HW3

```
load("TSvectors_2016data_011918.RData")
install.packages("forecast", repos = "http://cran.us.r-project.org",dependencies = TRUE)
```

```
##
## The downloaded binary packages are in
##  /var/folders/ns/ypy9ps197ln6h4_3y1f7c1ph0000gn/T//RtmpOm9b5i/downloaded_packages
```

```
install.packages("lmtest", repos = "http://cran.us.r-project.org", dependencies = TRUE)
```

```
##
## The downloaded binary packages are in
##  /var/folders/ns/ypy9ps197ln6h4_3y1f7c1ph0000gn/T//RtmpOm9b5i/downloaded_packages
```

```
require(forecast)
```

```
## Loading required package: forecast
```

```
require(lmtest)
```

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

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

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

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

```
## RACE-Implicit
## first subset to TEST/TRAIN
race.WtsTRAIN <- window(race.Wts, start = c(2007,1), end = c(2014, 12))
race.WtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.3278651 0.3277165 0.3322248 0.3161193 0.3333073 0.3357736 0.3340041
## 2008 0.3066140 0.3238721 0.3235213 0.3242149 0.3168418 0.3098822 0.3062285
## 2009 0.3093101 0.3008512 0.3237297 0.3264456 0.3074889 0.3126628 0.3038022
## 2010 0.3316669 0.3226309 0.3296421 0.3282486 0.3189349 0.2970956 0.3026737
## 2011 0.3218048 0.3212780 0.3259305 0.3326646 0.3182963 0.3050033 0.3108015
## 2012 0.3322995 0.3425013 0.3354685 0.3439547 0.3166026 0.3163159 0.2959624
## 2013 0.3108957 0.3274840 0.3401158 0.3425413 0.3261512 0.3155653 0.2859391
## 2014 0.3051787 0.3106835 0.3021592 0.3165764 0.2988989 0.2875568 0.3058738
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.3233254 0.3185749 0.3387294 0.3487443 0.3402152
## 2008 0.3060015 0.3262490 0.3150517 0.3204843 0.3233195
## 2009 0.3035338 0.3164414 0.3164856 0.3246348 0.3136264
## 2010 0.3031876 0.3290242 0.3231118 0.3336652 0.3320710
## 2011 0.3163496 0.3289761 0.3369904 0.3578439 0.3229158
## 2012 0.3188754 0.3116442 0.3421635 0.3446615 0.3124188
## 2013 0.2921285 0.3146941 0.3263020 0.3250838 0.3153784
## 2014 0.2820667 0.3113327 0.3099621 0.3079003 0.2666391
```

```
race.WtsTEST <- window(race.Wts, start = c(2015, 1))
race.WtsTEST
```

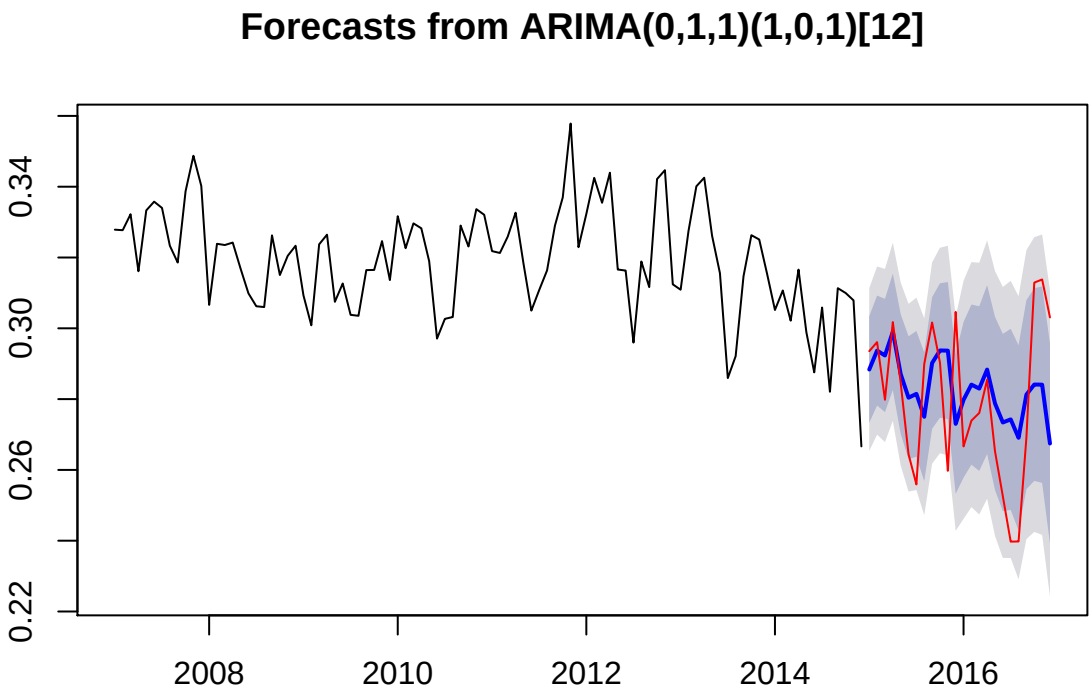
```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.2935401 0.2960996 0.2798079 0.3017520 0.2846378 0.2644353 0.2558995
## 2016 0.2666315 0.2739146 0.2760847 0.2854647 0.2652794 0.2525643 0.2397394
##            Aug       Sep       Oct       Nov       Dec
## 2015 0.2899113 0.3016353 0.2903120 0.2597358 0.3046285
## 2016 0.2397847 0.2691268 0.3129118 0.3137970 0.3030775
```

```
race.arimaTRAIN <- auto.arima(race.WtsTRAIN, stepwise = FALSE, approximation = FALSE)
race.arimaTRAIN
```

```
## Series: race.WtsTRAIN
## ARIMA(0,1,1)(1,0,1)[12]
##
## Coefficients:
##           ma1    sar1     sma1
##       -0.7431  0.8034  -0.4182
## s.e.   0.0795  0.1448   0.2509
##
## sigma^2 estimated as 0.0001376:  log likelihood=286.2
## AIC=-564.39   AICc=-563.95   BIC=-554.18
```

```
forecast.raceTRAIN <- forecast(race.arimaTRAIN, h = 24)

plot(forecast.raceTRAIN)
lines(race.WtsTEST, col = "red")
```




```
accuracy(forecast.raceTRAIN, race.WtsTEST)
```

```
##                       ME       RMSE         MAE        MPE     MAPE
## Training set -0.0009244842 0.01148418 0.008960577 -0.4202292 2.850205
## Test set     -0.0031203404 0.02016351 0.016656044 -1.6260492 6.061536
##                   MASE       ACF1 Theil's U
## Training set 0.740098 0.07923716        NA
## Test set     1.375704 0.27194343 0.9305793
```

```
## RACE-Explicit
## first subset to TEST/TRAIN
race.WEtsTRAIN <- window(race.WEts, start = c(2007,1), end = c(2014, 12))
race.WEtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.2972794 0.3080628 0.3032179 0.3184107 0.3342664 0.3332976 0.2966052
## 2008 0.2849656 0.3380543 0.2915453 0.3271904 0.2959925 0.2861835 0.2501636
## 2009 0.3814801 0.3130706 0.3025414 0.3306196 0.2634333 0.2497862 0.2137126
## 2010 0.3065371 0.3020712 0.3308234 0.3438548 0.2968175 0.2463514 0.2129187
## 2011 0.2974932 0.3379676 0.2962528 0.3510987 0.2886589 0.2392012 0.2639635
## 2012 0.3176411 0.3048442 0.3404067 0.4433680 0.3127280 0.2450710 0.2442104
## 2013 0.2588942 0.3122636 0.3424993 0.3282856 0.3433122 0.2893618 0.2203432
## 2014 0.2726419 0.2896059 0.2636067 0.3090315 0.2830347 0.2000353 0.2451451
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.2913953 0.2958121 0.3191373 0.3447576 0.3790787
## 2008 0.3083511 0.3122737 0.3184317 0.3072009 0.3059569
## 2009 0.2682769 0.2930316 0.3381498 0.4069068 0.2770997
## 2010 0.2357173 0.3240857 0.3164414 0.3398054 0.3362443
## 2011 0.2995190 0.2961563 0.3308826 0.3473602 0.3060479
## 2012 0.2452101 0.2791055 0.3401714 0.3392800 0.2916585
## 2013 0.2612450 0.2790665 0.2791832 0.2954922 0.3014450
## 2014 0.2273841 0.2625060 0.2606811 0.2853393 0.2888044
```

```
race.WEtsTEST <- window(race.WEts, start = c(2015, 1))
race.WEtsTEST
```

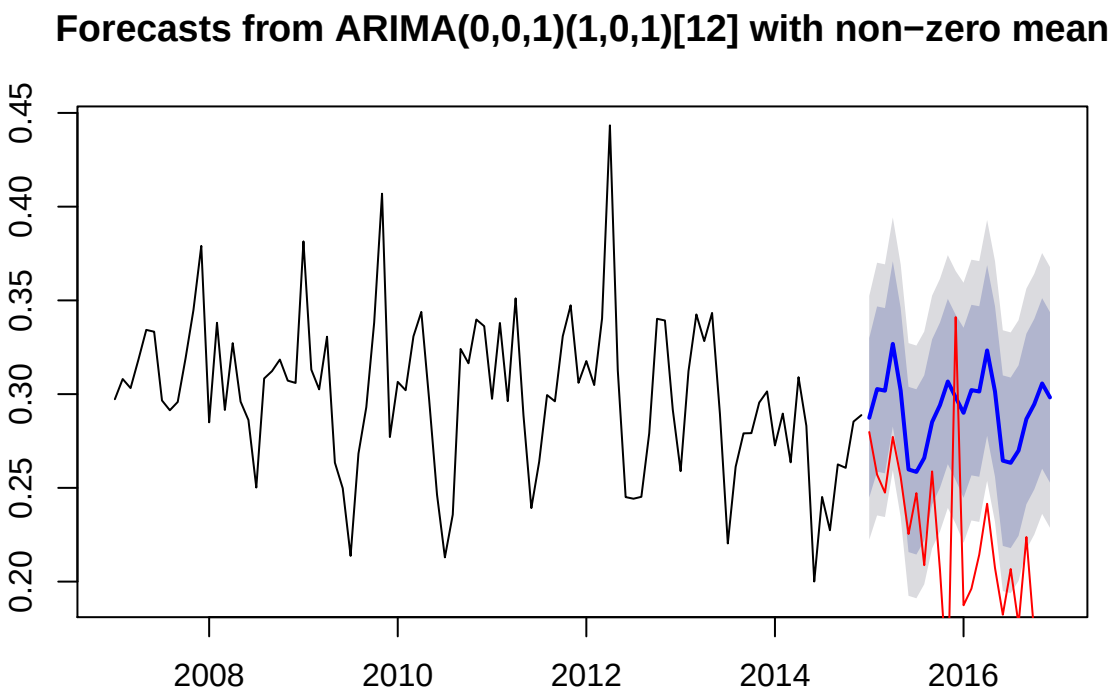
```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.2797652 0.2570422 0.2474654 0.2771901 0.2557851 0.2253841 0.2471792
## 2016 0.1873709 0.1962066 0.2143886 0.2414979 0.2073231 0.1823338 0.2066876
##            Aug       Sep       Oct       Nov       Dec
## 2015 0.2087542 0.2587711 0.2062020 0.1416336 0.3410587
## 2016 0.1771798 0.2237771 0.1719000 0.1502489 0.1679367
```

```
race.arimaTRAINE <- auto.arima(race.WEtsTRAIN, stepwise = FALSE, approximation = FALSE)
race.arimaTRAINE
```

```
## Series: race.WEtsTRAIN
## ARIMA(0,0,1)(1,0,1)[12] with non-zero mean
##
## Coefficients:
##          ma1    sar1     sma1    mean
##       0.2734  0.8778  -0.6229  0.2982
## s.e.  0.0978  0.1192   0.2108  0.0085
##
## sigma^2 estimated as 0.0011:  log likelihood=190.49
## AIC=-370.99   AICc=-370.32   BIC=-358.17
```

```
forecast.raceTRAINE <- forecast(race.arimaTRAINE, h = 24)

plot(forecast.raceTRAINE)
lines(race.WEtsTEST, col = "red")
```




```
accuracy(forecast.raceTRAINE, race.WEtsTEST)
```

```
##                       ME       RMSE        MAE        MPE      MAPE
## Training set -0.002489318 0.03247065 0.02564113  -2.117673  8.759395
## Test set     -0.071553578 0.08548371 0.07512129 -38.185594 39.231663
##                   MASE       ACF1 Theil's U
## Training set 0.8227448 0.02219077        NA
## Test set     2.4104107 0.08805025  1.278859
```

```
## Sex-Implicit
## first subset to TEST/TRAIN
sex.WtsTRAIN <- window(sex.Wts, start = c(2007,1), end = c(2014, 12))
sex.WtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.3265360 0.3522697 0.3485016 0.3451154 0.3321123 0.2953290 0.3012042
## 2008 0.3346560 0.3508209 0.3553962 0.3272156 0.3504607 0.3269194 0.3080710
## 2009 0.2659428 0.3030033 0.3313975 0.3275214 0.3215351 0.2996438 0.2806379
## 2010 0.3170490 0.3159271 0.3180961 0.3186364 0.2988502 0.3188454 0.3072706
## 2011 0.2864936 0.3082822 0.3050230 0.3000698 0.2829066 0.2816507 0.2419892
## 2012 0.3167466 0.3649840 0.3193078 0.3125897 0.2917982 0.3138732 0.3173755
## 2013 0.2575631 0.3060279 0.2698768 0.2747940 0.2752986 0.2408495 0.2399476
## 2014 0.2754268 0.2858208 0.2787057 0.2863256 0.2409578 0.2632142 0.2573910
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.3036669 0.3433994 0.3526544 0.3711056 0.3434839
## 2008 0.2602696 0.3460489 0.2929637 0.3206526 0.3004245
## 2009 0.2886007 0.3543236 0.3136907 0.3120748 0.3301335
## 2010 0.2644327 0.3257348 0.3011221 0.3156007 0.3182391
## 2011 0.2838372 0.3190739 0.3472757 0.3476877 0.3364345
## 2012 0.2937446 0.2987150 0.3092543 0.2903204 0.1774063
## 2013 0.2516527 0.2857484 0.2928770 0.2759097 0.2820090
## 2014 0.2497882 0.2555488 0.2767902 0.2380801 0.1507952
```

```
sex.WtsTEST <- window(sex.Wts, start = c(2015, 1))
sex.WtsTEST
```

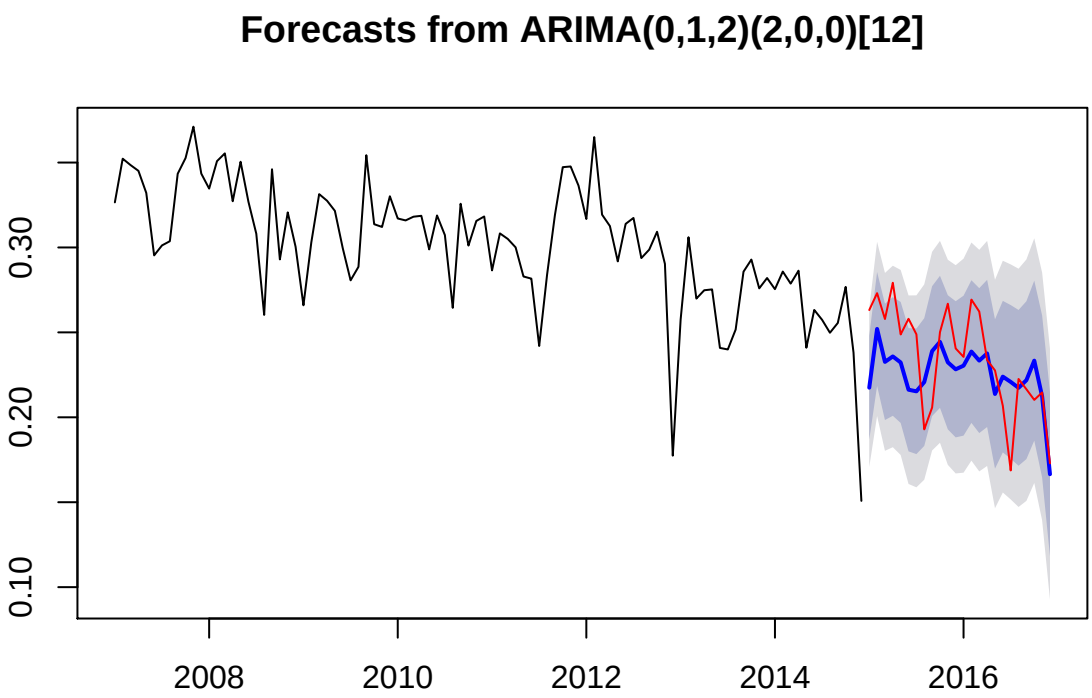
```
##             Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.2631441 0.2730882 0.2578701 0.2792069 0.2487748 0.2580040 0.2488610
## 2016 0.2355656 0.2693078 0.2622302 0.2337214 0.2276008 0.2067703 0.1687040
##             Aug       Sep       Oct       Nov       Dec
## 2015 0.1928939 0.2057437 0.2501003 0.2668644 0.2405414
## 2016 0.2225737 0.2165154 0.2102543 0.2146233 0.1728972
```

```
sex.arimaTRAIN <- auto.arima(sex.WtsTRAIN, stepwise = FALSE, approximation = FALSE)
sex.arimaTRAIN
```

```
## Series: sex.WtsTRAIN
## ARIMA(0,1,2)(2,0,0)[12]
##
## Coefficients:
##           ma1      ma2    sar1    sar2
##       -0.5477  -0.2247  0.0835  0.5200
## s.e.   0.1065   0.1120  0.0822  0.0915
##
## sigma^2 estimated as 0.000568:  log likelihood=217.88
## AIC=-425.76   AICc=-425.09   BIC=-412.99
```

```
forecast.sexTRAIN <- forecast(sex.arimaTRAIN, h = 24)

plot(forecast.sexTRAIN)
lines(sex.WtsTEST, col = "red")
```




```
accuracy(forecast.sexTRAIN, sex.WtsTEST)
```

```
##                       ME       RMSE        MAE       MPE     MAPE
## Training set -0.002542922 0.02320292 0.01613623 -1.634570 5.813209
## Test set      0.008728468 0.02669171 0.02228718  2.497053 9.572796
```

```
##                     MASE        ACF1 Theil's U
## Training set 0.5245049 -0.02107201        NA
## Test set     0.7244401  0.37614329 0.8690098
```

```
## Sex-Explicit
## first subset to TEST/TRAIN
sex.WEtsTRAIN <- window(sex.WEts, start = c(2007,1), end = c(2014, 12))
sex.WEtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.6734703 0.7381178 0.7233313 0.6919293 0.7036080 0.5027218 0.6022975
## 2008 0.7046343 0.7175276 0.7034127 0.6709587 0.7445799 0.6580025 0.6213110
## 2009 0.4980320 0.6085434 0.6334769 0.7000492 0.6756625 0.5489930 0.5176732
## 2010 0.6251780 0.6152028 0.6254815 0.6013239 0.5675455 0.5626712 0.5794610
## 2011 0.5374327 0.5650748 0.5644165 0.5339356 0.5372735 0.4817459 0.3684287
## 2012 0.6443125 0.7094839 0.5788942 0.5424572 0.5216664 0.5094027 0.4066524
## 2013 0.4261067 0.5335973 0.4316736 0.4819697 0.4880421 0.3978779 0.3701550
## 2014 0.4834190 0.4988272 0.4917043 0.4902771 0.3988562 0.3858934 0.3972798
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.5467638 0.7603495 0.7536227 0.7711566 0.7090658
## 2008 0.4831066 0.7121524 0.5480537 0.6318669 0.6741618
## 2009 0.5600045 0.6933654 0.6344124 0.5951027 0.7172140
## 2010 0.5004613 0.6234913 0.5700612 0.5934567 0.5897483
## 2011 0.4206863 0.6192493 0.6910277 0.6979414 0.5954457
## 2012 0.4724884 0.5175319 0.5016350 0.4803849 0.1723258
## 2013 0.3961926 0.4804212 0.4854107 0.4829076 0.4734006
## 2014 0.3764946 0.4365431 0.4438591 0.3587035 0.1363896
```

```
sex.WEtsTEST <- window(sex.WEts, start = c(2015, 1))
sex.WEtsTEST
```

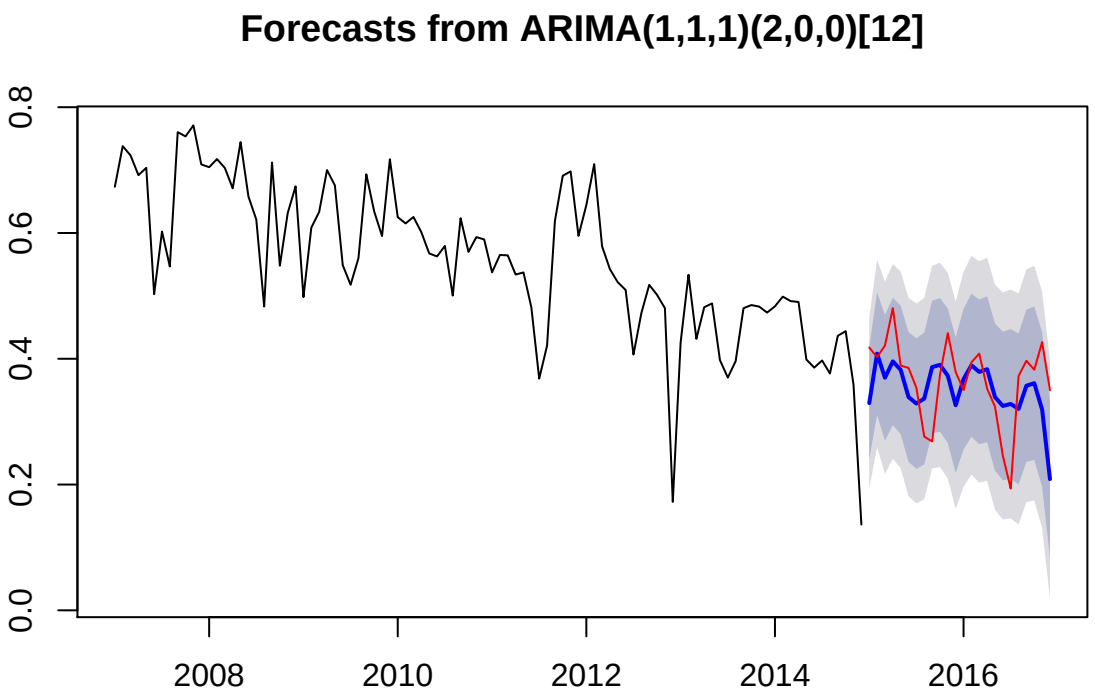
```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.4178273 0.4026680 0.4210426 0.4804102 0.3890474 0.3854842 0.3538747
## 2016 0.3501600 0.3943438 0.4081905 0.3525857 0.3237310 0.2459943 0.1936209
##            Aug       Sep       Oct       Nov       Dec
## 2015 0.2762480 0.2685532 0.3745455 0.4406636 0.3788953
## 2016 0.3724687 0.3968418 0.3825897 0.4264856 0.3499878
```

```
sex.arimaTRAINE <- auto.arima(sex.WEtsTRAIN, stepwise = FALSE, approximation = FALSE)
sex.arimaTRAINE
```

```
## Series: sex.WEtsTRAIN
## ARIMA(1,1,1)(2,0,0)[12]
##
## Coefficients:
##          ar1      ma1    sar1    sar2
##       0.3541  -0.9069  0.1912  0.4562
## s.e.  0.1230   0.0484  0.0951  0.1041
##
## sigma^2 estimated as 0.004815:  log likelihood=116.68
## AIC=-223.35   AICc=-222.68   BIC=-210.58
```

```
forecast.sexTRAINE <- forecast(sex.arimaTRAINE, h = 24)

plot(forecast.sexTRAINE)
lines(sex.WEtsTEST, col = "red")
```




```
accuracy(forecast.sexTRAINE, sex.WEtsTEST)
```

```
##                       ME       RMSE        MAE        MPE     MAPE
## Training set -0.01032176 0.06756049 0.04694381 -4.7628672 10.79244
## Test set      0.01424007 0.06728762 0.05399725  0.5447533 16.50563
##                   MASE        ACF1 Theil's U
## Training set 0.5782467 -0.03252414        NA
## Test set     0.6651299  0.36362748 0.8469654
```

```
## SKIN-Implicit
## first subset to TEST/TRAIN
skin.WtsTRAIN <- window(skin.Wts, start = c(2007,1), end = c(2014, 12))
skin.WtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.3256111 0.3249632 0.3272598 0.3087791 0.3304255 0.3204058 0.3241176
## 2008 0.3096758 0.3212589 0.3345951 0.3193459 0.3327284 0.3331242 0.3380725
## 2009 0.3183869 0.3314212 0.3293276 0.3094360 0.3165967 0.3101469 0.3117379
## 2010 0.3227664 0.3174255 0.3484501 0.3366193 0.3155270 0.3347465 0.3219250
## 2011 0.3363939 0.3389775 0.3347263 0.3389812 0.3404561 0.3500720 0.3188169
## 2012 0.3336575 0.3466565 0.3256512 0.3173179 0.3176402 0.3154815 0.3434414
## 2013 0.3257391 0.3299314 0.3029029 0.3057174 0.3292177 0.3321266 0.3090694
## 2014 0.2906547 0.2926292 0.2787284 0.3107986 0.2968059 0.3216507 0.3166985
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.3344487 0.3266321 0.3395781 0.3112908 0.3357339
## 2008 0.3202642 0.3295886 0.3264650 0.3142858 0.3281588
## 2009 0.3239009 0.3239829 0.3195583 0.3182162 0.3244799
## 2010 0.3415446 0.3324288 0.3330114 0.3062365 0.3292150
## 2011 0.3426871 0.3271917 0.3342485 0.3429755 0.3231019
## 2012 0.3030894 0.3477420 0.3444891 0.3294104 0.3159496
## 2013 0.3132132 0.3127012 0.3276258 0.3110981 0.3091631
## 2014 0.3079776 0.2912990 0.3091502 0.3073318 0.2920035
```

```
skin.WtsTEST <- window(skin.Wts, start = c(2015, 1))
skin.WtsTEST
```

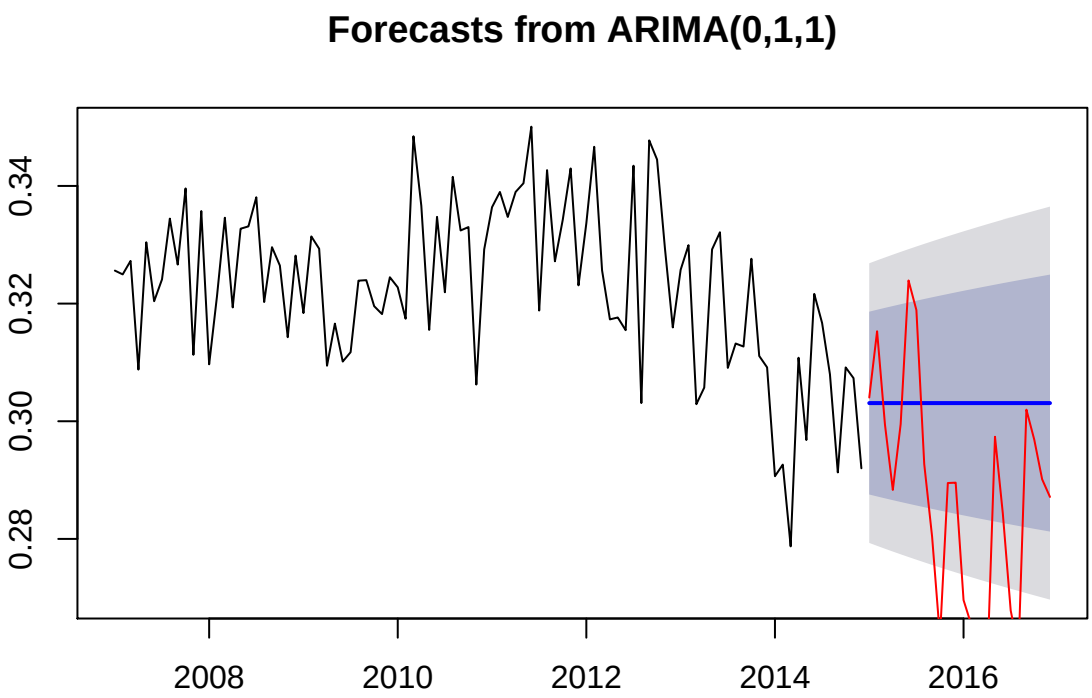
```
##             Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.3040282 0.3153009 0.2994368 0.2883226 0.2995084 0.3239284 0.3188877
## 2016 0.2696010 0.2653319 0.2518079 0.2573119 0.2973596 0.2843162 0.2678314
##             Aug       Sep       Oct       Nov       Dec
## 2015 0.2927106 0.2803769 0.2632759 0.2894989 0.2895618
## 2016 0.2611201 0.3019667 0.2968646 0.2901338 0.2871320
```

```
skin.arimaTRAIN <- auto.arima(skin.WtsTRAIN, stepwise = FALSE, approximation = FALSE)
skin.arimaTRAIN
```

```
## Series: skin.WtsTRAIN
## ARIMA(0,1,1)
##
## Coefficients:
##           ma1
##       -0.7941
## s.e.   0.0568
##
## sigma^2 estimated as 0.000147:  log likelihood=284.38
## AIC=-564.76   AICc=-564.63   BIC=-559.66
```

```
forecast.skinTRAIN <- forecast(skin.arimaTRAIN, h = 24)

plot(forecast.skinTRAIN)
lines(skin.WtsTEST, col = "red")
```




```
accuracy(forecast.skinTRAIN, skin.WtsTEST)
```

```
##                       ME       RMSE         MAE       MPE     MAPE
## Training set -0.001089645 0.01199936 0.009796312 -0.474065 3.068065
## Test set     -0.015767914 0.02481268 0.019918292 -5.963902 7.261780
```

```
##                     MASE        ACF1 Theil's U
## Training set 0.7011137 -0.05824147        NA
## Test set     1.4255352  0.55640517  1.406843
```

```
## SKIN-Explicit
## first subset to TEST/TRAIN
skin.WEtsTRAIN <- window(skin.WEts, start = c(2007,1), end = c(2014, 12))
skin.WEtsTRAIN
```

```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2007 0.3024452 0.2924003 0.2701169 0.2522686 0.2588336 0.2706076 0.2074788
## 2008 0.2342053 0.3254053 0.2530701 0.2951190 0.2638603 0.2583969 0.2103165
## 2009 0.3136302 0.2812282 0.2687019 0.2838913 0.2459158 0.2464956 0.2531876
## 2010 0.2884371 0.3145779 0.2919281 0.2762367 0.2474629 0.2455876 0.2421619
## 2011 0.3024312 0.3147860 0.2916465 0.3557108 0.3105716 0.2664439 0.2405312
## 2012 0.2997825 0.3194072 0.3294145 0.3487186 0.3421017 0.2736338 0.2522036
## 2013 0.3192226 0.3316173 0.3197635 0.3305386 0.3497449 0.2452530 0.2390661
## 2014 0.2792516 0.3176492 0.3030203 0.3412553 0.2893811 0.2983257 0.2610205
##            Aug       Sep       Oct       Nov       Dec
## 2007 0.2720069 0.2798642 0.3005894 0.2531610 0.3380244
## 2008 0.2529540 0.2648647 0.2724063 0.2731708 0.2486830
## 2009 0.2426209 0.2565688 0.3022015 0.3263044 0.2503919
## 2010 0.2340091 0.3014915 0.2914145 0.3348861 0.3038458
## 2011 0.2852737 0.2952436 0.3034713 0.3281935 0.2881230
## 2012 0.2373554 0.2999111 0.3122702 0.3266074 0.3119211
## 2013 0.2683043 0.2861110 0.2996367 0.2899507 0.2781164
## 2014 0.2514529 0.2556365 0.2982788 0.2879187 0.3140947
```

```
skin.WEtsTEST <- window(skin.WEts, start = c(2015, 1))
skin.WEtsTEST
```

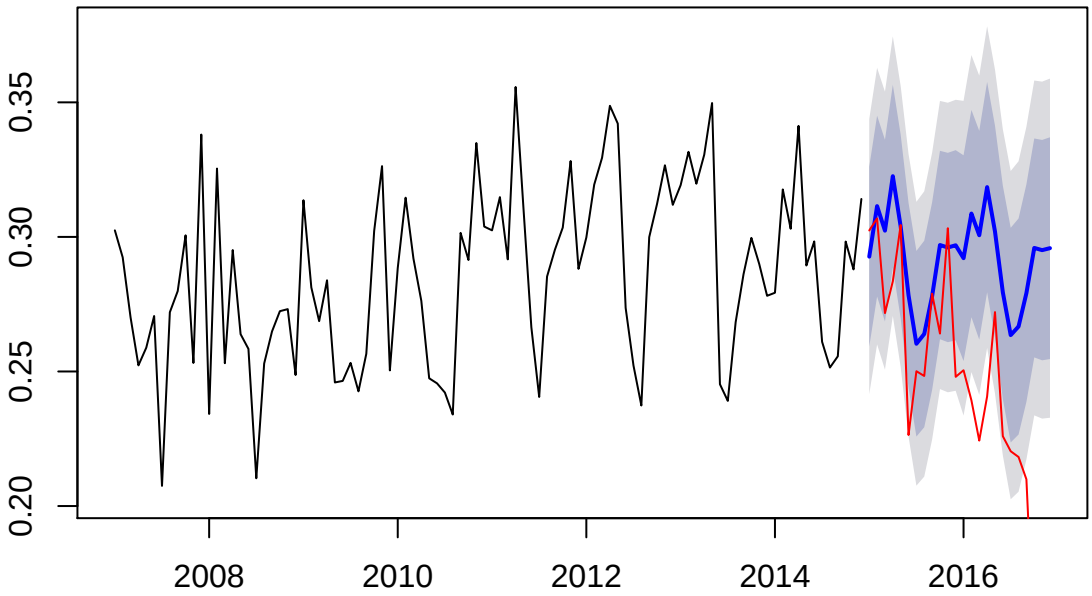
```
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015 0.3023885 0.3068677 0.2716912 0.2834996 0.3044234 0.2263910 0.2500999
## 2016 0.2504605 0.2392756 0.2243138 0.2407395 0.2720780 0.2259485 0.2203640
##            Aug       Sep       Oct       Nov       Dec
## 2015 0.2483277 0.2789010 0.2640764 0.3032428 0.2480113
## 2016 0.2182251 0.2099279 0.1462262 0.1324326 0.1461543
```

```
skin.arimaTRAINE <- auto.arima(skin.WEtsTRAIN, stepwise = FALSE, approximation = FALSE)
skin.arimaTRAINE
```

```
## Series: skin.WEtsTRAIN
## ARIMA(0,1,1)(1,0,1)[12]
##
## Coefficients:
##          ma1    sar1     sma1
##       -0.8958  0.8832  -0.5521
## s.e.   0.0505  0.1039   0.2111
##
## sigma^2 estimated as 0.0006794:  log likelihood=209.26
## AIC=-410.52   AICc=-410.07   BIC=-400.3
```

```
forecast.skinTRAINE <- forecast(skin.arimaTRAINE, h = 24)

plot(forecast.skinTRAINE)
lines(skin.WEtsTEST, col = "red")
```




```
accuracy(forecast.skinTRAINE, skin.WEtsTEST)
```

```
##                        ME       RMSE        MAE         MPE      MAPE
## Training set -0.0002523378 0.02551676 0.02008475  -0.8854791  7.183164
## Test set     -0.0494465256 0.06818467 0.05097779 -26.4525384 26.960427
##                    MASE        ACF1 Theil's U
## Training set 0.8836734 -0.07116659        NA
## Test set     2.2428811  0.64214945  3.289697
```