(life_Mex)
```




```
hist(pop_Mex)
```



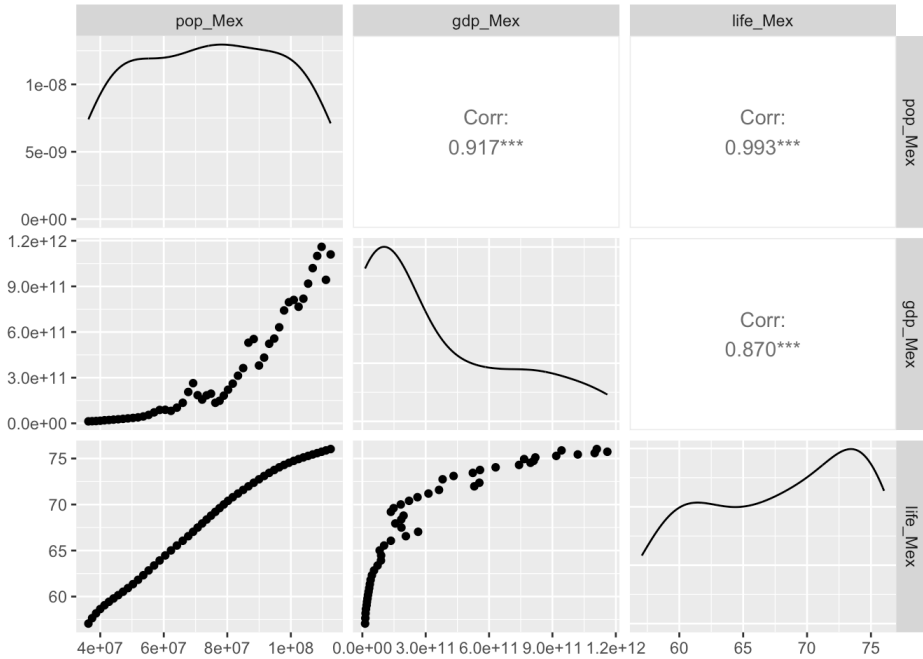

```
hist(gdp_Mex)
```




```
# Create dataframe for MLP model
tsMex_dataframe = data.frame(pop_Mex, gdp_Mex, life_Mex) # all years in a dataframe use for xreg
tsMex_dataframe
```

```
##      pop_Mex      gdp_Mex life_Mex
## 1   36268055 1.304000e+10 57.06563
## 2   37439317 1.416000e+10 57.65615
## 3   38683283 1.520000e+10 58.18024
## 4   39982118 1.696000e+10 58.64290
## 5   41333878 2.008000e+10 59.05559
## 6   42737991 2.184000e+10 59.43371
## 7   44180437 2.432000e+10 59.79322
## 8   45656963 2.656000e+10 60.15154
## 9   47170337 2.936000e+10 60.52310
## 10  48714394 3.248000e+10 60.91937
## 11  50289306 3.552000e+10 61.35024
## 12  51897675 3.920000e+10 61.81917
## 13  53543436 4.520000e+10 62.31766
## 14  55228203 5.528000e+10 62.83783
## 15  56945880 7.200000e+10 63.37427
## 16  58691882 8.800000e+10 63.92015
## 17  60452543 8.887592e+10 64.46861
## 18  62262505 8.191202e+10 65.01283
## 19  64123997 1.030000e+11 65.54593
## 20  65972912 1.350000e+11 66.06302
## 21  67705186 2.060000e+11 66.56022
## 22  69233769 2.640000e+11 67.03705
## 23  70656783 1.850000e+11 67.49593
## 24  72080310 1.560000e+11 67.94078
## 25  73489654 1.840000e+11 68.37202
## 26  74872006 1.950000e+11 68.79261
## 27  76224365 1.350000e+11 69.20344
## 28  77553504 1.480000e+11 69.60741
## 29  78892015 1.820000e+11 70.00649
## 30  80233749 2.210000e+11 70.40159
## 31  81720428 2.610000e+11 70.79573
## 32  83351595 3.130000e+11 71.19098
## 33  84993164 3.630000e+11 71.58583
## 34  86648447 5.300000e+11 71.97783
## 35  88314424 5.540000e+11 72.36385
## 36  89969572 3.800000e+11 72.73978
## 37  91586555 4.320000e+11 73.09890
## 38  93183094 5.230000e+11 73.43715
## 39  94767284 5.570000e+11 73.75141
## 40  96334810 6.310000e+11 74.03924
## 41  97873442 7.420000e+11 74.29973
## 42  99394288 7.960000e+11 74.53349
## 43 100917081 8.110000e+11 74.74471
## 44 102429341 7.660000e+11 74.93751
## 45 103945813 8.190000e+11 75.11549
## 46 105442402 9.180000e+11 75.28210
## 47 106886790 1.020000e+12 75.43878
## 48 108302973 1.100000e+12 75.58793
## 49 109684489 1.160000e+12 75.73246
## 50 111049428 9.430000e+11 75.87741
## 51 112532401 1.110000e+12 76.02678
```

```
ggpairs(data=tsMex_dataframe)
```




```
# Mex VAR
x_Mex = cbind(gdp_Mex,life_Mex, pop_Mex)
VAR_Mex = VARselect(x_Mex,lag.max = 8, type = "const")
VAR_Mex # AIC score selects phi=4
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      4      4      3      4
##
## $criteria
##                  1            2            3            4            5
## AIC(n) 6.684559e+01 6.215203e+01 5.893719e+01 5.864107e+01 5.871093e+01
## HQ(n)  6.702684e+01 6.246922e+01 5.939032e+01 5.923013e+01 5.943593e+01
## SC(n)  6.733709e+01 6.301215e+01 6.016594e+01 6.023844e+01 6.067693e+01
## FPE(n) 1.074914e+29 9.910413e+26 4.049407e+25 3.111033e+25 3.521373e+25
##                  6            7            8
## AIC(n) 5.881918e+01 5.869837e+01 5.881744e+01
## HQ(n)  5.968011e+01 5.969524e+01 5.995025e+01
## SC(n)  6.115379e+01 6.140160e+01 6.188930e+01
## FPE(n) 4.265806e+25 4.278342e+25 5.765251e+25
```

```
fit=VAR(x_Mex,p=4,type='const') # use phi=4, takes at 4 lags to see life expectancy
fit$p
```

```
## [1] 4
```

```
# summary(lsfit) # didnt work singularity - possible multi-collinaearity between varaibles
preds=predict(fit,n.ahead=5)
preds
```

```
## $gdp_Mex
##              fcst        lower        upper           CI
## [1,] 1.220339e+12 1.117164e+12 1.323514e+12 103175282336
## [2,] 1.253757e+12 1.139430e+12 1.368084e+12 114326812465
## [3,] 1.369787e+12 1.240039e+12 1.499535e+12 129748243027
## [4,] 1.408259e+12 1.257198e+12 1.559321e+12 151061251953
## [5,] 1.398383e+12 1.234491e+12 1.562276e+12 163892334894
##
## $life_Mex
##          fcst    lower    upper          CI
## [1,] 76.18127 76.17752 76.18502 0.003751827
## [2,] 76.33996 76.32668 76.35324 0.013276006
## [3,] 76.50215 76.47196 76.53235 0.030197098
## [4,] 76.66647 76.61110 76.72185 0.055374557
## [5,] 76.83089 76.74176 76.92002 0.089128115
##
## $pop_Mex
##           fcst     lower     upper        CI
## [1,] 114064773 113987303 114142243  77470.12
## [2,] 115614827 115402103 115827552 212724.45
## [3,] 117168488 116784544 117552433 383944.30
## [4,] 118697877 118137839 119257914 560037.83
## [5,] 120210424 119489286 120931561 721137.10
```

```
life.mex.f=preds$fcst$life_Mex[,1]
life.mex.f
```

```
## [1] 76.18127 76.33996 76.50215 76.66647 76.83089
```

```
t=1:56
t
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56
```

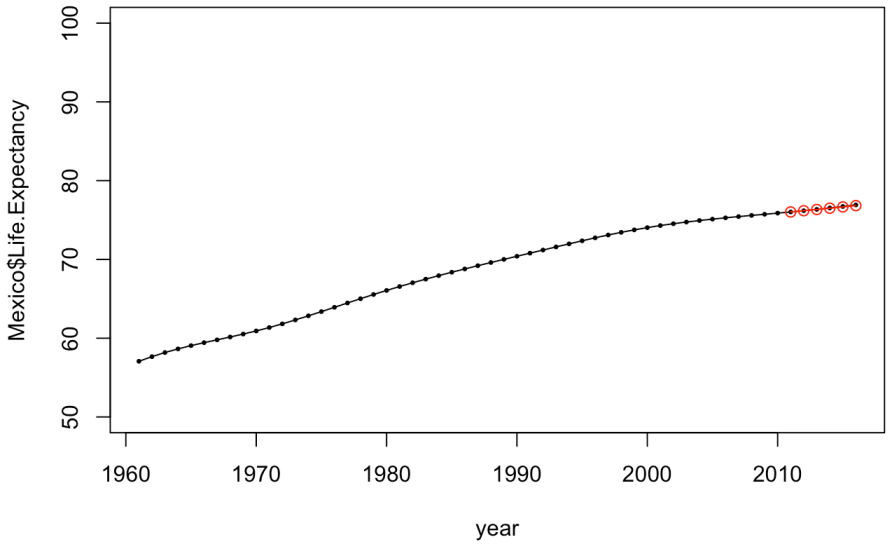
```
year=t+1960
year # 56 years
```

```
##  [1] 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975
## [16] 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
## [31] 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
## [46] 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
```

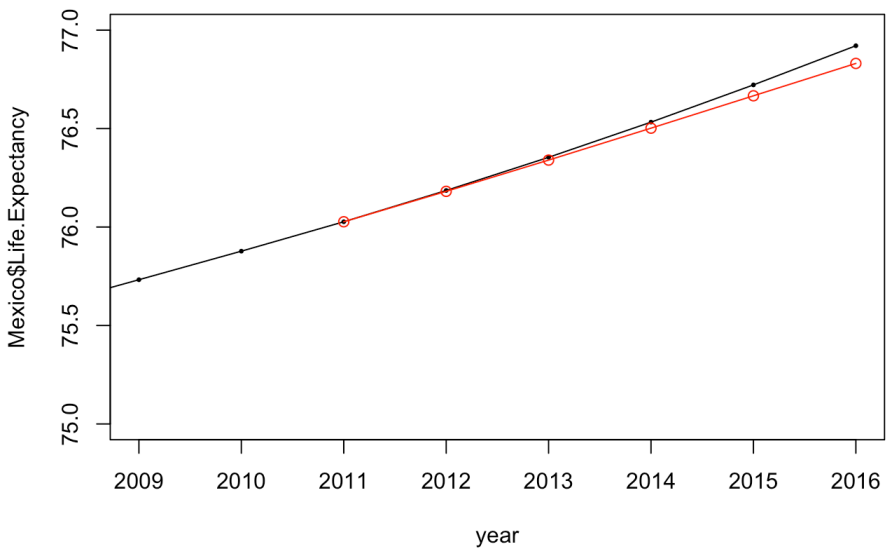
```
length(year)# Mexico Life.Expectancy forecast for last 5 years
```

```
## [1] 56
```

```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[51:56],c(Mexico$Life.Expectancy[51],life.mex.f),type='o',cex=1,pch=1, col='red') # we use 51-56 here
since and then we use the actual value at 51 followed by the 5 forecasts
```




```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2009,2016),ylim=c(75,77))  # zoom in on the plot s
o we can see the points
points(year[51:56],c(Mexico$Life.Expectancy[51],life.mex.f),type='o',cex=1,pch=1, col='red')
```




```
ASE = mean((Mexico$Life.Expectancy[52:56] - preds$fcst$life_Mex[1:5])^2) # ASE for the last 5 years
ASE #  0.002455944
```

```
## [1] 0.002455944
```

```
RMSE_VAR=sqrt(mean((Mexico$Life.Expectancy[52:56]-preds$fcst$life_Mex[,1][1:5])^2)) # RMSE for the last 10 years
RMSE_VAR # 0.04955748
```

```
## [1] 0.04955748
```

Consider the correlated variables and data spread. Not a lot of difference in GDP year to year.

Perhaps to improve for NN model accuracy scores the data could be scaled, however we will proceed with the data as is.

Given that our model variables are highly correlated, it was hypothesized that the VAR models may perform well.

Using VARSelects suggestion, a lag of 4 is utilized for the short term and a long term lag of 7.

Here we see the VAR models respective estimated coefficients for both short and long term.

SHORT TERM:

The forecasts for the short term at first seem to nearly overlap, on further inspection the short term 10th order VAR model is performing quite well. It does trail lower for the final two predictions.

VAR Mexico Long-Term 10 year

```
Mexico
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
## 52  Mexico          MEX Latin America & Caribbean Upper middle income 2011
## 53  Mexico          MEX Latin America & Caribbean Upper middle income 2012
## 54  Mexico          MEX Latin America & Caribbean Upper middle income 2013
## 55  Mexico          MEX Latin America & Caribbean Upper middle income 2014
## 56  Mexico          MEX Latin America & Caribbean Upper middle income 2015
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
```

```
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
## 52        76.18566 1.230000e+12  114150481
## 53        76.35410 1.260000e+12  115755909
## 54        76.53266 1.330000e+12  117290686
## 55        76.72185 1.360000e+12  118755887
## 56        76.92068 1.210000e+12  120149897
```

```
# Long Term  10 Year
# Mexico Data
Mex_small = Mexico[1:46,] # first 47, predict next 10 years for forecast
Mex_small
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
##    Life.Expectancy          GDP Population
## 1         57.06563  13040000000   36268055
## 2         57.65615  14160000000   37439317
## 3         58.18024  15200000000   38683283
## 4         58.64290  16960000000   39982118
## 5         59.05559  20080000000   41333878
## 6         59.43371  21840000000   42737991
## 7         59.79322  24320000000   44180437
## 8         60.15154  26560000000   45656963
## 9         60.52310  29360000000   47170337
## 10        60.91937  32480000000   48714394
## 11        61.35024  35520000000   50289306
## 12        61.81917  39200000000   51897675
## 13        62.31766  45200000000   53543436
## 14        62.83783  55280000000   55228203
## 15        63.37427  72000000000   56945880
## 16        63.92015  88000000000   58691882
## 17        64.46861  88875923765   60452543
## 18        65.01283  81912018784   62262505
## 19        65.54593 103000000000   64123997
## 20        66.06302 135000000000   65972912
## 21        66.56022 206000000000   67705186
## 22        67.03705 264000000000   69233769
## 23        67.49593 185000000000   70656783
## 24        67.94078 156000000000   72080310
## 25        68.37202 184000000000   73489654
## 26        68.79261 195000000000   74872006
```

```
## 27        69.20344 135000000000   76224365
## 28        69.60741 148000000000   77553504
## 29        70.00649 182000000000   78892015
## 30        70.40159 221000000000   80233749
## 31        70.79573 261000000000   81720428
## 32        71.19098 313000000000   83351595
## 33        71.58583 363000000000   84993164
## 34        71.97783 530000000000   86648447
## 35        72.36385 554000000000   88314424
## 36        72.73978 380000000000   89969572
## 37        73.09890 432000000000   91586555
## 38        73.43715 523000000000   93183094
## 39        73.75141 557000000000   94767284
## 40        74.03924 631000000000   96334810
## 41        74.29973 742000000000   97873442
## 42        74.53349 796000000000   99394288
## 43        74.74471 811000000000  100917081
## 44        74.93751 766000000000  102429341
## 45        75.11549 819000000000  103945813
## 46        75.28210 918000000000  105442402
```

```
pop_Mex = Mex_small$Population
gdp_Mex = Mex_small$GDP
life_Mex = Mex_small$Life.Expectancy
# Mex VAR
x_Mex = cbind(gdp_Mex,life_Mex, pop_Mex)
VAR_Mex = VARselect(x_Mex,lag.max = 8, type = "const")
VAR_Mex
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      7      4      3      4
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 6.631332e+01 6.178660e+01 5.844505e+01 5.819107e+01 5.842503e+01
## HQ(n)  6.649731e+01 6.210858e+01 5.890503e+01 5.878904e+01 5.916099e+01
## SC(n)  6.683045e+01 6.269158e+01 5.973788e+01 5.987175e+01 6.049356e+01
## FPE(n) 6.317272e+28 6.904329e+26 2.505439e+25 2.039406e+25 2.795213e+25
##                   6            7            8
## AIC(n) 5.821717e+01 5.799383e+01 5.811725e+01
## HQ(n)  5.909113e+01 5.900579e+01 5.926720e+01
## SC(n)  6.067355e+01 6.083806e+01 6.134933e+01
## FPE(n) 2.581533e+25 2.511274e+25 3.818335e+25
```

```
fit=VAR(x_Mex,p=7,type='const') # VAR select lowest AIC selects 7 lags to see life expectancy
fit$p
```

```
## [1] 7
```

```
# summary(lsfit) # didnt work singularity - possible multi-collinaearity between varaibles
preds=predict(fit,n.ahead=10)
preds
```

```
## $gdp_Mex
##               fcst        lower        upper           CI
##  [1,] 9.275203e+11 8.634644e+11 9.915762e+11  64055897472
##  [2,] 9.768910e+11 8.876956e+11 1.066086e+12  89195362054
##  [3,] 1.038023e+12 9.398393e+11 1.136206e+12  98183585137
##  [4,] 1.045488e+12 9.140953e+11 1.176881e+12 131392941561
##  [5,] 1.074184e+12 9.276865e+11 1.220681e+12 146497134850
##  [6,] 1.113087e+12 9.627966e+11 1.263378e+12 150290746285
##  [7,] 1.137753e+12 9.864666e+11 1.289040e+12 151286606846
##  [8,] 1.180657e+12 1.023696e+12 1.337618e+12 156961115630
##  [9,] 1.220584e+12 1.054471e+12 1.386698e+12 166113531180
## [10,] 1.237682e+12 1.064753e+12 1.410610e+12 172928457497
##
## $life_Mex
##           fcst    lower    upper          CI
##  [1,] 75.43945 75.43581 75.44309 0.003639806
##  [2,] 75.58742 75.57561 75.59924 0.011810792
##  [3,] 75.72691 75.70271 75.75112 0.024200840
##  [4,] 75.86014 75.81948 75.90080 0.040660489
##  [5,] 75.98915 75.92800 76.05030 0.061153073
##  [6,] 76.11577 76.03035 76.20119 0.085418854
##  [7,] 76.24003 76.12653 76.35353 0.113500132
##  [8,] 76.36160 76.21612 76.50708 0.145477567
##  [9,] 76.48123 76.29978 76.66269 0.181451814
## [10,] 76.59957 76.37853 76.82062 0.221043302
##
## $pop_Mex
##            fcst     lower     upper        CI
##  [1,] 106883893 106806468 106961317  77424.63
##  [2,] 108268293 108054120 108482466 214172.97
##  [3,] 109619012 109259132 109978893 359880.46
##  [4,] 110967144 110478325 111455964 488819.63
##  [5,] 112336969 111742979 112930959 593989.64
##  [6,] 113734860 113051529 114418191 683330.88
##  [7,] 115131039 114367640 115894438 763398.91
##  [8,] 116490618 115659585 117321652 831033.68
##  [9,] 117801674 116919341 118684008 882333.71
## [10,] 119056694 118139609 119973778 917084.40
```

```
life.mex.f=preds$fcst$life_Mex[,1]
life.mex.f
```

```
##  [1] 75.43945 75.58742 75.72691 75.86014 75.98915 76.11577 76.24003 76.36160
##  [9] 76.48123 76.59957
```

```
t=1:56
t
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56
```

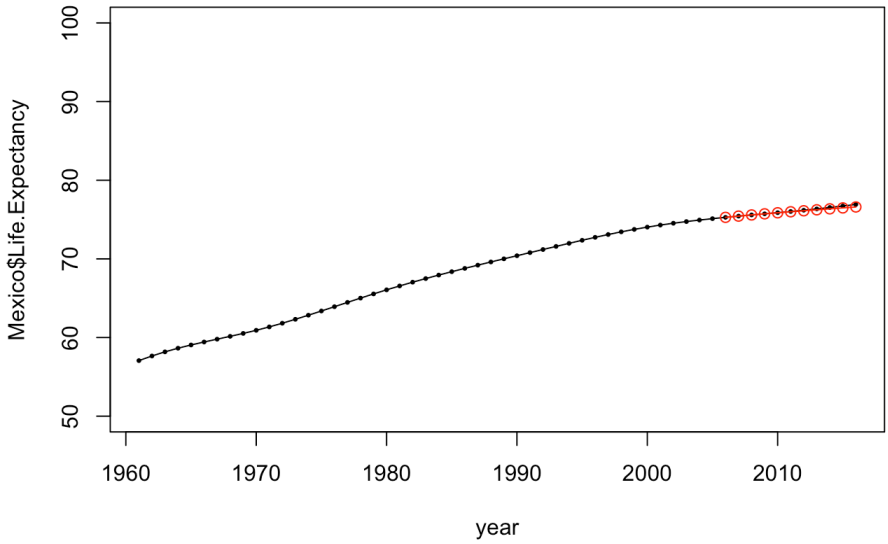
```
year=t+1960
year # 56 years
```

```
##  [1] 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975
## [16] 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
## [31] 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
## [46] 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
```

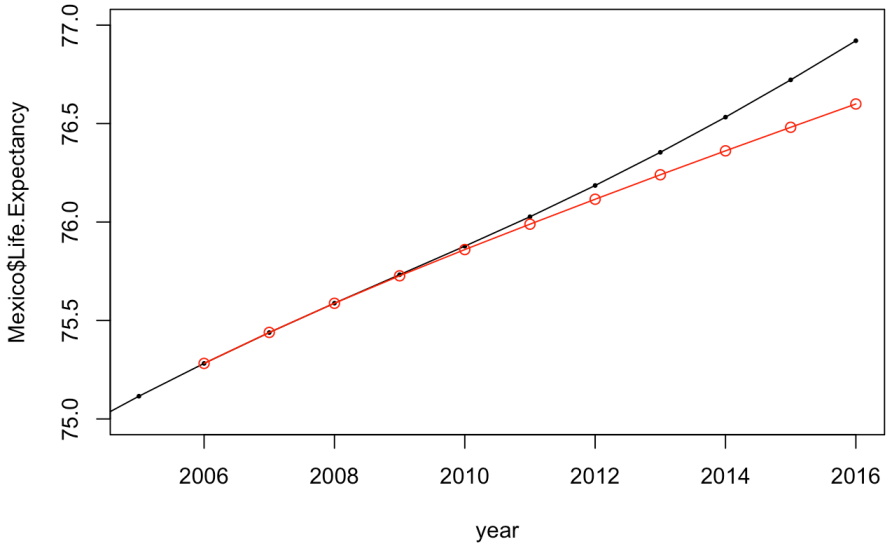
```
length(year)# Mexico Life.Expectancy forecast for last 10 years
```

```
## [1] 56
```

```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[46:56],c(Mexico$Life.Expectancy[46],life.mex.f),type='o',cex=1,pch=1, col='red') # we use 46-56 here
since and then we use the actual value at 46 followed by the 10 forecasts
```




```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005,2016),ylim=c(75,77))  # zoom in on the plot s
o we can see the points
points(year[46:56],c(Mexico$Life.Expectancy[46],life.mex.f),type='o',cex=1,pch=1, col='red')
```




```
ASE = mean((Mexico$Life.Expectancy[47:56] - preds$fcst$life_Mex[1:10])^2) # ASE for the last 10 years
ASE #  0.02099135
```

```
## [1] 0.02099135
```

```
RMSE_VAR=sqrt(mean((Mexico$Life.Expectancy[47:56]-preds$fcst$life_Mex[,1][1:10])^2)) # RMSE for the last 10 years
RMSE_VAR # 0.1448839
```

```
## [1] 0.1448839
```

LONG-TERM:

The forecasts for the long term 10th order VAR Model again similar to the short term forecast able to predict rather accurately the the first few years and again trails consistenly lower as predictions get further out in time.

Assessment:

The Var models for both long and short term forecasting were useful to detect the relationship between the data, and enhanced the forecasts the following ASE scores with the short term, forecasted model having a lower ASE. The short term 10th Order Var model appears to be more useful at predicting life-expectancy compared to a long-term forecast. However we can possibly do better with other modeling techniques.

VAR United States Short-Term 5 Year

```
# Short Term
UnitedStates
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
## 108 United States          USA North America  High income 2011        78.64146
## 109 United States          USA North America  High income 2012        78.74146
## 110 United States          USA North America  High income 2013        78.74146
## 111 United States          USA North America  High income 2014        78.74146
## 112 United States          USA North America  High income 2015        78.74146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
```

```
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
## 108 1.56e+13  311583481
## 109 1.63e+13  313877662
## 110 1.68e+13  316059947
## 111 1.76e+13  318386329
## 112 1.82e+13  320738994
```

```
US_small = UnitedStates[1:51,] # first 46, predict next 10 years for forecast
US_small
```

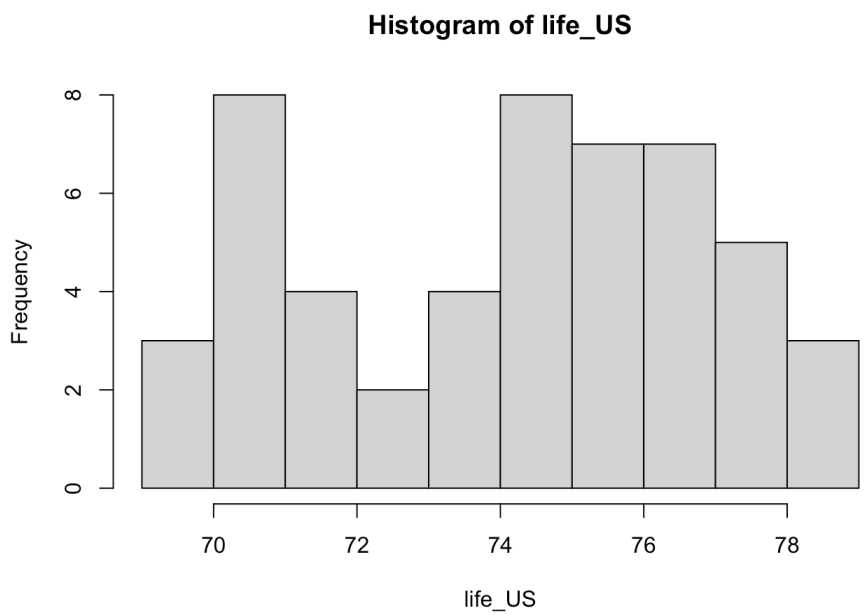
```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
```

```
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
```

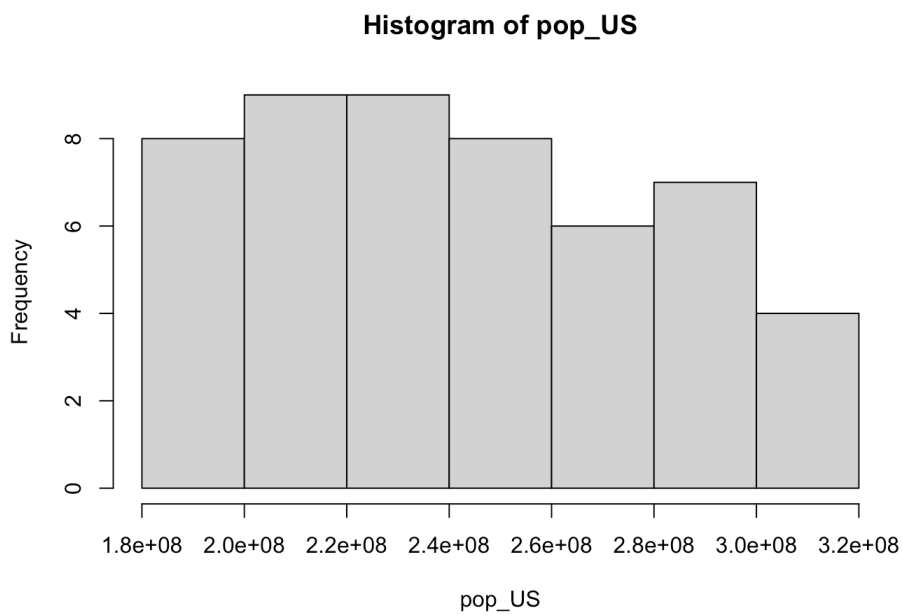
```
pop_US = US_small$Population
gdp_US = US_small$GDP
life_US = US_small$Life.Expectancy
life_US
```

```
##  [1] 69.77073 70.27073 70.11951 69.91707 70.16585 70.21463 70.21220 70.56098
##  [9] 69.95122 70.50732 70.80732 71.10732 71.15610 71.35610 71.95610 72.60488
## [17] 72.85610 73.25610 73.35610 73.80488 73.60976 74.00976 74.36098 74.46341
## [25] 74.56341 74.56341 74.61463 74.76585 74.76585 75.01707 75.21463 75.36585
## [33] 75.61707 75.41951 75.61951 75.62195 76.02683 76.42927 76.58049 76.58293
## [41] 76.63659 76.83659 76.93659 77.03659 77.48780 77.48780 77.68780 77.98780
## [49] 78.03902 78.39024 78.54146
```

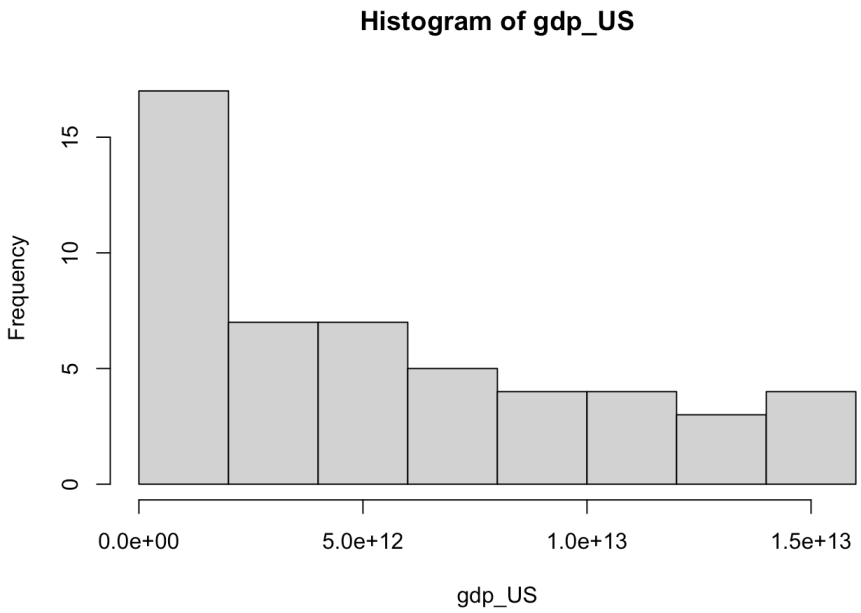
```
hist(life_US)
```



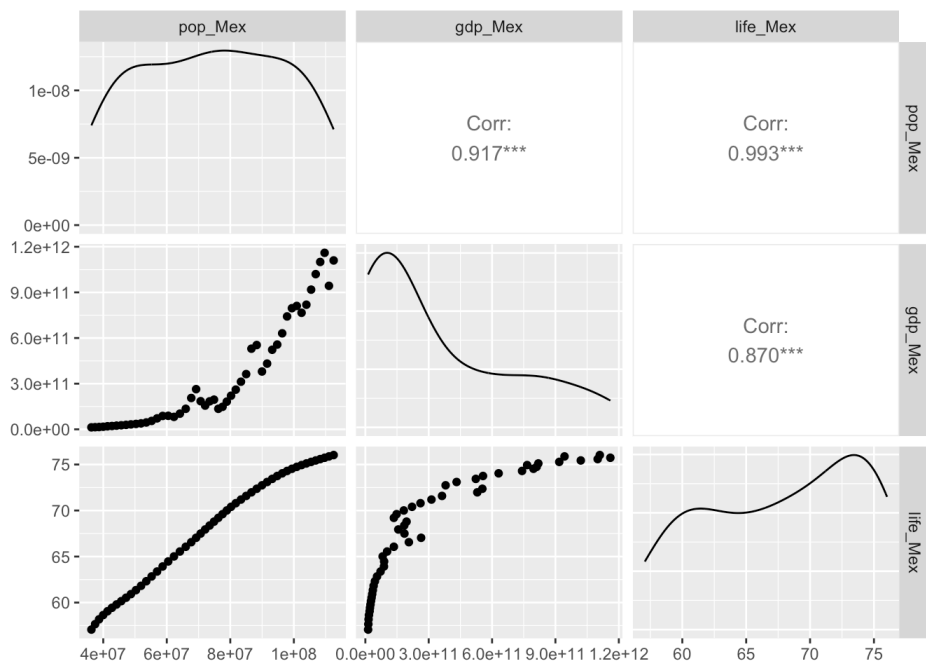

```
hist(pop_US)
```




```
hist(gdp_US)
```




```
# Mex VAR
ggpairs(data=tsMex_dataframe)
```




```
X_US = cbind(pop_US,gdp_US,life_US)
x_Mex = cbind(gdp_Mex,life_Mex, pop_Mex)# all variables highly correlated
VAR_US = VARselect(cbind(pop_US,gdp_US,life_US),lag.max = 10, type = "both")
VAR_US
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##     10     10      2     10
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 7.398307e+01 7.240742e+01 7.253875e+01 7.267446e+01 7.235000e+01
## HQ(n)  7.421136e+01 7.277268e+01 7.304098e+01 7.331367e+01 7.312618e+01
## SC(n)  7.460999e+01 7.341049e+01 7.391797e+01 7.442983e+01 7.448152e+01
## FPE(n) 1.355277e+32 2.836268e+31 3.316778e+31 3.975026e+31 3.093253e+31
##                   6            7            8            9           10
## AIC(n) 7.200991e+01 7.171048e+01 7.148490e+01 7.032055e+01 6.959136e+01
## HQ(n)  7.292307e+01 7.276061e+01 7.267200e+01 7.164463e+01 7.105240e+01
## SC(n)  7.451758e+01 7.459430e+01 7.474487e+01 7.395667e+01 7.360362e+01
## FPE(n) 2.464526e+31 2.159824e+31 2.202981e+31 9.873592e+30 8.253035e+30
```

```
fit_US =VAR(X_US,p=10,type='const') # use phi=10
fit_US$varresult
```

```
## $pop_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   2.367e+00    7.542e-07   -9.883e+05   -1.531e+00   -8.044e-07   -3.466e+05
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -7.981e-01    6.070e-07    3.222e+05    1.240e+00   -1.263e-06    5.433e+05
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -4.854e-01    9.069e-07   -9.643e+04    6.092e-01   -1.031e-06    3.882e+04
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   1.295e-01   -5.327e-07   -3.395e+05   -1.204e+00   -7.672e-07    9.784e+04
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   3.879e-01   -3.400e-07    2.356e+05    3.882e-01    2.220e-06   -5.675e+04
##       const
##   2.508e+07
##
##
## $gdp_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##  -2.074e+05    6.718e-01    2.765e+11    2.102e+05   -6.987e-01    1.565e+11
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##   2.653e+05    6.295e-02   -2.982e+11   -2.133e+05   -3.083e-01   -1.328e+11
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -5.351e+05    1.772e-01    2.275e+11    6.683e+05    9.875e-02    1.885e+11
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -1.988e+05    1.022e+00   -4.658e+10    2.488e+05    6.567e-01    6.812e+10
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##  -1.555e+05   -8.844e-01    4.087e+10   -7.706e+04    2.566e-01   -1.723e+11
##       const
##  -2.280e+13
##
##
## $life_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   3.024e-07    6.165e-13   -5.046e-01   -5.259e-07   -5.619e-13    8.585e-02
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -2.158e-07    2.282e-13    1.355e-01    4.303e-07    1.335e-14    4.601e-01
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##   4.111e-08   -2.853e-13    2.745e-01    5.591e-07   -9.842e-13   -3.940e-01
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -4.870e-07   -1.920e-13   -3.671e-01   -4.547e-07   -7.901e-13    3.011e-01
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##  -6.836e-08   -3.230e-14    2.148e-02    5.663e-07    1.597e-12   -1.460e-01
##       const
##   5.494e+01
```

```
fit_US$p
```

```
## [1] 10
```

```
fit_US$K
```

```
## [1] 3
```

```
# summary(lsfit)
preds_US=predict(fit_US,n.ahead=5)
preds_US$fcst
```

```
## $pop_US
##           fcst     lower     upper        CI
## [1,] 311677605 311312248 312042963  365357.5
## [2,] 313812260 312868013 314756507  944247.0
## [3,] 316606614 314984574 318228654 1622039.9
## [4,] 320214854 318018368 322411339 2196485.4
## [5,] 324210168 321570879 326849457 2639289.0
##
## $gdp_US
##               fcst        lower        upper           CI
## [1,] 1.642538e+13 1.623148e+13 1.661927e+13 193896134897
## [2,] 1.804561e+13 1.778469e+13 1.830653e+13 260917553274
## [3,] 1.926616e+13 1.897249e+13 1.955983e+13 293670520589
## [4,] 1.953263e+13 1.921610e+13 1.984916e+13 316530836788
## [5,] 1.904501e+13 1.868183e+13 1.940819e+13 363183430182
##
## $life_US
##          fcst    lower    upper        CI
## [1,] 78.47854 78.25377 78.70330 0.2247651
## [2,] 78.54731 78.27660 78.81803 0.2707159
## [3,] 78.50655 78.23101 78.78209 0.2755386
## [4,] 79.52160 79.20281 79.84039 0.3187890
## [5,] 80.04957 79.68444 80.41471 0.3651360
```

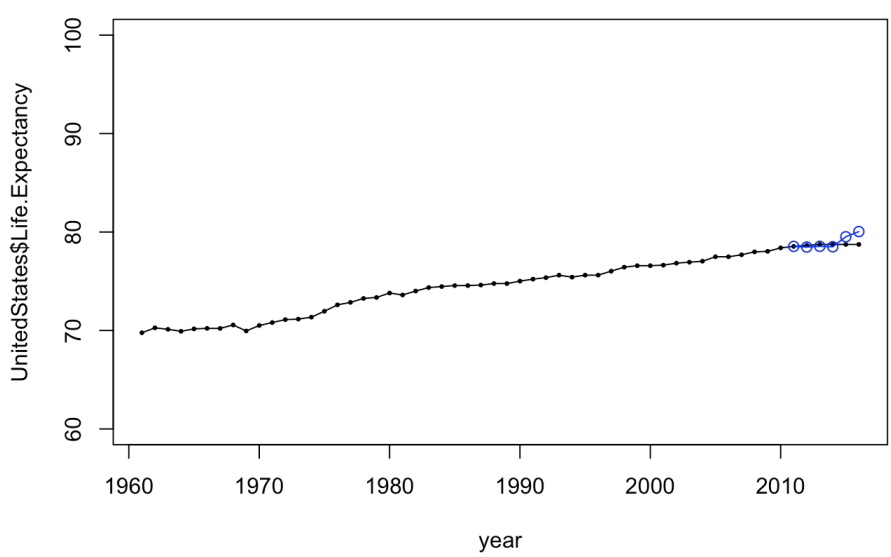
```
life.US.f=preds_US$fcst$life_US[,1]
life.US.f
```

```
## [1] 78.47854 78.54731 78.50655 79.52160 80.04957
```

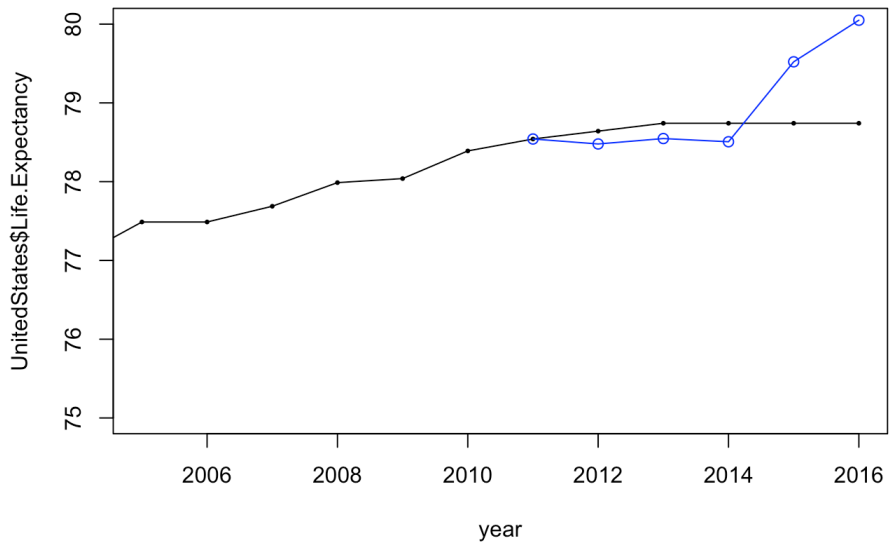
```
t=1:56
year=t+1960
year # 56 years
```

```
##  [1] 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975
## [16] 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
## [31] 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
## [46] 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
```

```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(60,100))  # 5 year
points(year[51:56],c(UnitedStates$Life.Expectancy[51],life.US.f),type='o',cex=1,pch=1, col='blue') # 6 years sele
cted, the first actual observeration at index 51, followed by the 5 year forecast values
```



```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2005,2016), ylim=c(75,80))  # 10 year zoom in
points(year[51:56],c(UnitedStates$Life.Expectancy[51],life.US.f),type='o',cex=1,pch=1, col='blue')
```




```
ASE = mean((UnitedStates$Life.Expectancy[52:56] - preds_US$fcst$life_US[1:5])^2)
ASE # 0.4878381
```

```
## [1] 0.4878381
```

```
RMSE_VAR=sqrt(mean((UnitedStates$Life.Expectancy[52:56]-preds_US$fcst$life_US[,1][1:5])^2))
RMSE_VAR # 0.6984541
```

```
## [1] 0.6984541
```

Consider the correlated variables and data spread. Not a lot of difference in GDP year to year. To perhaps to improve for NN model the data could be scaled. Given that our model variables are highly correlated, it was hypothesized that the VAR models may perform well.

The forecasts for the short and long term Var Models for United States.

SHORT TERM:

The forecasts for the short term at first seem to nearly overlap, but on further inspection we see that the predictions were consistently lower for the first three years, and wandered higher for the last two years forecasted.

VAR United States Long-Term 10 year

```
# Long Term
UnitedStates
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
## 108 United States          USA North America  High income 2011        78.64146
## 109 United States          USA North America  High income 2012        78.74146
## 110 United States          USA North America  High income 2013        78.74146
## 111 United States          USA North America  High income 2014        78.74146
## 112 United States          USA North America  High income 2015        78.74146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
```

```
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
## 108 1.56e+13  311583481
## 109 1.63e+13  313877662
## 110 1.68e+13  316059947
## 111 1.76e+13  318386329
## 112 1.82e+13  320738994
```

```
US_small = UnitedStates[1:46,] # first 46, predict next 10 years for forecast
US_small
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
```

```
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
```

```
pop_US = US_small$Population
gdp_US = US_small$GDP
life_US = US_small$Life.Expectancy
life_US
```

```
##  [1] 69.77073 70.27073 70.11951 69.91707 70.16585 70.21463 70.21220 70.56098
##  [9] 69.95122 70.50732 70.80732 71.10732 71.15610 71.35610 71.95610 72.60488
## [17] 72.85610 73.25610 73.35610 73.80488 73.60976 74.00976 74.36098 74.46341
## [25] 74.56341 74.56341 74.61463 74.76585 74.76585 75.01707 75.21463 75.36585
## [33] 75.61707 75.41951 75.61951 75.62195 76.02683 76.42927 76.58049 76.58293
## [41] 76.63659 76.83659 76.93659 77.03659 77.48780 77.48780
```

```
X_US = cbind(pop_US,gdp_US,life_US)
VAR_US = VARselect(cbind(pop_US,gdp_US,life_US),lag.max = 10, type = "both")
VAR_US
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##     10     10     10      9
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 7.303850e+01 7.136972e+01 7.125429e+01 7.153465e+01 7.115011e+01
## HQ(n)  7.326879e+01 7.173818e+01 7.176092e+01 7.217946e+01 7.193309e+01
## SC(n)  7.369830e+01 7.242540e+01 7.270584e+01 7.338209e+01 7.339343e+01
## FPE(n) 5.279249e+31 1.012276e+31 9.367205e+30 1.328597e+31 1.014303e+31
##                   6            7            8            9           10
## AIC(n) 7.111737e+01 7.130843e+01 7.003502e+01 6.857568e+01 6.781829e+01
## HQ(n)  7.203852e+01 7.236775e+01 7.123252e+01 6.991135e+01 6.929213e+01
## SC(n)  7.375657e+01 7.434350e+01 7.346598e+01 7.240252e+01 7.204101e+01
## FPE(n) 1.176084e+31 1.882724e+31 8.148079e+30 3.858291e+30 6.733142e+30
```

```
fit_US =VAR(X_US,p=10,type='const') # use phi=10
fit_US$varresult
```

```
## $pop_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   1.925e+00    2.694e-07   -6.242e+05   -1.192e+00   -2.063e-07    3.755e+05
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -7.271e-01    6.531e-07    5.209e+05    1.262e+00   -1.142e-06    4.923e+05
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -3.282e-01   -1.997e-07   -2.277e+05   -7.887e-02   -6.617e-07   -1.423e+05
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   4.263e-01   -3.745e-07   -1.350e+05   -1.422e+00   -4.715e-07    2.718e+05
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   8.308e-01    9.733e-07    1.751e+05    1.867e-01    2.456e-06    2.333e+04
##       const
##  -2.389e+07
##
##
## $gdp_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##  -2.651e+05    5.442e-01    4.239e+11   -2.312e+05   -3.073e-01    1.004e+12
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##   8.809e+05    2.153e-02   -1.351e+11   -7.864e+04   -6.231e-02   -3.942e+11
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -5.006e+05   -2.113e-01   -7.111e+10   -1.941e+05   -6.106e-01    1.769e+11
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   2.618e+03    9.387e-01    1.592e+11    3.890e+05    1.689e+00    2.743e+11
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   2.930e+05    6.674e-01   -3.155e+10   -4.534e+05   -6.247e-01   -1.429e+11
##       const
##  -5.864e+13
##
##
## $life_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   4.427e-07    3.509e-13   -6.042e-01   -9.451e-07   -3.852e-13    4.928e-01
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -9.620e-08    1.571e-13    3.172e-01    8.856e-07    1.520e-13    3.766e-01
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -6.095e-08   -4.594e-14    2.990e-02    1.923e-07   -1.349e-12   -4.347e-01
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -4.901e-07   -1.041e-12   -2.226e-01   -5.545e-07   -2.765e-14    4.153e-01
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   5.653e-07    8.945e-13    2.767e-02    1.654e-07    1.142e-12   -1.786e-01
##       const
##   3.816e+01
```

```
fit_US$p
```

```
## [1] 10
```

```
fit_US$K
```

```
## [1] 3
```

```
# summary(lsfit)
preds_US=predict(fit_US,n.ahead=10)
preds_US$fcst
```

```
## $pop_US
##            fcst     lower     upper        CI
##  [1,] 299108903 298808113 299409692  300789.4
##  [2,] 303965341 303345238 304585445  620103.7
##  [3,] 310101848 309216495 310987202  885353.3
##  [4,] 316747093 315721332 317772854 1025760.8
##  [5,] 323328558 322204893 324452223 1123665.0
##  [6,] 328629339 327436017 329822660 1193321.1
##  [7,] 331926900 330626463 333227336 1300436.2
##  [8,] 333894961 332413209 335376713 1481752.3
##  [9,] 336387592 334615475 338159710 1772117.7
## [10,] 340912772 338906378 342919165 2006393.6
##
## $gdp_US
##               fcst        lower        upper           CI
##  [1,] 1.393486e+13 1.379942e+13 1.407031e+13 135443936435
##  [2,] 1.485271e+13 1.467487e+13 1.503056e+13 177843187848
##  [3,] 1.534522e+13 1.504380e+13 1.564663e+13 301412261743
##  [4,] 1.546184e+13 1.515390e+13 1.576978e+13 307940980848
##  [5,] 1.573649e+13 1.542103e+13 1.605194e+13 315456070674
##  [6,] 1.622248e+13 1.589150e+13 1.655346e+13 330975272084
##  [7,] 1.680969e+13 1.647443e+13 1.714495e+13 335261515216
##  [8,] 1.798696e+13 1.763096e+13 1.834296e+13 356003208480
##  [9,] 1.997719e+13 1.956952e+13 2.038486e+13 407667695509
## [10,] 2.169628e+13 2.120992e+13 2.218264e+13 486360632329
##
## $life_US
##           fcst    lower    upper        CI
##  [1,] 77.54287 77.32279 77.76295 0.2200783
##  [2,] 78.02394 77.75758 78.29030 0.2663596
##  [3,] 78.79499 78.48313 79.10685 0.3118563
##  [4,] 78.72093 78.37040 79.07146 0.3505272
##  [5,] 78.31847 77.94798 78.68895 0.3704820
##  [6,] 77.78615 77.40684 78.16545 0.3793058
##  [7,] 77.55611 77.09763 78.01459 0.4584811
##  [8,] 77.14201 76.58082 77.70321 0.5611951
##  [9,] 78.08037 77.42313 78.73761 0.6572439
## [10,] 79.81467 79.13218 80.49716 0.6824903
```

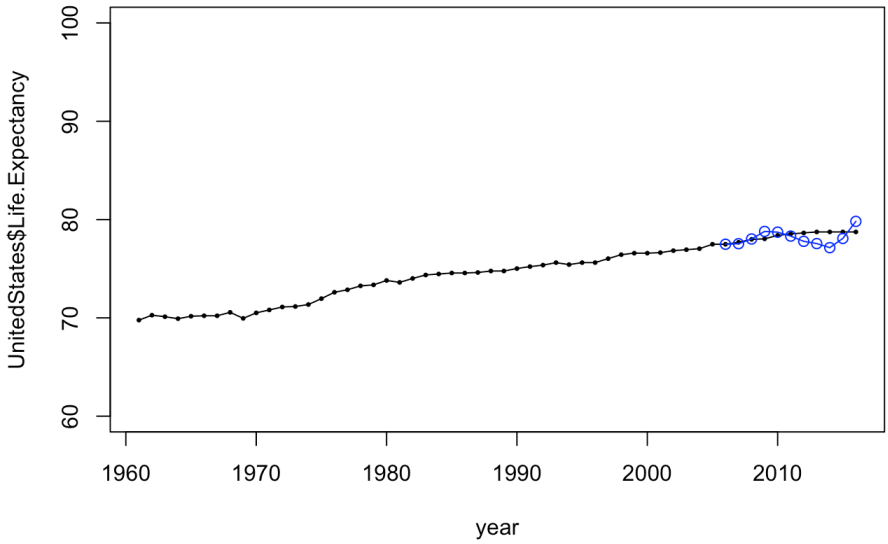
```
life.US.f=preds_US$fcst$life_US[,1]
life.US.f
```

```
##  [1] 77.54287 78.02394 78.79499 78.72093 78.31847 77.78615 77.55611 77.14201
##  [9] 78.08037 79.81467
```

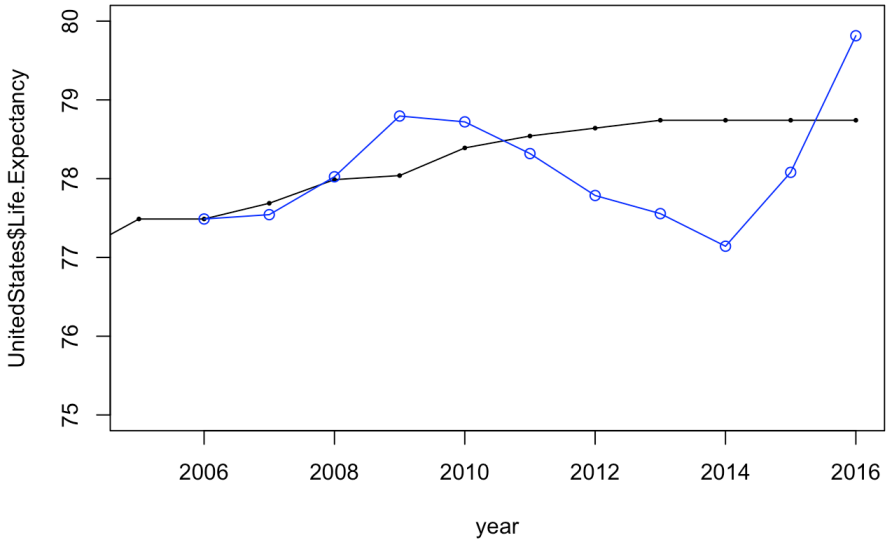
```
t=1:56
year=t+1960
year # 56 years
```

```
##  [1] 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975
## [16] 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
## [31] 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
## [46] 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
```

```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(60,100))  # 10 year
points(year[46:56],c(UnitedStates$Life.Expectancy[46],life.US.f),type='o',cex=1,pch=1, col='blue')
```




```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2005,2016), ylim=c(75,80))  # 10 year zoom in
points(year[46:56],c(UnitedStates$Life.Expectancy[46],life.US.f),type='o',cex=1,pch=1, col='blue')
```




```
ASE = mean((UnitedStates$Life.Expectancy[47:56] - preds_US$fcst$life_US[1:10])^2)
ASE # 0.7036564
```

```
## [1] 0.7036564
```

```
RMSE_VAR=sqrt(mean((UnitedStates$Life.Expectancy[47:56]-preds_US$fcst$life_US[,1][1:10])^2))
RMSE_VAR # 0.8388423
```

```
## [1] 0.8388423
```

LONG-TERM:

The forecasts for the long term 10th order VAR Model again similar to the short term forecast able to predict rather accurately the the first three years, but the next 8 oscillate high then low before rising again.

Assessment:

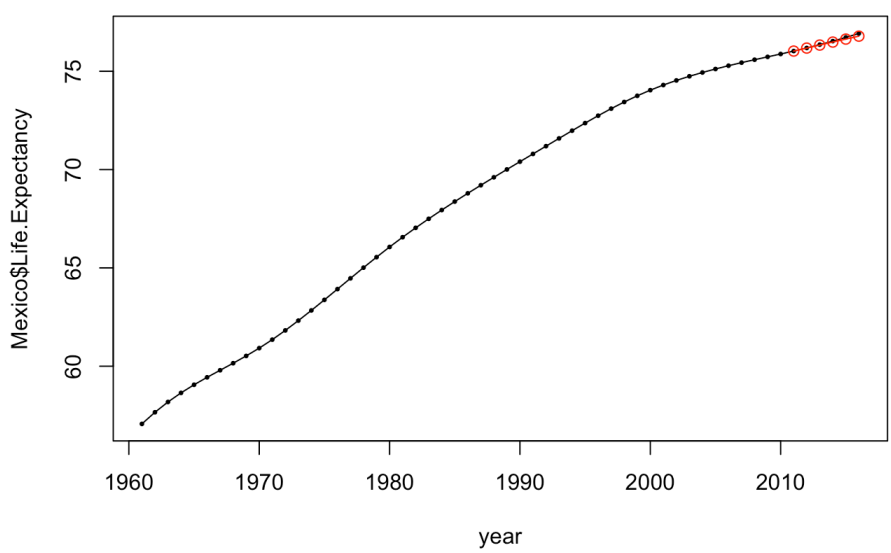
The Var models for both long and short term forecasting were useful to detect the relationship between the data, and enhanced the forecasts and had an ASE the following ASE scores with the short term, forecasted model having a lower ASE. The short term 10th Order Var model appears to be more useful at predicting life-expectancy compared to a long-term forecast. However we can possibly do better with other modeling techniques.

MLP Mexico Short Term 5 year

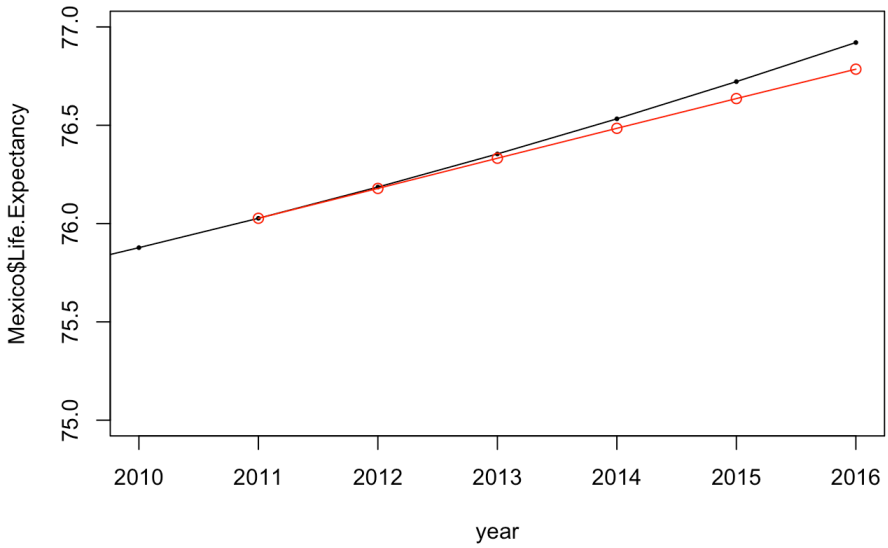
```
# Short Term 5 year
MexicoTrain=ts(Mexico$Life.Expectancy[1:51])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
set.seed(2)
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=5,xreg=MexicoVar)

f$mean
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 76.17869 76.33218 76.48439 76.63563 76.78519
```

```
# plot(Mexico$Life.Expectancy[47:57],type = "o")
# lines(seq(1,10),f$mean, col = "blue")
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(57,77))  # 5 year
points(year[51:56],c(Mexico$Life.Expectancy[51],f$mean),type='o',cex=1,pch=1, col="red")
```




```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2010,2016), ylim=c(75,77))  # 5 year zoom in
points(year[51:56],c(Mexico$Life.Expectancy[51],f$mean),type='o',cex=1,pch=1, col='red')
```




```
ASE = mean((Mexico$Life.Expectancy[52:56]-f$mean)^2)
ASE # 0.005730392
```

```
## [1] 0.005730392
```

```
RMSE=sqrt(mean((Mexico$Life.Expectancy[52:56]-f$mean[1:5])^2))
RMSE # 0.07569935
```

```
## [1] 0.07569935
```

Another model we tried was the Multilayer perceptron, using the mlp function in the nnfor package.

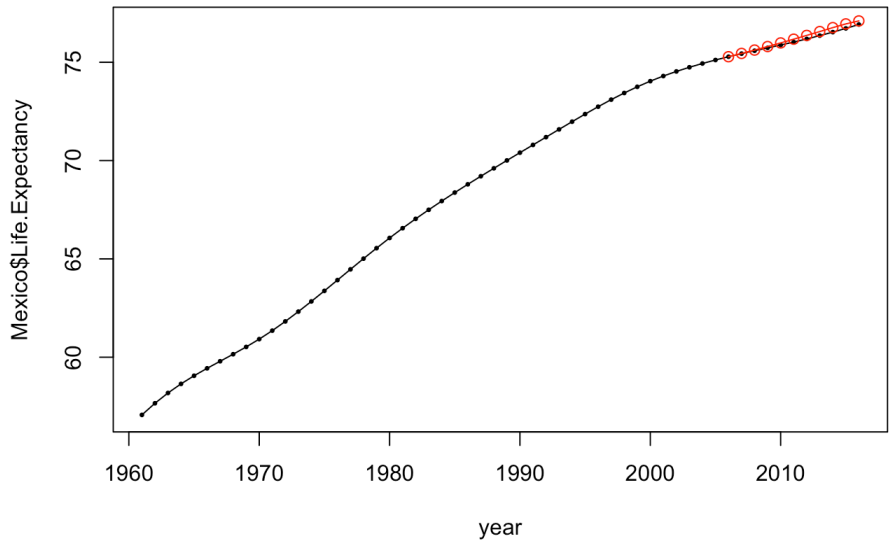
SHORT TERM: Again similar to the previous VAR Model selected, the MLP is able to predict the first three years well and trails off lower as it approaches the 5th year forecast.

MLP Mexico Short Term 10 year

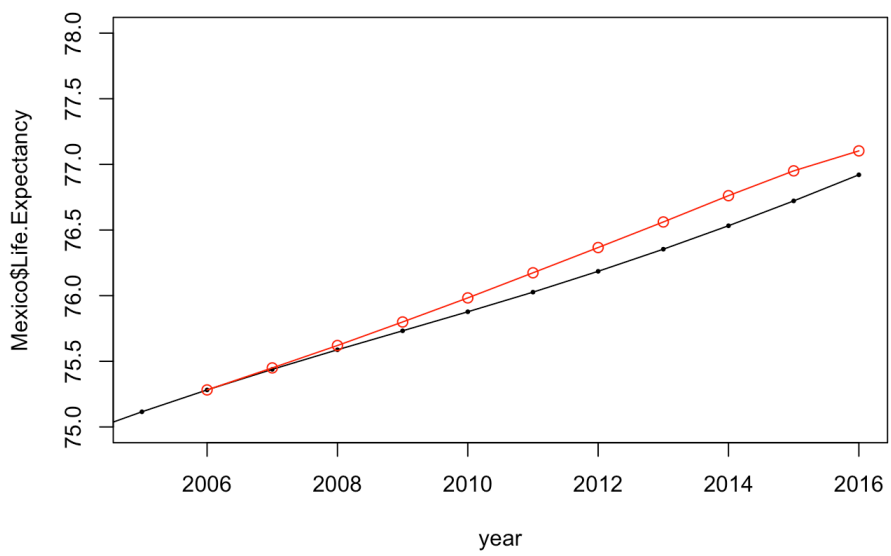
```
# Long Term 10 year
MexicoTrain=ts(Mexico$Life.Expectancy[1:46])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
set.seed(2)
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=10,xreg=MexicoVar)
f$mean
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 75.44976 75.62038 75.79973 75.98304 76.17431 76.36669 76.56154 76.76185
##      t+9     t+10
## 76.95080 77.10300
```

```
# plot(Mexico$Life.Expectancy[47:57],type = "o")
# lines(seq(1,10),f$mean, col = "blue")
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(57,77))  # 10 year
points(year[46:56],c(Mexico$Life.Expectancy[46],f$mean),type='o',cex=1,pch=1, col="red")
```




```
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2005,2016), ylim=c(75,78))  # 10 year zoom in
points(year[46:56],c(Mexico$Life.Expectancy[46],f$mean),type='o',cex=1,pch=1, col='red')
```




```
ASE = mean((Mexico$Life.Expectancy[47:56]-f$mean)^2)
ASE # 0.02526074
```

```
## [1] 0.02526074
```

```
RMSE=sqrt(mean((Mexico$Life.Expectancy[47:56]-f$mean[1:10])^2))
RMSE # 0.1589363
```

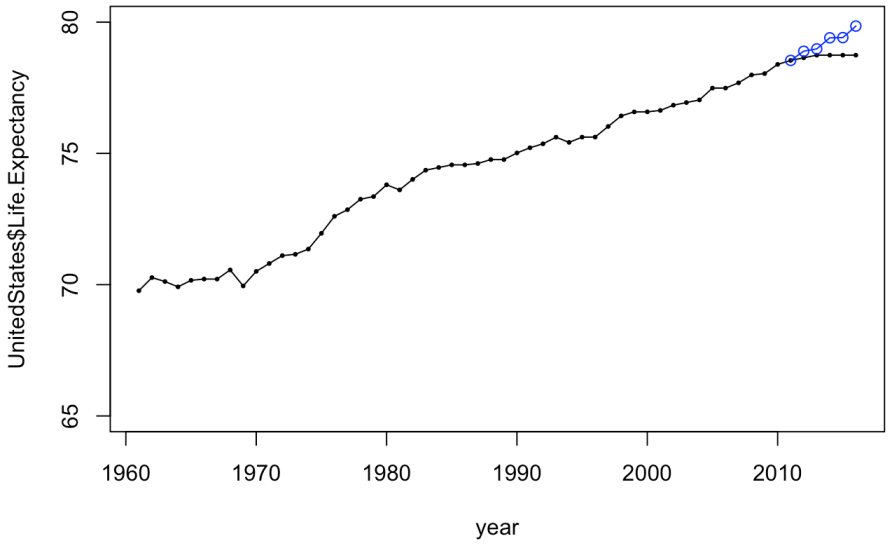
```
## [1] 0.1589363
```

LONG TERM: Here its interesting, that in the short term forecasts it trailed lower than the actual values for life expectancy on the 4th and 5th year, in the long term forecast the MLP model trails slightly higher than the actual values from years 2-10.

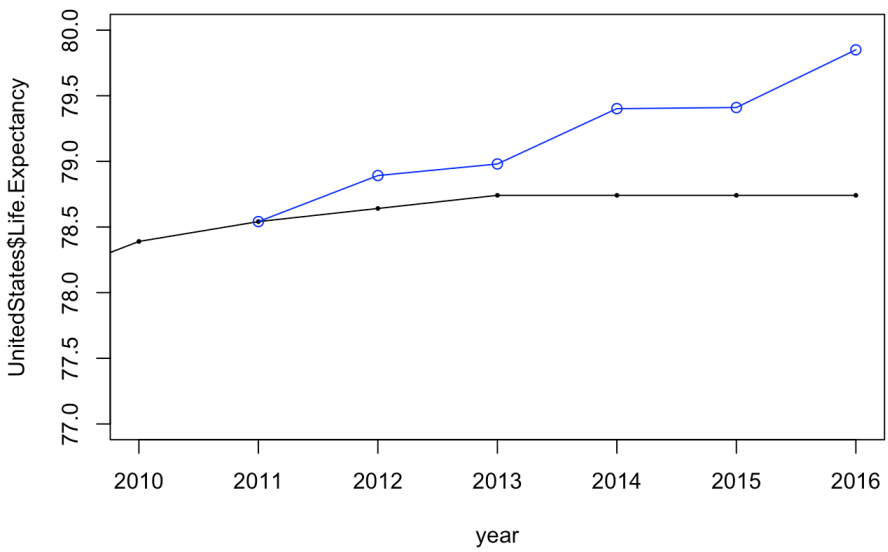
Overall both short and long term models appear to be useful with low ASE for a 5 year forecast, lower than that of the long-term forecast ASE.

MLP United States Short-term 5 year

```
# Short Term 5 year
USTrain=ts(UnitedStates$Life.Expectancy[1:51])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
set.seed(2)
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=5,xreg=USVar)
# plot(Mexico$Life.Expectancy[47:57],type = "o")
# lines(seq(1,10),f$mean, col = "blue")
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(65,80))  # 5 year
points(year[51:56],c(UnitedStates$Life.Expectancy[51],f$mean),type='o',cex=1,pch=1, col="blue")
```




```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2010,2016), ylim=c(77,80))  # 5 year zoom i
n
points(year[51:56],c(UnitedStates$Life.Expectancy[51],f$mean),type='o',cex=1,pch=1, col='blue')
```




```
ASE = mean((UnitedStates$Life.Expectancy[52:56]-f$mean)^2)
ASE # 0.4465622
```

```
## [1] 0.4465622
```

```
RMSE=sqrt(mean((UnitedStates$Life.Expectancy[52:56]-f$mean[1:5])^2))
RMSE # 0.6682531
```

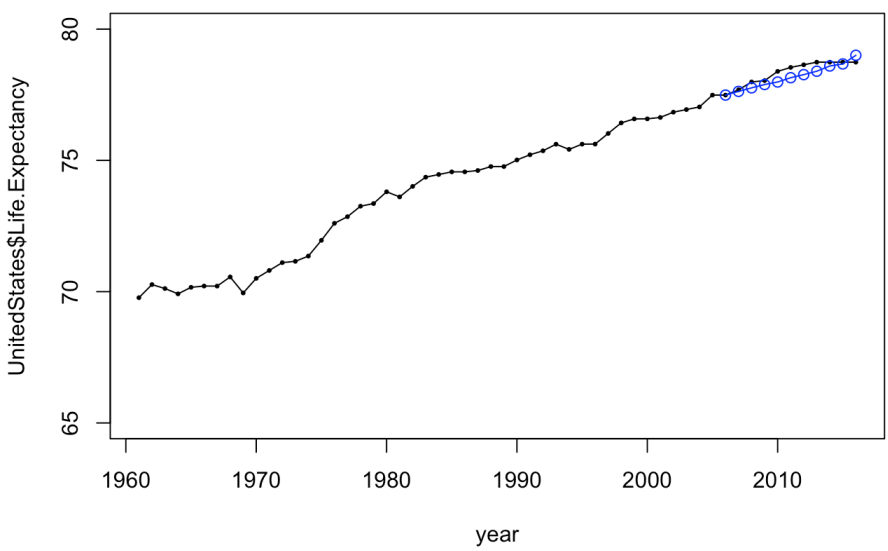
```
## [1] 0.6682531
```

Another model we tried was the Multilayer perceptron, using the mlp function in the nnfor package.

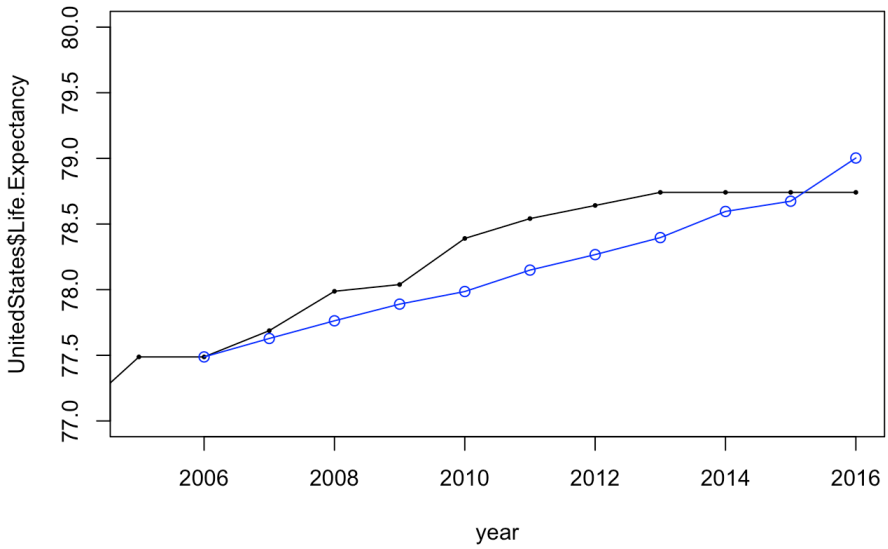
SHORT TERM: Almost immediately the MLP prediction are higher than that of the actual values and seem to be wandering higher

MLP United States Long-term 10 year

```
# Long Term 10 year
USTrain=ts(UnitedStates$Life.Expectancy[1:46])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
set.seed(2)
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=10,xreg=USVar)
# plot(Mexico$Life.Expectancy[47:57],type = "o")
# lines(seq(1,10),f$mean, col = "blue")
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(65,80))  # 10 year
points(year[46:56],c(UnitedStates$Life.Expectancy[46],f$mean),type='o',cex=1,pch=1, col="blue")
```




```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5, xlim=c(2005,2016), ylim=c(77,80))  # 10 year zoom
in
points(year[46:56],c(UnitedStates$Life.Expectancy[46],f$mean),type='o',cex=1,pch=1, col='blue')
```




```
ASE = mean((UnitedStates$Life.Expectancy[47:56]-f$mean)^2)
ASE # 0.07298946
```

```
## [1] 0.07469813
```

```
RMSE=sqrt(mean((UnitedStates$Life.Expectancy[47:56]-f$mean[1:10])^2))
RMSE # 0.2701656
```

```
## [1] 0.2733096
```

LONG TERM: On a longer time frame, the forecasts seems to capture the trend of the actual observations while not exactly hitting the actual values, but two predicted values were nearly spot on.

Overall the short-term model does not appear to be useful. The long-term model however seems quite useful and capturing the data. This is reflected in the ASEs, long-term ASE significantly lower than that of the short term model.

Ensemble: MLP & VAR Mexico Short Term 5 year

```
# VAR Mexico Short term 5 year
Mexico
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
## 52  Mexico          MEX Latin America & Caribbean Upper middle income 2011
## 53  Mexico          MEX Latin America & Caribbean Upper middle income 2012
## 54  Mexico          MEX Latin America & Caribbean Upper middle income 2013
## 55  Mexico          MEX Latin America & Caribbean Upper middle income 2014
## 56  Mexico          MEX Latin America & Caribbean Upper middle income 2015
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
```

```
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
## 52        76.18566 1.230000e+12  114150481
## 53        76.35410 1.260000e+12  115755909
## 54        76.53266 1.330000e+12  117290686
## 55        76.72185 1.360000e+12  118755887
## 56        76.92068 1.210000e+12  120149897
```

```
# Mexico Data
Mex_small = Mexico[1:51,] # first 51, predict next 5 years for forecast
Mex_small
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
```

```
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
```

```
pop_Mex = Mex_small$Population
gdp_Mex = Mex_small$GDP
life_Mex = Mex_small$Life.Expectancy
# Mex VAR
x_Mex = cbind(gdp_Mex,life_Mex, pop_Mex)
VAR_Mex = VARselect(x_Mex,lag.max = 8, type = "const")
VAR_Mex
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      4      4      3      4
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 6.684559e+01 6.215203e+01 5.893719e+01 5.864107e+01 5.871093e+01
## HQ(n)  6.702684e+01 6.246922e+01 5.939032e+01 5.923013e+01 5.943593e+01
## SC(n)  6.733709e+01 6.301215e+01 6.016594e+01 6.023844e+01 6.067693e+01
## FPE(n) 1.074914e+29 9.910413e+26 4.049407e+25 3.111033e+25 3.521373e+25
##                   6            7            8
## AIC(n) 5.881918e+01 5.869837e+01 5.881744e+01
## HQ(n)  5.968011e+01 5.969524e+01 5.995025e+01
## SC(n)  6.115379e+01 6.140160e+01 6.188930e+01
## FPE(n) 4.265806e+25 4.278342e+25 5.765251e+25
```

```
fit=VAR(x_Mex,p=7,type='const') # VAR select lowest AIC selects 7 lags to see life expectancy
fit$p
```

```
## [1] 7
```

```
# summary(lsfit) # didnt work singularity - possible multi-collinaearity between varaibles
preds=predict(fit,n.ahead=5)
preds
```

```
## $gdp_Mex
##              fcst        lower        upper           CI
## [1,] 1.203822e+12 1.100826e+12 1.306818e+12 102996130447
## [2,] 1.222824e+12 1.109477e+12 1.336170e+12 113346536362
## [3,] 1.346329e+12 1.223129e+12 1.469529e+12 123200276519
## [4,] 1.364905e+12 1.214570e+12 1.515241e+12 150335629391
## [5,] 1.277205e+12 1.118365e+12 1.436045e+12 158839953682
##
## $life_Mex
##          fcst    lower    upper          CI
## [1,] 76.18026 76.17667 76.18385 0.003592634
## [2,] 76.33722 76.32540 76.34905 0.011822754
## [3,] 76.49504 76.47045 76.51963 0.024589807
## [4,] 76.65538 76.61360 76.69716 0.041781906
## [5,] 76.81962 76.75631 76.88293 0.063310508
##
## $pop_Mex
##           fcst     lower     upper        CI
## [1,] 114068212 113995064 114141361  73148.35
## [2,] 115585422 115384938 115785906 200483.95
## [3,] 117046489 116716051 117376927 330437.84
## [4,] 118404801 117960756 118848847 444045.52
## [5,] 119715005 119181860 120248150 533144.66
```

```
life.mex.f=preds$fcst$life_Mex[,1]
life.mex.f
```

```
## [1] 76.18026 76.33722 76.49504 76.65538 76.81962
```

```
t=1:56
t
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56
```

```
year=t+1960

#MLP Mexico Long term 10 year
MexicoTrain=ts(Mexico$Life.Expectancy[1:51])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
MexicoVar
```

```
##             GDP       Pop
## 1  1.304000e+10  36268055
## 2  1.416000e+10  37439317
## 3  1.520000e+10  38683283
## 4  1.696000e+10  39982118
## 5  2.008000e+10  41333878
## 6  2.184000e+10  42737991
## 7  2.432000e+10  44180437
## 8  2.656000e+10  45656963
## 9  2.936000e+10  47170337
## 10 3.248000e+10  48714394
## 11 3.552000e+10  50289306
## 12 3.920000e+10  51897675
## 13 4.520000e+10  53543436
## 14 5.528000e+10  55228203
## 15 7.200000e+10  56945880
## 16 8.800000e+10  58691882
## 17 8.887592e+10  60452543
## 18 8.191202e+10  62262505
## 19 1.030000e+11  64123997
## 20 1.350000e+11  65972912
## 21 2.060000e+11  67705186
## 22 2.640000e+11  69233769
## 23 1.850000e+11  70656783
## 24 1.560000e+11  72080310
## 25 1.840000e+11  73489654
## 26 1.950000e+11  74872006
## 27 1.350000e+11  76224365
## 28 1.480000e+11  77553504
## 29 1.820000e+11  78892015
## 30 2.210000e+11  80233749
## 31 2.610000e+11  81720428
## 32 3.130000e+11  83351595
## 33 3.630000e+11  84993164
## 34 5.300000e+11  86648447
## 35 5.540000e+11  88314424
## 36 3.800000e+11  89969572
## 37 4.320000e+11  91586555
## 38 5.230000e+11  93183094
## 39 5.570000e+11  94767284
## 40 6.310000e+11  96334810
## 41 7.420000e+11  97873442
## 42 7.960000e+11  99394288
## 43 8.110000e+11 100917081
## 44 7.660000e+11 102429341
## 45 8.190000e+11 103945813
## 46 9.180000e+11 105442402
## 47 1.020000e+12 106886790
## 48 1.100000e+12 108302973
## 49 1.160000e+12 109684489
## 50 9.430000e+11 111049428
## 51 1.110000e+12 112532401
## 52 1.230000e+12 114150481
## 53 1.260000e+12 115755909
## 54 1.330000e+12 117290686
## 55 1.360000e+12 118755887
## 56 1.210000e+12 120149897
```

```
set.seed(2)
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=5,xreg=MexicoVar)
f$mean
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 76.17869 76.33218 76.48439 76.63563 76.78519
```

```
################
f$mean # MLP long term 10 year predictions
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 76.17869 76.33218 76.48439 76.63563 76.78519
```

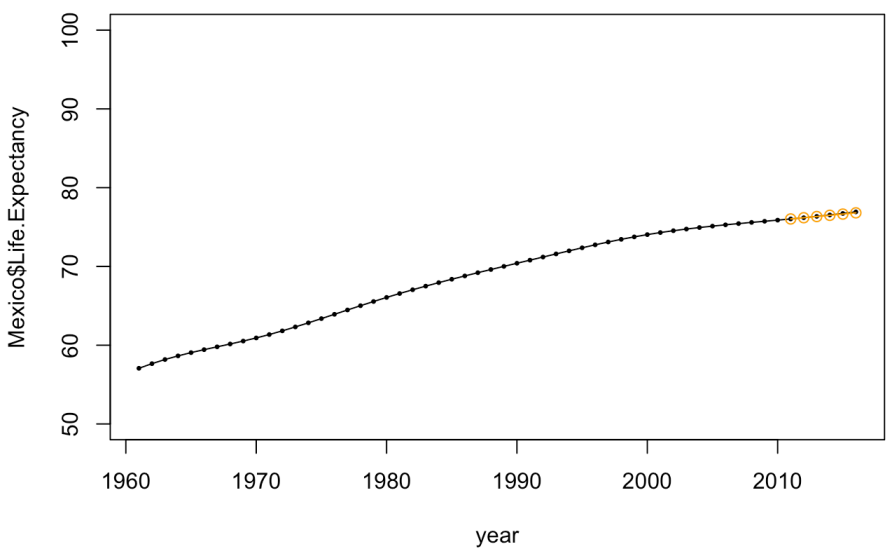
```
life.mex.f # VAR long term 10 year predictions
```

```
## [1] 76.18026 76.33722 76.49504 76.65538 76.81962
```

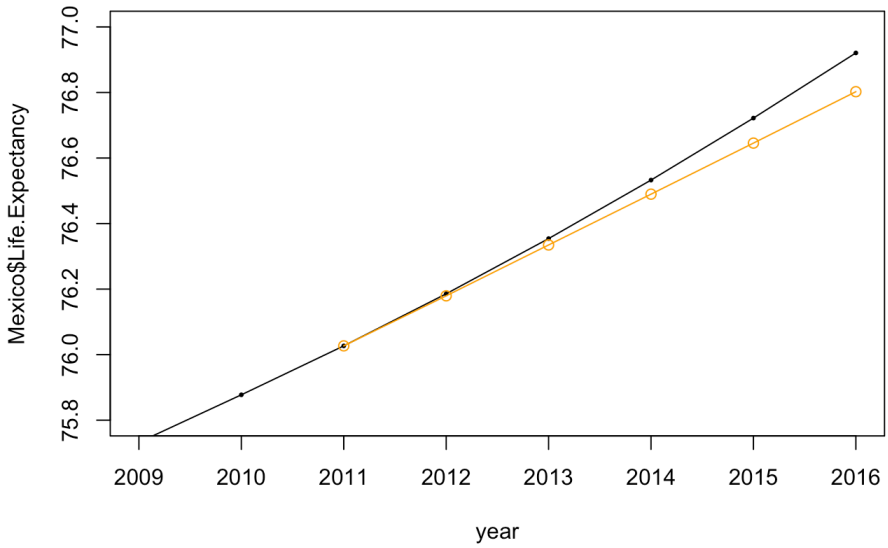
```
ensemble_MEX = (life.mex.f + f$mean)/2
ensemble_MEX
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 76.17948 76.33470 76.48971 76.64551 76.80241
```

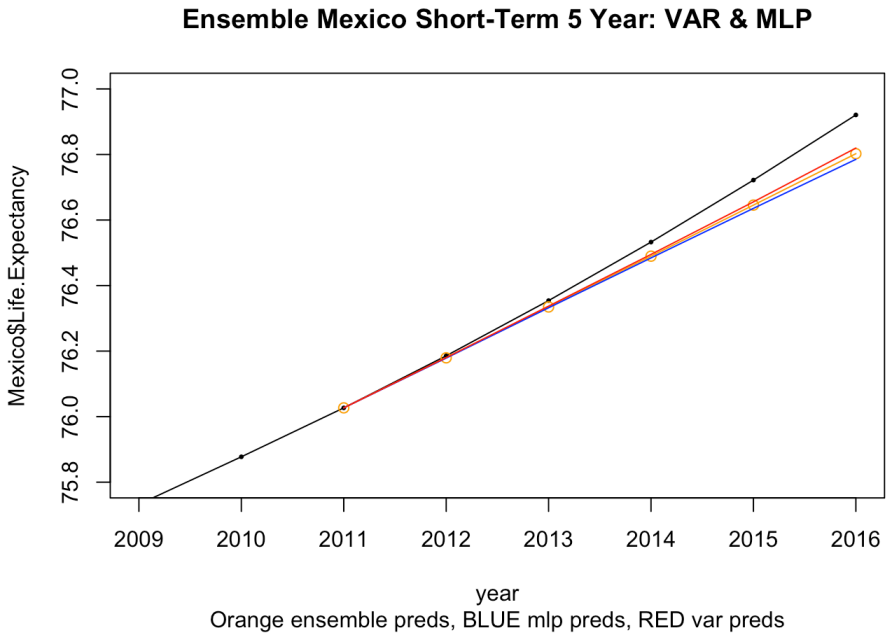
```
################
#Plot
################
# all years plotted
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[51:56],c(Mexico$Life.Expectancy[51],ensemble_MEX),type='o',cex=1,pch=1, col='orange')
```




```
# zoom in on predictions
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2009, 2016), ylim=c(75.8,77)) # zoom in on 10 year forecast
points(year[51:56],c(Mexico$Life.Expectancy[51],ensemble_MEX),type='o',cex=1,pch=1, col='orange')
```




```
# all plotted together
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2009, 2016), ylim=c(75.8,77), main='Ensemble Mexic
o Short-Term 5 Year: VAR & MLP', sub='Orange ensemble preds, BLUE mlp preds, RED var preds') # zoom in on 10 year
forecast
points(year[51:56],c(Mexico$Life.Expectancy[51],ensemble_MEX),type='o',cex=1,pch=1, col='orange')# ensemble predi
ctions
points(year[51:56],c(Mexico$Life.Expectancy[51],f$mean),type='l',cex=1,pch=1, col='blue') # MLP predictions
points(year[51:56],c(Mexico$Life.Expectancy[51],life.mex.f),type='l',cex=1,pch=1, col='red') # VAR predictions
```




```
################

ASE = mean((Mexico$Life.Expectancy[52:56]-ensemble_MEX)^2)
ASE # 0.004415432
```

```
## [1] 0.004415432
```

```
RMSE=sqrt(mean((Mexico$Life.Expectancy[52:56]-ensemble_MEX)^2))
RMSE # 0.06644871
```

```
## [1] 0.06644871
```

Given that the VAR and MLP models were not useless models, let's use the combo of models to create a multivariate ensemble model to see how well it performs.

Ensemble: MLP & VAR Mexico Long Term 10 year

```
Mexico
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
## 25  Mexico          MEX Latin America & Caribbean Upper middle income 1984
## 26  Mexico          MEX Latin America & Caribbean Upper middle income 1985
## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
## 47  Mexico          MEX Latin America & Caribbean Upper middle income 2006
## 48  Mexico          MEX Latin America & Caribbean Upper middle income 2007
## 49  Mexico          MEX Latin America & Caribbean Upper middle income 2008
## 50  Mexico          MEX Latin America & Caribbean Upper middle income 2009
## 51  Mexico          MEX Latin America & Caribbean Upper middle income 2010
## 52  Mexico          MEX Latin America & Caribbean Upper middle income 2011
## 53  Mexico          MEX Latin America & Caribbean Upper middle income 2012
## 54  Mexico          MEX Latin America & Caribbean Upper middle income 2013
## 55  Mexico          MEX Latin America & Caribbean Upper middle income 2014
## 56  Mexico          MEX Latin America & Caribbean Upper middle income 2015
##    Life.Expectancy          GDP Population
## 1         57.06563 1.304000e+10   36268055
## 2         57.65615 1.416000e+10   37439317
## 3         58.18024 1.520000e+10   38683283
## 4         58.64290 1.696000e+10   39982118
## 5         59.05559 2.008000e+10   41333878
## 6         59.43371 2.184000e+10   42737991
## 7         59.79322 2.432000e+10   44180437
## 8         60.15154 2.656000e+10   45656963
## 9         60.52310 2.936000e+10   47170337
## 10        60.91937 3.248000e+10   48714394
## 11        61.35024 3.552000e+10   50289306
## 12        61.81917 3.920000e+10   51897675
## 13        62.31766 4.520000e+10   53543436
## 14        62.83783 5.528000e+10   55228203
## 15        63.37427 7.200000e+10   56945880
## 16        63.92015 8.800000e+10   58691882
```

```
## 17        64.46861 8.887592e+10   60452543
## 18        65.01283 8.191202e+10   62262505
## 19        65.54593 1.030000e+11   64123997
## 20        66.06302 1.350000e+11   65972912
## 21        66.56022 2.060000e+11   67705186
## 22        67.03705 2.640000e+11   69233769
## 23        67.49593 1.850000e+11   70656783
## 24        67.94078 1.560000e+11   72080310
## 25        68.37202 1.840000e+11   73489654
## 26        68.79261 1.950000e+11   74872006
## 27        69.20344 1.350000e+11   76224365
## 28        69.60741 1.480000e+11   77553504
## 29        70.00649 1.820000e+11   78892015
## 30        70.40159 2.210000e+11   80233749
## 31        70.79573 2.610000e+11   81720428
## 32        71.19098 3.130000e+11   83351595
## 33        71.58583 3.630000e+11   84993164
## 34        71.97783 5.300000e+11   86648447
## 35        72.36385 5.540000e+11   88314424
## 36        72.73978 3.800000e+11   89969572
## 37        73.09890 4.320000e+11   91586555
## 38        73.43715 5.230000e+11   93183094
## 39        73.75141 5.570000e+11   94767284
## 40        74.03924 6.310000e+11   96334810
## 41        74.29973 7.420000e+11   97873442
## 42        74.53349 7.960000e+11   99394288
## 43        74.74471 8.110000e+11  100917081
## 44        74.93751 7.660000e+11  102429341
## 45        75.11549 8.190000e+11  103945813
## 46        75.28210 9.180000e+11  105442402
## 47        75.43878 1.020000e+12  106886790
## 48        75.58793 1.100000e+12  108302973
## 49        75.73246 1.160000e+12  109684489
## 50        75.87741 9.430000e+11  111049428
## 51        76.02678 1.110000e+12  112532401
## 52        76.18566 1.230000e+12  114150481
## 53        76.35410 1.260000e+12  115755909
## 54        76.53266 1.330000e+12  117290686
## 55        76.72185 1.360000e+12  118755887
## 56        76.92068 1.210000e+12  120149897
```

```
# Mexico Data
Mex_small = Mexico[1:46,] # first 47, predict next 10 years for forecast
Mex_small
```

```
##    Country Country.Code                    Region        Income.Group Year
## 1   Mexico          MEX Latin America & Caribbean Upper middle income 1960
## 2   Mexico          MEX Latin America & Caribbean Upper middle income 1961
## 3   Mexico          MEX Latin America & Caribbean Upper middle income 1962
## 4   Mexico          MEX Latin America & Caribbean Upper middle income 1963
## 5   Mexico          MEX Latin America & Caribbean Upper middle income 1964
## 6   Mexico          MEX Latin America & Caribbean Upper middle income 1965
## 7   Mexico          MEX Latin America & Caribbean Upper middle income 1966
## 8   Mexico          MEX Latin America & Caribbean Upper middle income 1967
## 9   Mexico          MEX Latin America & Caribbean Upper middle income 1968
## 10  Mexico          MEX Latin America & Caribbean Upper middle income 1969
## 11  Mexico          MEX Latin America & Caribbean Upper middle income 1970
## 12  Mexico          MEX Latin America & Caribbean Upper middle income 1971
## 13  Mexico          MEX Latin America & Caribbean Upper middle income 1972
## 14  Mexico          MEX Latin America & Caribbean Upper middle income 1973
## 15  Mexico          MEX Latin America & Caribbean Upper middle income 1974
## 16  Mexico          MEX Latin America & Caribbean Upper middle income 1975
## 17  Mexico          MEX Latin America & Caribbean Upper middle income 1976
## 18  Mexico          MEX Latin America & Caribbean Upper middle income 1977
## 19  Mexico          MEX Latin America & Caribbean Upper middle income 1978
## 20  Mexico          MEX Latin America & Caribbean Upper middle income 1979
## 21  Mexico          MEX Latin America & Caribbean Upper middle income 1980
## 22  Mexico          MEX Latin America & Caribbean Upper middle income 1981
## 23  Mexico          MEX Latin America & Caribbean Upper middle income 1982
## 24  Mexico          MEX Latin America & Caribbean Upper middle income 1983
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## 27  Mexico          MEX Latin America & Caribbean Upper middle income 1986
## 28  Mexico          MEX Latin America & Caribbean Upper middle income 1987
## 29  Mexico          MEX Latin America & Caribbean Upper middle income 1988
## 30  Mexico          MEX Latin America & Caribbean Upper middle income 1989
## 31  Mexico          MEX Latin America & Caribbean Upper middle income 1990
## 32  Mexico          MEX Latin America & Caribbean Upper middle income 1991
## 33  Mexico          MEX Latin America & Caribbean Upper middle income 1992
## 34  Mexico          MEX Latin America & Caribbean Upper middle income 1993
## 35  Mexico          MEX Latin America & Caribbean Upper middle income 1994
## 36  Mexico          MEX Latin America & Caribbean Upper middle income 1995
## 37  Mexico          MEX Latin America & Caribbean Upper middle income 1996
## 38  Mexico          MEX Latin America & Caribbean Upper middle income 1997
## 39  Mexico          MEX Latin America & Caribbean Upper middle income 1998
## 40  Mexico          MEX Latin America & Caribbean Upper middle income 1999
## 41  Mexico          MEX Latin America & Caribbean Upper middle income 2000
## 42  Mexico          MEX Latin America & Caribbean Upper middle income 2001
## 43  Mexico          MEX Latin America & Caribbean Upper middle income 2002
## 44  Mexico          MEX Latin America & Caribbean Upper middle income 2003
## 45  Mexico          MEX Latin America & Caribbean Upper middle income 2004
## 46  Mexico          MEX Latin America & Caribbean Upper middle income 2005
##    Life.Expectancy          GDP Population
## 1         57.06563  13040000000   36268055
## 2         57.65615  14160000000   37439317
## 3         58.18024  15200000000   38683283
## 4         58.64290  16960000000   39982118
## 5         59.05559  20080000000   41333878
## 6         59.43371  21840000000   42737991
## 7         59.79322  24320000000   44180437
## 8         60.15154  26560000000   45656963
## 9         60.52310  29360000000   47170337
## 10        60.91937  32480000000   48714394
## 11        61.35024  35520000000   50289306
## 12        61.81917  39200000000   51897675
## 13        62.31766  45200000000   53543436
## 14        62.83783  55280000000   55228203
## 15        63.37427  72000000000   56945880
## 16        63.92015  88000000000   58691882
## 17        64.46861  88875923765   60452543
## 18        65.01283  81912018784   62262505
## 19        65.54593 103000000000   64123997
## 20        66.06302 135000000000   65972912
## 21        66.56022 206000000000   67705186
## 22        67.03705 264000000000   69233769
## 23        67.49593 185000000000   70656783
## 24        67.94078 156000000000   72080310
## 25        68.37202 184000000000   73489654
## 26        68.79261 195000000000   74872006
```

```
## 27        69.20344 135000000000   76224365
## 28        69.60741 148000000000   77553504
## 29        70.00649 182000000000   78892015
## 30        70.40159 221000000000   80233749
## 31        70.79573 261000000000   81720428
## 32        71.19098 313000000000   83351595
## 33        71.58583 363000000000   84993164
## 34        71.97783 530000000000   86648447
## 35        72.36385 554000000000   88314424
## 36        72.73978 380000000000   89969572
## 37        73.09890 432000000000   91586555
## 38        73.43715 523000000000   93183094
## 39        73.75141 557000000000   94767284
## 40        74.03924 631000000000   96334810
## 41        74.29973 742000000000   97873442
## 42        74.53349 796000000000   99394288
## 43        74.74471 811000000000  100917081
## 44        74.93751 766000000000  102429341
## 45        75.11549 819000000000  103945813
## 46        75.28210 918000000000  105442402
```

```
pop_Mex = Mex_small$Population
gdp_Mex = Mex_small$GDP
life_Mex = Mex_small$Life.Expectancy
# Mex VAR
x_Mex = cbind(gdp_Mex,life_Mex, pop_Mex)
VAR_Mex = VARselect(x_Mex,lag.max = 8, type = "const")
VAR_Mex
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      7      4      3      4
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 6.631332e+01 6.178660e+01 5.844505e+01 5.819107e+01 5.842503e+01
## HQ(n)  6.649731e+01 6.210858e+01 5.890503e+01 5.878904e+01 5.916099e+01
## SC(n)  6.683045e+01 6.269158e+01 5.973788e+01 5.987175e+01 6.049356e+01
## FPE(n) 6.317272e+28 6.904329e+26 2.505439e+25 2.039406e+25 2.795213e+25
##                   6            7            8
## AIC(n) 5.821717e+01 5.799383e+01 5.811725e+01
## HQ(n)  5.909113e+01 5.900579e+01 5.926720e+01
## SC(n)  6.067355e+01 6.083806e+01 6.134933e+01
## FPE(n) 2.581533e+25 2.511274e+25 3.818335e+25
```

```
fit=VAR(x_Mex,p=7,type='const') # VAR select lowest AIC selects 7 lags to see life expectancy
fit$p
```

```
## [1] 7
```

```
# summary(lsfit) # didnt work singularity - possible multi-collinaearity between varaibles
preds=predict(fit,n.ahead=10)
preds
```

```
## $gdp_Mex
##               fcst        lower        upper           CI
##  [1,] 9.275203e+11 8.634644e+11 9.915762e+11  64055897472
##  [2,] 9.768910e+11 8.876956e+11 1.066086e+12  89195362054
##  [3,] 1.038023e+12 9.398393e+11 1.136206e+12  98183585137
##  [4,] 1.045488e+12 9.140953e+11 1.176881e+12 131392941561
##  [5,] 1.074184e+12 9.276865e+11 1.220681e+12 146497134850
##  [6,] 1.113087e+12 9.627966e+11 1.263378e+12 150290746285
##  [7,] 1.137753e+12 9.864666e+11 1.289040e+12 151286606846
##  [8,] 1.180657e+12 1.023696e+12 1.337618e+12 156961115630
##  [9,] 1.220584e+12 1.054471e+12 1.386698e+12 166113531180
## [10,] 1.237682e+12 1.064753e+12 1.410610e+12 172928457497
##
## $life_Mex
##           fcst    lower    upper          CI
##  [1,] 75.43945 75.43581 75.44309 0.003639806
##  [2,] 75.58742 75.57561 75.59924 0.011810792
##  [3,] 75.72691 75.70271 75.75112 0.024200840
##  [4,] 75.86014 75.81948 75.90080 0.040660489
##  [5,] 75.98915 75.92800 76.05030 0.061153073
##  [6,] 76.11577 76.03035 76.20119 0.085418854
##  [7,] 76.24003 76.12653 76.35353 0.113500132
##  [8,] 76.36160 76.21612 76.50708 0.145477567
##  [9,] 76.48123 76.29978 76.66269 0.181451814
## [10,] 76.59957 76.37853 76.82062 0.221043302
##
## $pop_Mex
##            fcst     lower     upper        CI
##  [1,] 106883893 106806468 106961317  77424.63
##  [2,] 108268293 108054120 108482466 214172.97
##  [3,] 109619012 109259132 109978893 359880.46
##  [4,] 110967144 110478325 111455964 488819.63
##  [5,] 112336969 111742979 112930959 593989.64
##  [6,] 113734860 113051529 114418191 683330.88
##  [7,] 115131039 114367640 115894438 763398.91
##  [8,] 116490618 115659585 117321652 831033.68
##  [9,] 117801674 116919341 118684008 882333.71
## [10,] 119056694 118139609 119973778 917084.40
```

```
life.mex.f=preds$fcst$life_Mex[,1]
life.mex.f
```

```
##  [1] 75.43945 75.58742 75.72691 75.86014 75.98915 76.11577 76.24003 76.36160
##  [9] 76.48123 76.59957
```

```
t=1:56
t
```

```
##  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
## [26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
## [51] 51 52 53 54 55 56
```

```
year=t+1960

#MLP Mexico Long term 10 year
MexicoTrain=ts(Mexico$Life.Expectancy[1:46])
MexicoVar=data.frame(GDP = ts(Mexico$GDP), Pop = ts(Mexico$Population))
MexicoVar
```

```
##             GDP       Pop
## 1  1.304000e+10  36268055
## 2  1.416000e+10  37439317
## 3  1.520000e+10  38683283
## 4  1.696000e+10  39982118
## 5  2.008000e+10  41333878
## 6  2.184000e+10  42737991
## 7  2.432000e+10  44180437
## 8  2.656000e+10  45656963
## 9  2.936000e+10  47170337
## 10 3.248000e+10  48714394
## 11 3.552000e+10  50289306
## 12 3.920000e+10  51897675
## 13 4.520000e+10  53543436
## 14 5.528000e+10  55228203
## 15 7.200000e+10  56945880
## 16 8.800000e+10  58691882
## 17 8.887592e+10  60452543
## 18 8.191202e+10  62262505
## 19 1.030000e+11  64123997
## 20 1.350000e+11  65972912
## 21 2.060000e+11  67705186
## 22 2.640000e+11  69233769
## 23 1.850000e+11  70656783
## 24 1.560000e+11  72080310
## 25 1.840000e+11  73489654
## 26 1.950000e+11  74872006
## 27 1.350000e+11  76224365
## 28 1.480000e+11  77553504
## 29 1.820000e+11  78892015
## 30 2.210000e+11  80233749
## 31 2.610000e+11  81720428
## 32 3.130000e+11  83351595
## 33 3.630000e+11  84993164
## 34 5.300000e+11  86648447
## 35 5.540000e+11  88314424
## 36 3.800000e+11  89969572
## 37 4.320000e+11  91586555
## 38 5.230000e+11  93183094
## 39 5.570000e+11  94767284
## 40 6.310000e+11  96334810
## 41 7.420000e+11  97873442
## 42 7.960000e+11  99394288
## 43 8.110000e+11 100917081
## 44 7.660000e+11 102429341
## 45 8.190000e+11 103945813
## 46 9.180000e+11 105442402
## 47 1.020000e+12 106886790
## 48 1.100000e+12 108302973
## 49 1.160000e+12 109684489
## 50 9.430000e+11 111049428
## 51 1.110000e+12 112532401
## 52 1.230000e+12 114150481
## 53 1.260000e+12 115755909
## 54 1.330000e+12 117290686
## 55 1.360000e+12 118755887
## 56 1.210000e+12 120149897
```

```
set.seed(2)
fit=mlp(MexicoTrain,xreg=MexicoVar)
f=forecast(fit,h=10,xreg=MexicoVar)
f$mean
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 75.44976 75.62038 75.79973 75.98304 76.17431 76.36669 76.56154 76.76185
##      t+9     t+10
## 76.95080 77.10300
```

```
################
f$mean # MLP long term 10 year predictions
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 75.44976 75.62038 75.79973 75.98304 76.17431 76.36669 76.56154 76.76185
##      t+9     t+10
## 76.95080 77.10300
```

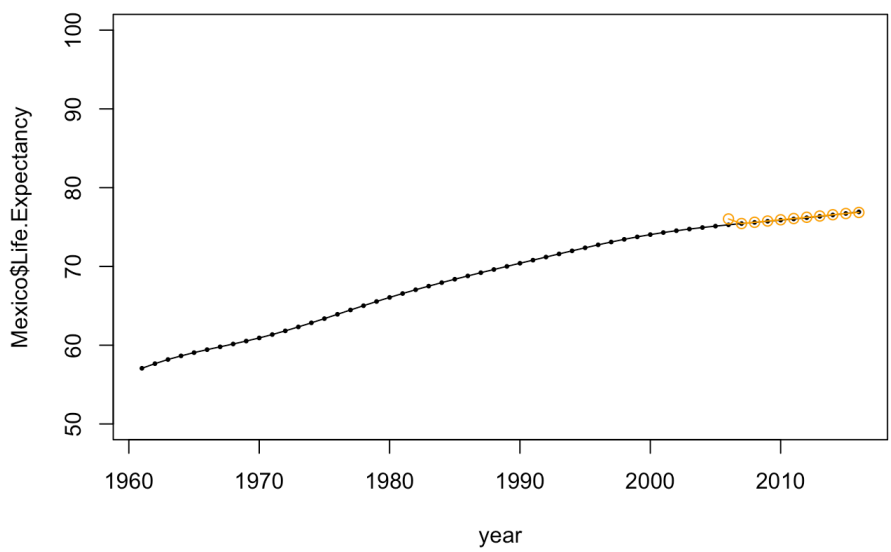
```
life.mex.f # VAR long term 10 year predictions
```

```
##  [1] 75.43945 75.58742 75.72691 75.86014 75.98915 76.11577 76.24003 76.36160
##  [9] 76.48123 76.59957
```

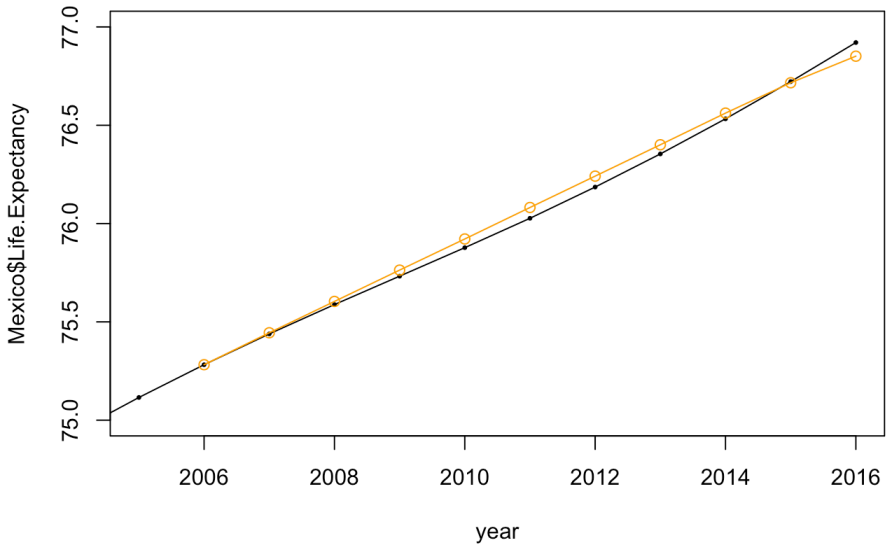
```
ensemble_MEX = (life.mex.f + f$mean)/2
ensemble_MEX
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 75.44461 75.60390 75.76332 75.92159 76.08173 76.24123 76.40079 76.56173
##      t+9     t+10
## 76.71602 76.85128
```

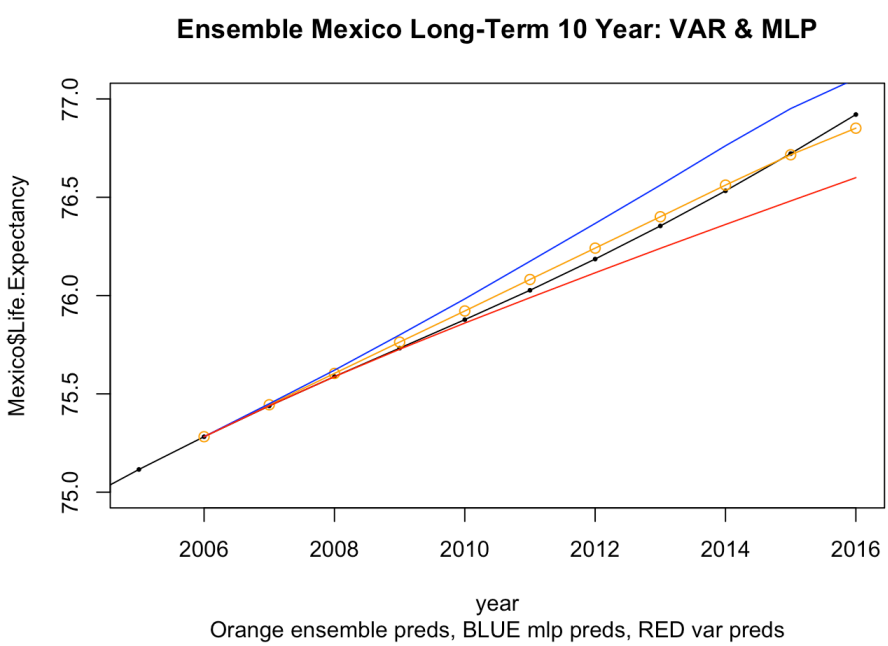
```
################
#Plot
################
# plotting all years
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[46:56],c(Mexico$Life.Expectancy[51],ensemble_MEX),type='o',cex=1,pch=1, col='orange')
```




```
# zooming in only on the predictions
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75, 77)) # zoom in on 10 year
forecast
points(year[46:56],c(Mexico$Life.Expectancy[46],ensemble_MEX),type='o',cex=1,pch=1, col='orange')
```




```
# all plotted together
plot(year,Mexico$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75,77), main='Ensemble Mexico
Long-Term 10 Year: VAR & MLP', sub='Orange ensemble preds, BLUE mlp preds, RED var preds') # zoom in on 10 year f
orecast
points(year[46:56],c(Mexico$Life.Expectancy[46],ensemble_MEX),type='o',cex=1,pch=1, col='orange')# ensemble predi
ctions
points(year[46:56],c(Mexico$Life.Expectancy[46],f$mean),type='l',cex=1,pch=1, col='blue') # MLP predictions
points(year[46:56],c(Mexico$Life.Expectancy[46],life.mex.f),type='l',cex=1,pch=1, col='red') # VAR predictions
```




```
################

ASE = mean((Mexico$Life.Expectancy[47:56]-ensemble_MEX)^2)
ASE # 0.001717489
```

```
## [1] 0.001717489
```

```
RMSE=sqrt(mean((Mexico$Life.Expectancy[47:56]-ensemble_MEX)^2))
RMSE # 0.04144259
```

```
## [1] 0.04144259
```

The Mexico predictions for both short-term and long-term have very low ASEs, with the long-term forecast having the lower ASE. When we zoom in the long-term forecast using the ensemble method appears to be quite useful.

Ensemble: MLP & VAR United States Short Term 5 year

```
# VAR Short term 5 year United States
UnitedStates
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
## 108 United States          USA North America  High income 2011        78.64146
## 109 United States          USA North America  High income 2012        78.74146
## 110 United States          USA North America  High income 2013        78.74146
## 111 United States          USA North America  High income 2014        78.74146
## 112 United States          USA North America  High income 2015        78.74146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
```

```
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
## 108 1.56e+13  311583481
## 109 1.63e+13  313877662
## 110 1.68e+13  316059947
## 111 1.76e+13  318386329
## 112 1.82e+13  320738994
```

```
US_small = UnitedStates[1:51,] # first 46, predict next 10 years for forecast
US_small
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
```

```
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
```

```
pop_US = US_small$Population
gdp_US = US_small$GDP
life_US = US_small$Life.Expectancy
life_US
```

```
##  [1] 69.77073 70.27073 70.11951 69.91707 70.16585 70.21463 70.21220 70.56098
##  [9] 69.95122 70.50732 70.80732 71.10732 71.15610 71.35610 71.95610 72.60488
## [17] 72.85610 73.25610 73.35610 73.80488 73.60976 74.00976 74.36098 74.46341
## [25] 74.56341 74.56341 74.61463 74.76585 74.76585 75.01707 75.21463 75.36585
## [33] 75.61707 75.41951 75.61951 75.62195 76.02683 76.42927 76.58049 76.58293
## [41] 76.63659 76.83659 76.93659 77.03659 77.48780 77.48780 77.68780 77.98780
## [49] 78.03902 78.39024 78.54146
```

```
X_US = cbind(pop_US,gdp_US,life_US)
VAR_US = VARselect(cbind(pop_US,gdp_US,life_US),lag.max = 10, type = "both")
VAR_US
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##     10     10      2     10
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 7.398307e+01 7.240742e+01 7.253875e+01 7.267446e+01 7.235000e+01
## HQ(n)  7.421136e+01 7.277268e+01 7.304098e+01 7.331367e+01 7.312618e+01
## SC(n)  7.460999e+01 7.341049e+01 7.391797e+01 7.442983e+01 7.448152e+01
## FPE(n) 1.355277e+32 2.836268e+31 3.316778e+31 3.975026e+31 3.093253e+31
##                   6            7            8            9           10
## AIC(n) 7.200991e+01 7.171048e+01 7.148490e+01 7.032055e+01 6.959136e+01
## HQ(n)  7.292307e+01 7.276061e+01 7.267200e+01 7.164463e+01 7.105240e+01
## SC(n)  7.451758e+01 7.459430e+01 7.474487e+01 7.395667e+01 7.360362e+01
## FPE(n) 2.464526e+31 2.159824e+31 2.202981e+31 9.873592e+30 8.253035e+30
```

```
fit_US =VAR(X_US,p=10,type='const') # use phi=10
fit_US$varresult
```

```
## $pop_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   2.367e+00    7.542e-07   -9.883e+05   -1.531e+00   -8.044e-07   -3.466e+05
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -7.981e-01    6.070e-07    3.222e+05    1.240e+00   -1.263e-06    5.433e+05
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -4.854e-01    9.069e-07   -9.643e+04    6.092e-01   -1.031e-06    3.882e+04
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   1.295e-01   -5.327e-07   -3.395e+05   -1.204e+00   -7.672e-07    9.784e+04
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   3.879e-01   -3.400e-07    2.356e+05    3.882e-01    2.220e-06   -5.675e+04
##       const
##   2.508e+07
##
##
## $gdp_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##  -2.074e+05    6.718e-01    2.765e+11    2.102e+05   -6.987e-01    1.565e+11
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##   2.653e+05    6.295e-02   -2.982e+11   -2.133e+05   -3.083e-01   -1.328e+11
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -5.351e+05    1.772e-01    2.275e+11    6.683e+05    9.875e-02    1.885e+11
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -1.988e+05    1.022e+00   -4.658e+10    2.488e+05    6.567e-01    6.812e+10
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##  -1.555e+05   -8.844e-01    4.087e+10   -7.706e+04    2.566e-01   -1.723e+11
##       const
##  -2.280e+13
##
##
## $life_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   3.024e-07    6.165e-13   -5.046e-01   -5.259e-07   -5.619e-13    8.585e-02
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -2.158e-07    2.282e-13    1.355e-01    4.303e-07    1.335e-14    4.601e-01
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##   4.111e-08   -2.853e-13    2.745e-01    5.591e-07   -9.842e-13   -3.940e-01
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -4.870e-07   -1.920e-13   -3.671e-01   -4.547e-07   -7.901e-13    3.011e-01
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##  -6.836e-08   -3.230e-14    2.148e-02    5.663e-07    1.597e-12   -1.460e-01
##       const
##   5.494e+01
```

```
fit_US$p
```

```
## [1] 10
```

```
fit_US$K
```

```
## [1] 3
```

```
# summary(lsfit)
preds_US=predict(fit_US,n.ahead=5)
preds_US$fcst
```

```
## $pop_US
##           fcst     lower     upper        CI
## [1,] 311677605 311312248 312042963  365357.5
## [2,] 313812260 312868013 314756507  944247.0
## [3,] 316606614 314984574 318228654 1622039.9
## [4,] 320214854 318018368 322411339 2196485.4
## [5,] 324210168 321570879 326849457 2639289.0
##
## $gdp_US
##               fcst        lower        upper           CI
## [1,] 1.642538e+13 1.623148e+13 1.661927e+13 193896134897
## [2,] 1.804561e+13 1.778469e+13 1.830653e+13 260917553274
## [3,] 1.926616e+13 1.897249e+13 1.955983e+13 293670520589
## [4,] 1.953263e+13 1.921610e+13 1.984916e+13 316530836788
## [5,] 1.904501e+13 1.868183e+13 1.940819e+13 363183430182
##
## $life_US
##          fcst    lower    upper        CI
## [1,] 78.47854 78.25377 78.70330 0.2247651
## [2,] 78.54731 78.27660 78.81803 0.2707159
## [3,] 78.50655 78.23101 78.78209 0.2755386
## [4,] 79.52160 79.20281 79.84039 0.3187890
## [5,] 80.04957 79.68444 80.41471 0.3651360
```

```
life.US.f=preds_US$fcst$life_US[,1]
life.US.f
```

```
## [1] 78.47854 78.54731 78.50655 79.52160 80.04957
```

```
t=1:56
year=t+1960

# MLP Long term 10 year United States
USTrain=ts(UnitedStates$Life.Expectancy[1:51])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
set.seed(2)
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=5,xreg=USVar)

################
f$mean # MLP long term 5 year predictions
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 78.89221 78.98052 79.40205 79.41036 79.85006
```

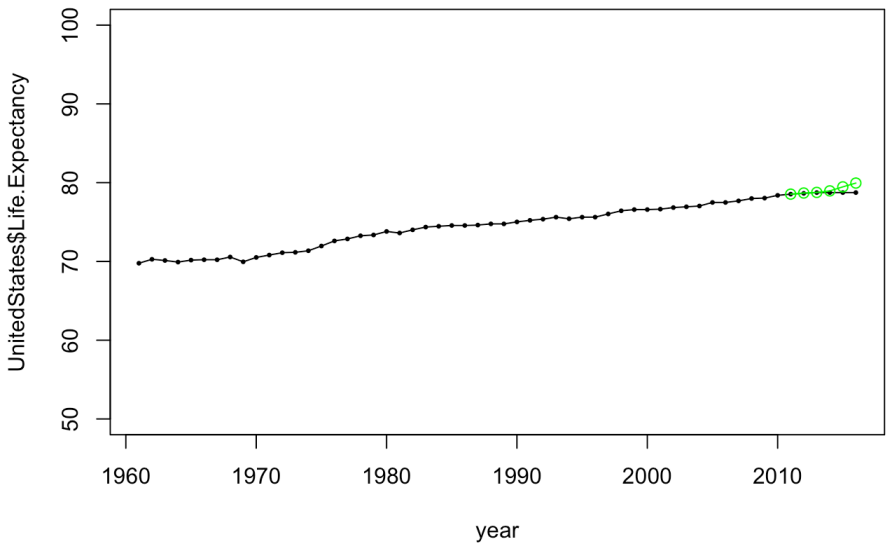
```
life.US.f # VAR long term 5 year predictions
```

```
## [1] 78.47854 78.54731 78.50655 79.52160 80.04957
```

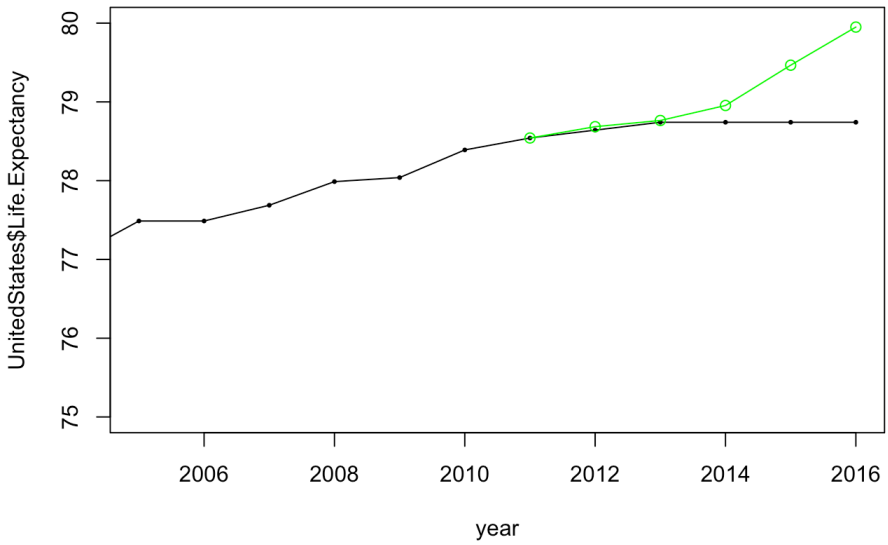
```
ensemble_US = (life.US.f + f$mean)/2
ensemble_US
```

```
## Time Series:
## Start = 52
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5
## 78.68537 78.76392 78.95430 79.46598 79.94982
```

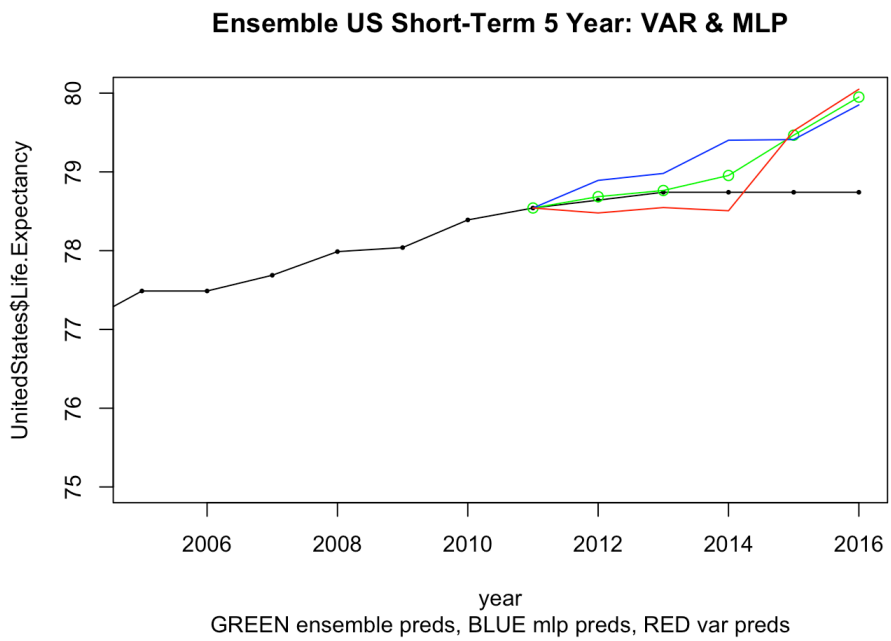
```
################
#Plot
################
# plot showing all years
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[51:56],c(UnitedStates$Life.Expectancy[51],ensemble_US),type='o',cex=1,pch=1, col='green')
```




```
# zoomed in plot to better see the predictions
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75,80)) # zoom in on 10 year forecast
points(year[51:56],c(UnitedStates$Life.Expectancy[51],ensemble_US),type='o',cex=1,pch=1, col='green')
```



```
# ALL preds together
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75,80), main='Ensemble U
S Short-Term 5 Year: VAR & MLP', sub='GREEN ensemble preds, BLUE mlp preds, RED var preds') # zoom in on 10 year
forecast
points(year[51:56],c(UnitedStates$Life.Expectancy[51],ensemble_US),type='o',cex=1,pch=1, col='green')# ensemble p
redictions
points(year[51:56],c(UnitedStates$Life.Expectancy[51],f$mean),type='l',cex=1,pch=1, col='blue') # MLP predictions
points(year[51:56],c(UnitedStates$Life.Expectancy[51],life.US.f),type='l',cex=1,pch=1, col='red') # VAR predictio
ns
```




```
################

ASE = mean((UnitedStates$Life.Expectancy[52:56]-ensemble_US)^2)
ASE # 0.4065556
```

```
## [1] 0.4065556
```

```
RMSE=sqrt(mean((UnitedStates$Life.Expectancy[52:56]-ensemble_US)^2))
RMSE # 0.6376171
```

```
## [1] 0.6376171
```

Given that the VAR and MLP models were not useless models, let's use the combo of models to create a multivariate ensemble model to see how well it performs.

Ensemble: MLP & VAR United States Long Term 10 year

```
# VAR Long term 10 year United States
# Long Term
UnitedStates
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
## 103 United States          USA North America  High income 2006        77.68780
## 104 United States          USA North America  High income 2007        77.98780
## 105 United States          USA North America  High income 2008        78.03902
## 106 United States          USA North America  High income 2009        78.39024
## 107 United States          USA North America  High income 2010        78.54146
## 108 United States          USA North America  High income 2011        78.64146
## 109 United States          USA North America  High income 2012        78.74146
## 110 United States          USA North America  High income 2013        78.74146
## 111 United States          USA North America  High income 2014        78.74146
## 112 United States          USA North America  High income 2015        78.74146
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
```

```
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
## 103 1.38e+13  298379912
## 104 1.45e+13  301231207
## 105 1.48e+13  304093966
## 106 1.45e+13  306771529
## 107 1.50e+13  309327143
## 108 1.56e+13  311583481
## 109 1.63e+13  313877662
## 110 1.68e+13  316059947
## 111 1.76e+13  318386329
## 112 1.82e+13  320738994
```

```
US_small = UnitedStates[1:46,] # first 46, predict next 10 years for forecast
US_small
```

```
##           Country Country.Code        Region Income.Group Year Life.Expectancy
## 57  United States          USA North America  High income 1960        69.77073
## 58  United States          USA North America  High income 1961        70.27073
## 59  United States          USA North America  High income 1962        70.11951
## 60  United States          USA North America  High income 1963        69.91707
## 61  United States          USA North America  High income 1964        70.16585
## 62  United States          USA North America  High income 1965        70.21463
## 63  United States          USA North America  High income 1966        70.21220
## 64  United States          USA North America  High income 1967        70.56098
## 65  United States          USA North America  High income 1968        69.95122
## 66  United States          USA North America  High income 1969        70.50732
## 67  United States          USA North America  High income 1970        70.80732
## 68  United States          USA North America  High income 1971        71.10732
## 69  United States          USA North America  High income 1972        71.15610
## 70  United States          USA North America  High income 1973        71.35610
## 71  United States          USA North America  High income 1974        71.95610
## 72  United States          USA North America  High income 1975        72.60488
## 73  United States          USA North America  High income 1976        72.85610
## 74  United States          USA North America  High income 1977        73.25610
## 75  United States          USA North America  High income 1978        73.35610
## 76  United States          USA North America  High income 1979        73.80488
## 77  United States          USA North America  High income 1980        73.60976
## 78  United States          USA North America  High income 1981        74.00976
## 79  United States          USA North America  High income 1982        74.36098
## 80  United States          USA North America  High income 1983        74.46341
## 81  United States          USA North America  High income 1984        74.56341
## 82  United States          USA North America  High income 1985        74.56341
## 83  United States          USA North America  High income 1986        74.61463
## 84  United States          USA North America  High income 1987        74.76585
## 85  United States          USA North America  High income 1988        74.76585
## 86  United States          USA North America  High income 1989        75.01707
## 87  United States          USA North America  High income 1990        75.21463
## 88  United States          USA North America  High income 1991        75.36585
## 89  United States          USA North America  High income 1992        75.61707
## 90  United States          USA North America  High income 1993        75.41951
## 91  United States          USA North America  High income 1994        75.61951
## 92  United States          USA North America  High income 1995        75.62195
## 93  United States          USA North America  High income 1996        76.02683
## 94  United States          USA North America  High income 1997        76.42927
## 95  United States          USA North America  High income 1998        76.58049
## 96  United States          USA North America  High income 1999        76.58293
## 97  United States          USA North America  High income 2000        76.63659
## 98  United States          USA North America  High income 2001        76.83659
## 99  United States          USA North America  High income 2002        76.93659
## 100 United States          USA North America  High income 2003        77.03659
## 101 United States          USA North America  High income 2004        77.48780
## 102 United States          USA North America  High income 2005        77.48780
##          GDP Population
## 57  5.43e+11  180671000
## 58  5.63e+11  183691000
## 59  6.05e+11  186538000
## 60  6.39e+11  189242000
## 61  6.86e+11  191889000
## 62  7.44e+11  194303000
## 63  8.15e+11  196560000
## 64  8.62e+11  198712000
## 65  9.43e+11  200706000
## 66  1.02e+12  202677000
## 67  1.07e+12  205052000
## 68  1.16e+12  207661000
## 69  1.28e+12  209896000
## 70  1.43e+12  211909000
## 71  1.55e+12  213854000
## 72  1.68e+12  215973000
## 73  1.87e+12  218035000
## 74  2.08e+12  220239000
## 75  2.35e+12  222585000
## 76  2.63e+12  225055000
## 77  2.86e+12  227225000
## 78  3.21e+12  229466000
## 79  3.34e+12  231664000
## 80  3.63e+12  233792000
## 81  4.04e+12  235825000
## 82  4.34e+12  237924000
```

```
## 83  4.58e+12  240133000
## 84  4.86e+12  242289000
## 85  5.24e+12  244499000
## 86  5.64e+12  246819000
## 87  5.96e+12  249623000
## 88  6.16e+12  252981000
## 89  6.52e+12  256514000
## 90  6.86e+12  259919000
## 91  7.29e+12  263126000
## 92  7.64e+12  266278000
## 93  8.07e+12  269394000
## 94  8.58e+12  272657000
## 95  9.06e+12  275854000
## 96  9.63e+12  279040000
## 97  1.03e+13  282162411
## 98  1.06e+13  284968955
## 99  1.09e+13  287625193
## 100 1.15e+13  290107933
## 101 1.22e+13  292805298
## 102 1.30e+13  295516599
```

```
pop_US = US_small$Population
gdp_US = US_small$GDP
life_US = US_small$Life.Expectancy
life_US
```

```
##  [1] 69.77073 70.27073 70.11951 69.91707 70.16585 70.21463 70.21220 70.56098
##  [9] 69.95122 70.50732 70.80732 71.10732 71.15610 71.35610 71.95610 72.60488
## [17] 72.85610 73.25610 73.35610 73.80488 73.60976 74.00976 74.36098 74.46341
## [25] 74.56341 74.56341 74.61463 74.76585 74.76585 75.01707 75.21463 75.36585
## [33] 75.61707 75.41951 75.61951 75.62195 76.02683 76.42927 76.58049 76.58293
## [41] 76.63659 76.83659 76.93659 77.03659 77.48780 77.48780
```

```
X_US = cbind(pop_US,gdp_US,life_US)
VAR_US = VARselect(cbind(pop_US,gdp_US,life_US),lag.max = 10, type = "both")
VAR_US
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##     10     10     10      9
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 7.303850e+01 7.136972e+01 7.125429e+01 7.153465e+01 7.115011e+01
## HQ(n)  7.326879e+01 7.173818e+01 7.176092e+01 7.217946e+01 7.193309e+01
## SC(n)  7.369830e+01 7.242540e+01 7.270584e+01 7.338209e+01 7.339343e+01
## FPE(n) 5.279249e+31 1.012276e+31 9.367205e+30 1.328597e+31 1.014303e+31
##                   6            7            8            9           10
## AIC(n) 7.111737e+01 7.130843e+01 7.003502e+01 6.857568e+01 6.781829e+01
## HQ(n)  7.203852e+01 7.236775e+01 7.123252e+01 6.991135e+01 6.929213e+01
## SC(n)  7.375657e+01 7.434350e+01 7.346598e+01 7.240252e+01 7.204101e+01
## FPE(n) 1.176084e+31 1.882724e+31 8.148079e+30 3.858291e+30 6.733142e+30
```

```
fit_US =VAR(X_US,p=10,type='const') # use phi=10
fit_US$varresult
```

```
## $pop_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   1.925e+00    2.694e-07   -6.242e+05   -1.192e+00   -2.063e-07    3.755e+05
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -7.271e-01    6.531e-07    5.209e+05    1.262e+00   -1.142e-06    4.923e+05
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -3.282e-01   -1.997e-07   -2.277e+05   -7.887e-02   -6.617e-07   -1.423e+05
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   4.263e-01   -3.745e-07   -1.350e+05   -1.422e+00   -4.715e-07    2.718e+05
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   8.308e-01    9.733e-07    1.751e+05    1.867e-01    2.456e-06    2.333e+04
##       const
##  -2.389e+07
##
##
## $gdp_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##  -2.651e+05    5.442e-01    4.239e+11   -2.312e+05   -3.073e-01    1.004e+12
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##   8.809e+05    2.153e-02   -1.351e+11   -7.864e+04   -6.231e-02   -3.942e+11
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -5.006e+05   -2.113e-01   -7.111e+10   -1.941e+05   -6.106e-01    1.769e+11
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##   2.618e+03    9.387e-01    1.592e+11    3.890e+05    1.689e+00    2.743e+11
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   2.930e+05    6.674e-01   -3.155e+10   -4.534e+05   -6.247e-01   -1.429e+11
##       const
##  -5.864e+13
##
##
## $life_US
##
## Call:
## lm(formula = y ~ -1 + ., data = datamat)
##
## Coefficients:
##   pop_US.l1    gdp_US.l1   life_US.l1    pop_US.l2    gdp_US.l2   life_US.l2
##   4.427e-07    3.509e-13   -6.042e-01   -9.451e-07   -3.852e-13    4.928e-01
##   pop_US.l3    gdp_US.l3   life_US.l3    pop_US.l4    gdp_US.l4   life_US.l4
##  -9.620e-08    1.571e-13    3.172e-01    8.856e-07    1.520e-13    3.766e-01
##   pop_US.l5    gdp_US.l5   life_US.l5    pop_US.l6    gdp_US.l6   life_US.l6
##  -6.095e-08   -4.594e-14    2.990e-02    1.923e-07   -1.349e-12   -4.347e-01
##   pop_US.l7    gdp_US.l7   life_US.l7    pop_US.l8    gdp_US.l8   life_US.l8
##  -4.901e-07   -1.041e-12   -2.226e-01   -5.545e-07   -2.765e-14    4.153e-01
##   pop_US.l9    gdp_US.l9   life_US.l9   pop_US.l10   gdp_US.l10  life_US.l10
##   5.653e-07    8.945e-13    2.767e-02    1.654e-07    1.142e-12   -1.786e-01
##       const
##   3.816e+01
```

```
fit_US$p
```

```
## [1] 10
```

```
fit_US$K
```

```
## [1] 3
```

```
# summary(lsfit)
preds_US=predict(fit_US,n.ahead=10)
preds_US$fcst
```

```
## $pop_US
##            fcst     lower     upper        CI
##  [1,] 299108903 298808113 299409692  300789.4
##  [2,] 303965341 303345238 304585445  620103.7
##  [3,] 310101848 309216495 310987202  885353.3
##  [4,] 316747093 315721332 317772854 1025760.8
##  [5,] 323328558 322204893 324452223 1123665.0
##  [6,] 328629339 327436017 329822660 1193321.1
##  [7,] 331926900 330626463 333227336 1300436.2
##  [8,] 333894961 332413209 335376713 1481752.3
##  [9,] 336387592 334615475 338159710 1772117.7
## [10,] 340912772 338906378 342919165 2006393.6
##
## $gdp_US
##               fcst        lower        upper           CI
##  [1,] 1.393486e+13 1.379942e+13 1.407031e+13 135443936435
##  [2,] 1.485271e+13 1.467487e+13 1.503056e+13 177843187848
##  [3,] 1.534522e+13 1.504380e+13 1.564663e+13 301412261743
##  [4,] 1.546184e+13 1.515390e+13 1.576978e+13 307940980848
##  [5,] 1.573649e+13 1.542103e+13 1.605194e+13 315456070674
##  [6,] 1.622248e+13 1.589150e+13 1.655346e+13 330975272084
##  [7,] 1.680969e+13 1.647443e+13 1.714495e+13 335261515216
##  [8,] 1.798696e+13 1.763096e+13 1.834296e+13 356003208480
##  [9,] 1.997719e+13 1.956952e+13 2.038486e+13 407667695509
## [10,] 2.169628e+13 2.120992e+13 2.218264e+13 486360632329
##
## $life_US
##           fcst    lower    upper        CI
##  [1,] 77.54287 77.32279 77.76295 0.2200783
##  [2,] 78.02394 77.75758 78.29030 0.2663596
##  [3,] 78.79499 78.48313 79.10685 0.3118563
##  [4,] 78.72093 78.37040 79.07146 0.3505272
##  [5,] 78.31847 77.94798 78.68895 0.3704820
##  [6,] 77.78615 77.40684 78.16545 0.3793058
##  [7,] 77.55611 77.09763 78.01459 0.4584811
##  [8,] 77.14201 76.58082 77.70321 0.5611951
##  [9,] 78.08037 77.42313 78.73761 0.6572439
## [10,] 79.81467 79.13218 80.49716 0.6824903
```

```
life.US.f=preds_US$fcst$life_US[,1]
life.US.f
```

```
##  [1] 77.54287 78.02394 78.79499 78.72093 78.31847 77.78615 77.55611 77.14201
##  [9] 78.08037 79.81467
```

```
t=1:56
year=t+1960

# MLP Long term 10 year United States
USTrain=ts(UnitedStates$Life.Expectancy[1:46])
USVar=data.frame(GDP = ts(UnitedStates$GDP), Pop = ts(UnitedStates$Population))
set.seed(2)
fit=mlp(USTrain,xreg=USVar)
f=forecast(fit,h=10,xreg=USVar)

################
f$mean # MLP long term 10 year predictions
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 77.62826 77.76296 77.88989 77.98598 78.14913 78.26706 78.39659 78.59593
##      t+9     t+10
## 78.67388 79.00303
```

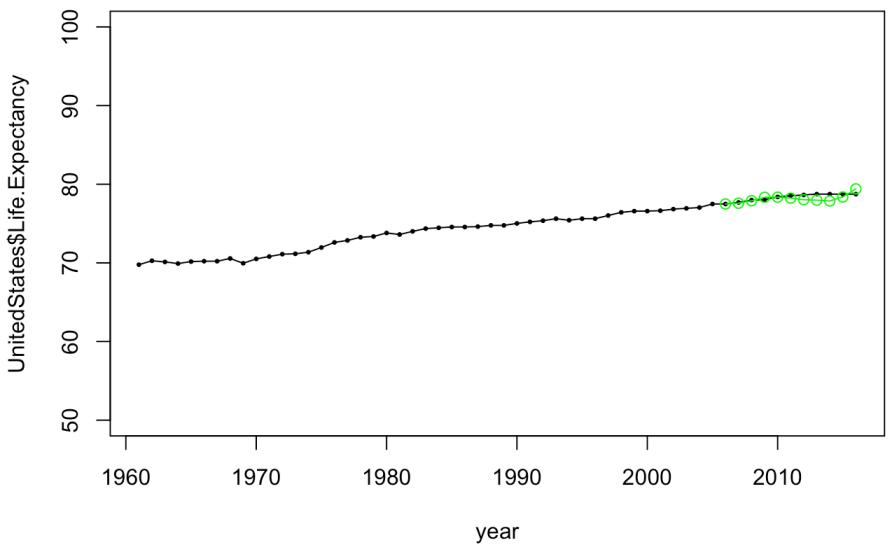
```
life.US.f # VAR long term 10 year predictions
```

```
##  [1] 77.54287 78.02394 78.79499 78.72093 78.31847 77.78615 77.55611 77.14201
##  [9] 78.08037 79.81467
```

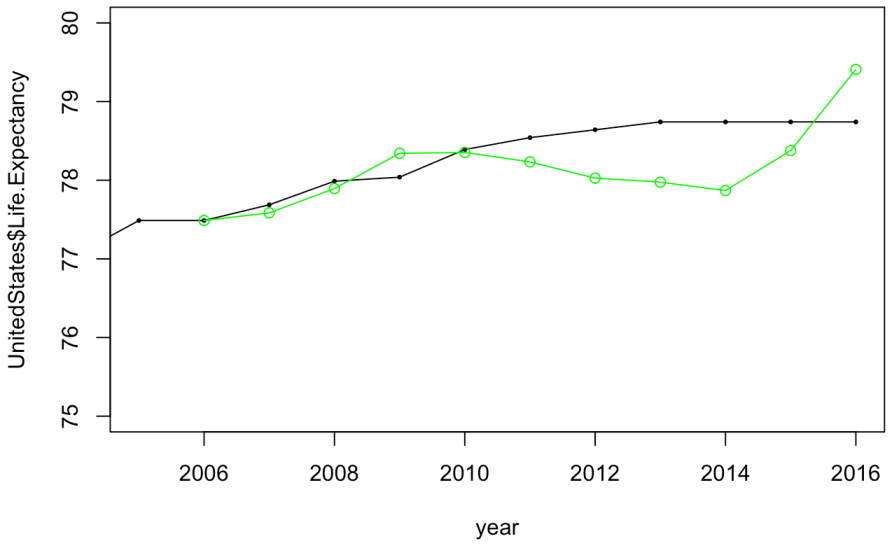
```
ensemble_US = (life.US.f + f$mean)/2
ensemble_US
```

```
## Time Series:
## Start = 47
## End = 56
## Frequency = 1
##      t+1      t+2      t+3      t+4      t+5      t+6      t+7      t+8
## 77.58556 77.89345 78.34244 78.35346 78.23380 78.02660 77.97635 77.86897
##      t+9     t+10
## 78.37713 79.40885
```

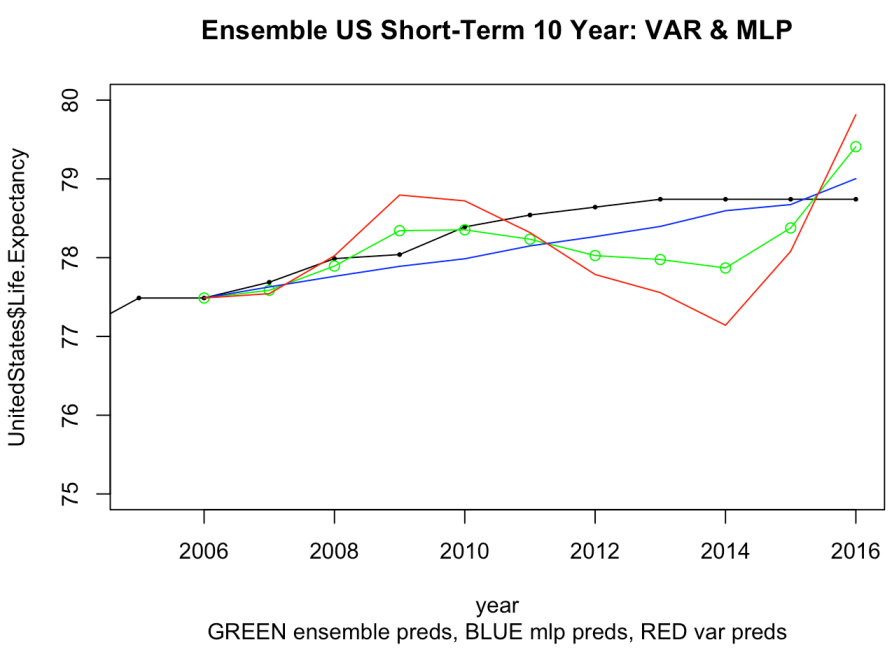
```
################
#Plot
################
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,ylim=c(50,100))
points(year[46:56],c(UnitedStates$Life.Expectancy[46],ensemble_US),type='o',cex=1,pch=1, col='green')
```




```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75,80)) # zoom in on 10 year forecast
points(year[46:56],c(UnitedStates$Life.Expectancy[46],ensemble_US),type='o',cex=1,pch=1, col='green')
```




```
plot(year,UnitedStates$Life.Expectancy,type="o",pch=20,cex=.5,xlim=c(2005, 2016), ylim=c(75,80), main='Ensemble U
S Short-Term 10 Year: VAR & MLP', sub='GREEN ensemble preds, BLUE mlp preds, RED var preds') # zoom in on 10 year
forecast
points(year[46:56],c(UnitedStates$Life.Expectancy[46],ensemble_US),type='o',cex=1,pch=1, col='green')# ensemble p
redictions
points(year[46:56],c(UnitedStates$Life.Expectancy[46],f$mean),type='l',cex=1,pch=1, col='blue') # MLP predictions
points(year[46:56],c(UnitedStates$Life.Expectancy[46],life.US.f),type='l',cex=1,pch=1, col='red')
```




```
################

ASE = mean((UnitedStates$Life.Expectancy[47:56]-ensemble_US)^2)
ASE # 0.2510273
```

```
## [1] 0.2510273
```

```
RMSE=sqrt(mean((UnitedStates$Life.Expectancy[47:56]-ensemble_US)^2))
RMSE # 0.5010262
```

```
## [1] 0.5010262
```

The United States predictions for both short-term model performs worse as compared to the longer-term forecasts. The Shorter term model looks to be wandering higher and perhaps is not useful as the long-term model which shows the models is capture some trend around in the data to oscillate low then high around the actual predictions.

The ensemble combo of VAR and MLP did not perform well compared to either VAR or MLP models.

Looking at the shorter term forecast we see that the lowest ASE model for the US was the ensemble combo of 10th Order Var and MLP Model.

For Mexico, the most useful model at predicting life-expectancy was the 4th Order VAR model.

The ensemble combo of VAR and MLP did not perform well compared to either VAR or MLP models.

Looking at the shorter term forecast we see that the lowest ASE model for the US was the ensemble combo of 10th Order Var and MLP Model.

For Mexico, the most useful model at predicting life-expectancy was the multivariate ensemble (combo of 7tth Order VAR model and Multivariate Preceptron Model).