MIMIC II Data Analysis

Ivana Malenica and Rachael Phillips

September, 2019

Contents

1 Overview of the Data

We only considered patients that had:

- at least 8 hours of data.
- at most 1 min time gap between two consecutive measurements.

In the table below, we explore how many patients had at least one hypotensive episode. The outcome function `Y1` was used to specify hypotensive events. By definition, a hypotensive episode for time t is defined as either:

1. `abpmean` at time $t < 65$ mmHg and the 5-minute window around time t (i.e., 10 time-points, $t_{-5}, ..., t_{+5}$) contains at least 5 time-points in which `abpmean` < 65.
2. the 5-minute window around time t contains at least 8 time-points in which `abpmean` < 65.

```
##                           Number of Samples
## > 0 hypotensive episodes               421
## 0 hypotensive episodes                 259
```

2 Prepare Data for the Analysis

Below we list covariates we use for the further analysis. In particular, we can classify them as follows:

- Baseline Covariates

```
##  [1] "gender"               "age"                  "care_unit"
##  [4] "admission_type_descr" "sapsi_first"          "sofa_first"
##  [7] "bmi"                  "rank_icu"             "imputed_age"
## [10] "imputed_bmi"          "imputed_sofa"         "imputed_sapsi"
```

- Time-varying Covariates

```
## [1] "amine"           "sedation"        "ventilation"     "spo2"
## [5] "hr"              "abpmean"         "imputed_abpmean"
```

3 Build the Combined Super Learner

The combined online super learner also uses the individual super learner, which learns only from one sample at a time. For the individual super learner, we incorporate the above described covariates as well. In addition, we consider two different Cross-Validation schemes that are used to *train* the combined super learner:

- Rolling Origin:
  - initial training set size 15 minutes
  - test set size 15 minutes
  - increase training set size by increments of 5 minutes
  - for example, the first fold trains on minutes 1-15 and tests on minutes 15-30, the second fold trains on minutes 1-20 and tests on minutes 20-35, and the third fold trains on minutes 1-25 and tests on minutes 25-40.

- Rolling Window:
  - each window size is 15 minutes
  - test set size 15 minutes
  - increase training set size by increments of 5 minutes
  - for example, the first fold trains on minutes 1-15 and tests on minutes 15-30, the second fold trains on minutes 5-20 and tests on minutes 20-35, and the third fold trains on minutes 10-25 and tests on minutes 25-40.

Note that the test sets described in the two cross-validation schemes are used to train the pooled/global and individual SLs. These test sets are not used to construct the weights for the combined SL.

To *construct* the combined super learner (i.e., combine the weights from the pooled SL and individual SL), we incorporate a gap of 30 minutes between the last trained time point and the first prediction time point. Also, the prediction period is the first 15-minutes following the 30-minute gap between the training data.

As explored in previous simulations, we only consider the binary outcome, instead of the continuous (even though the combined SL has support for both).

For the base learning library, we consider variations of xgboost:

[1] “Lrnr_xgboost_20_1_2_0.001” “Lrnr_xgboost_20_1_4_0.001” [3] “Lrnr_xgboost_20_1_6_0.001” “Lrnr_xgboost_20_1_8_0.001” [5] “Lrnr_xgboost_20_1_2_0.01” “Lrnr_xgboost_20_1_4_0.01” [7] “Lrnr_xgboost_20_1_6_0.01” “Lrnr_xgboost_20_1_8_0.01” [9] “Lrnr_xgboost_20_1_2_0.1” “Lrnr_xgboost_20_1_4_0.1”
[11] “Lrnr_xgboost_20_1_6_0.1” “Lrnr_xgboost_20_1_8_0.1”
[13] “Lrnr_xgboost_20_1_2_0.2” “Lrnr_xgboost_20_1_4_0.2”
[15] “Lrnr_xgboost_20_1_6_0.2” “Lrnr_xgboost_20_1_8_0.2”
[17] “Lrnr_xgboost_20_1_2_0.3” “Lrnr_xgboost_20_1_4_0.3”
[19] “Lrnr_xgboost_20_1_6_0.3” “Lrnr_xgboost_20_1_8_0.3”

On the previous page, we mentioned that we consider a 30-minute time gap between the last trained time point and the first prediction time point. For evaluation purposes, we consider the following gaps of time (in minutes) between the last trained time point and the first prediction time point:

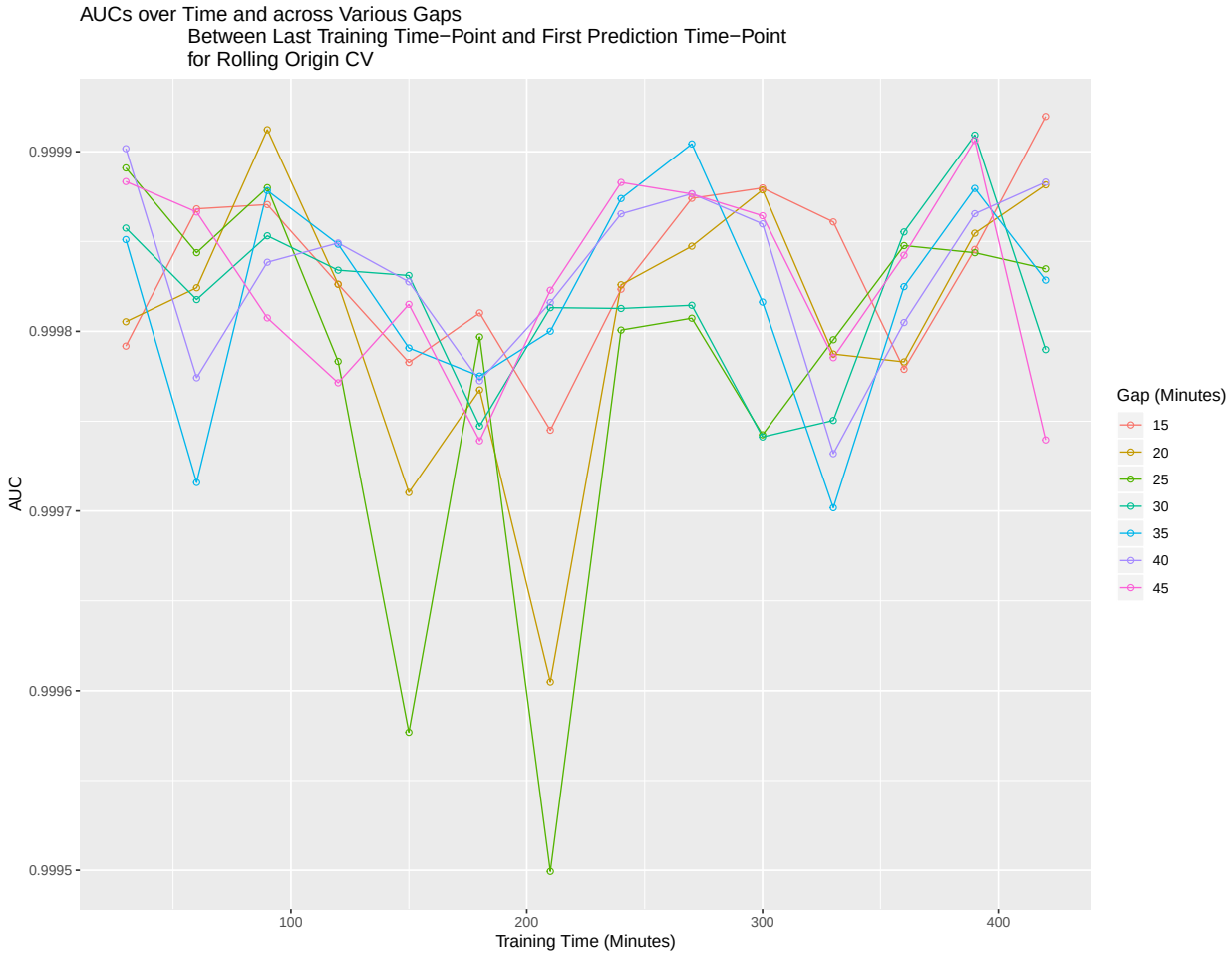
[1] 15 20 25 30 35 40 45

We also consider the following training times:

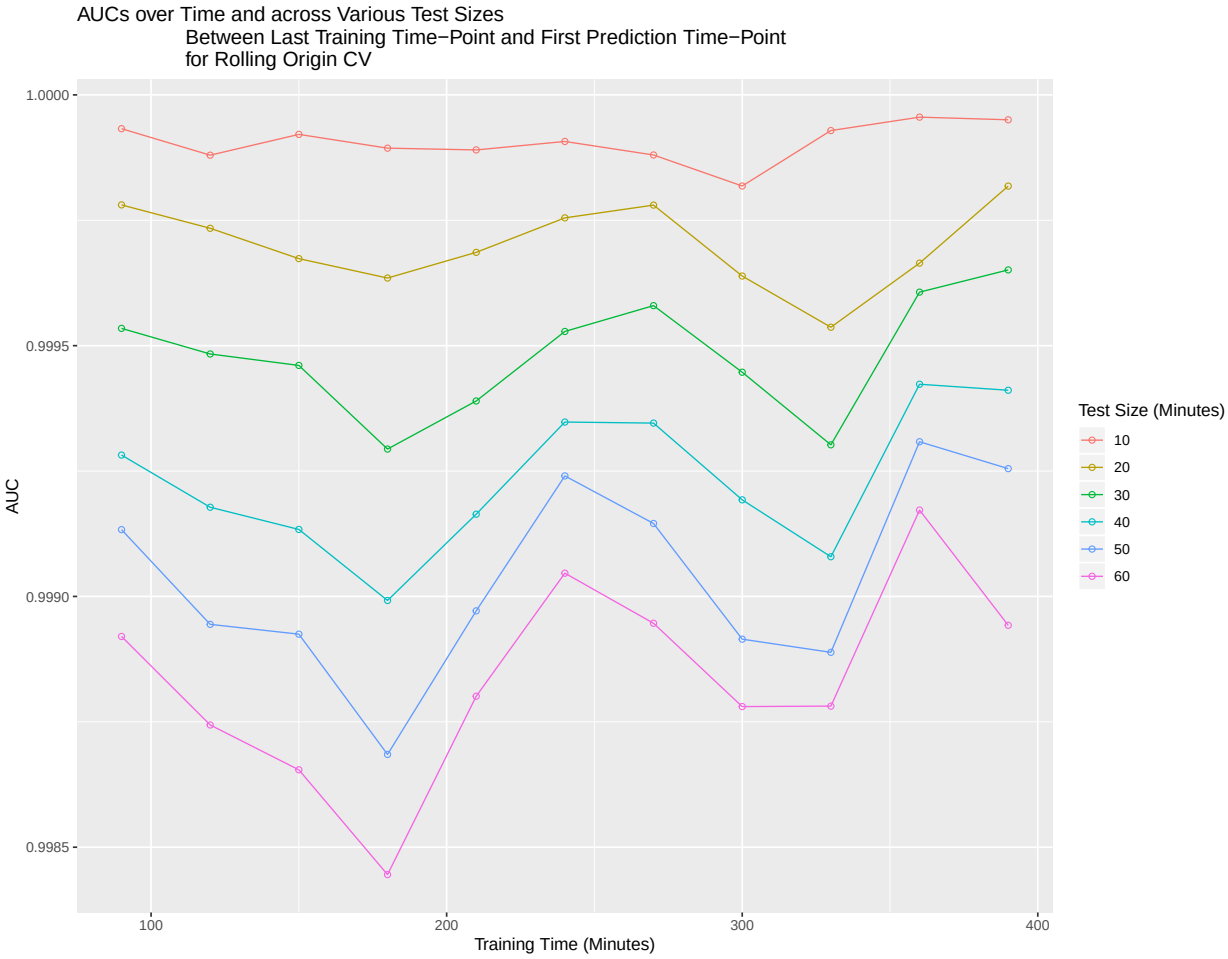
[1] 30 60 90 120 150 180 210 240 270 300 330 360 390 420

4 Evaluate Performance for Combined Super Learner

4.1 AUC

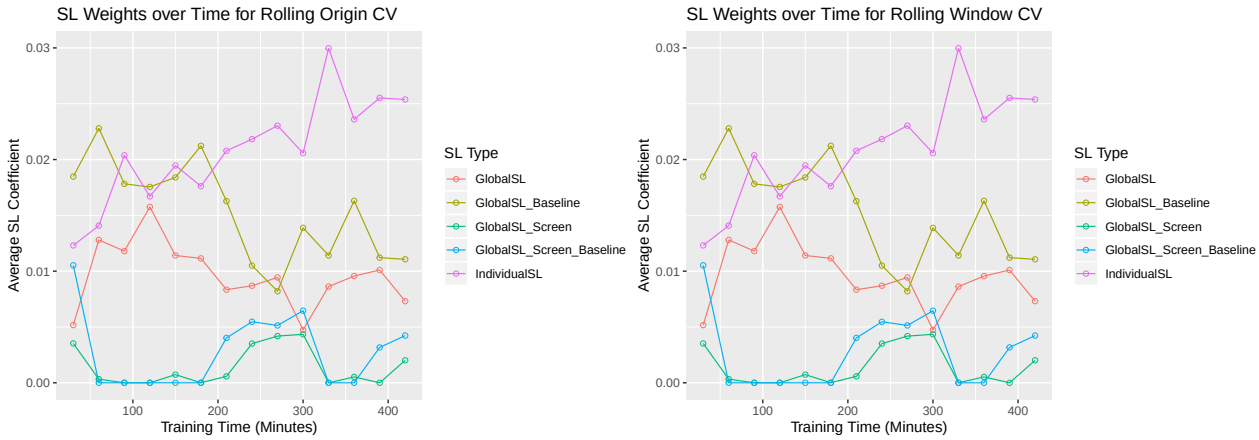



AUCs over Time and across Various Gaps
Between Last Training Time−Point and First Prediction Time−Point
for Rolling Window CV
AUC
0.9999
0.9998
0.9997
0.9996
0.9995
100
200
300
400
Training Time (Minutes)
Gap (Minutes)
15
20
25
30
35
40
45

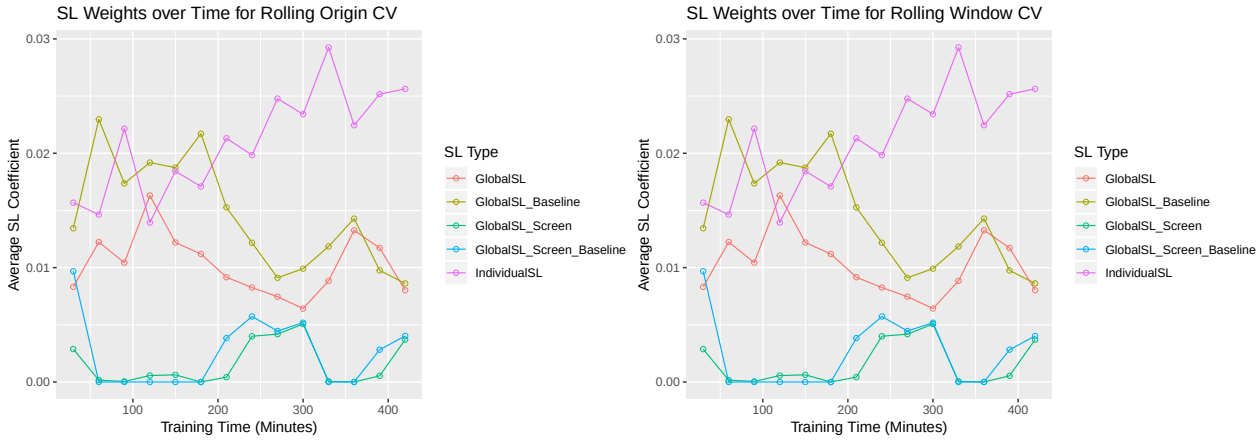

AUCs over Time and across Various Test Sizes
Between Last Training Time−Point and First Prediction Time−Point
for Rolling Origin CV
1.0000
0.9995
0.9990
0.9985
AUC
100
200
300
400
Training Time (Minutes)
Test Size (Minutes)
10
20
30
40
50
60

4.2 Super Learner Coefficients

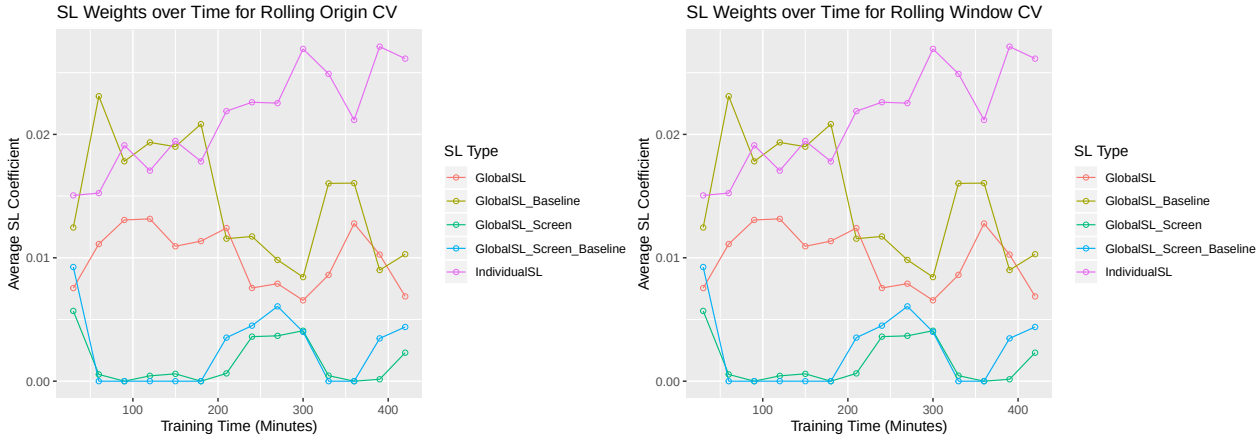
4.2.1 15-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



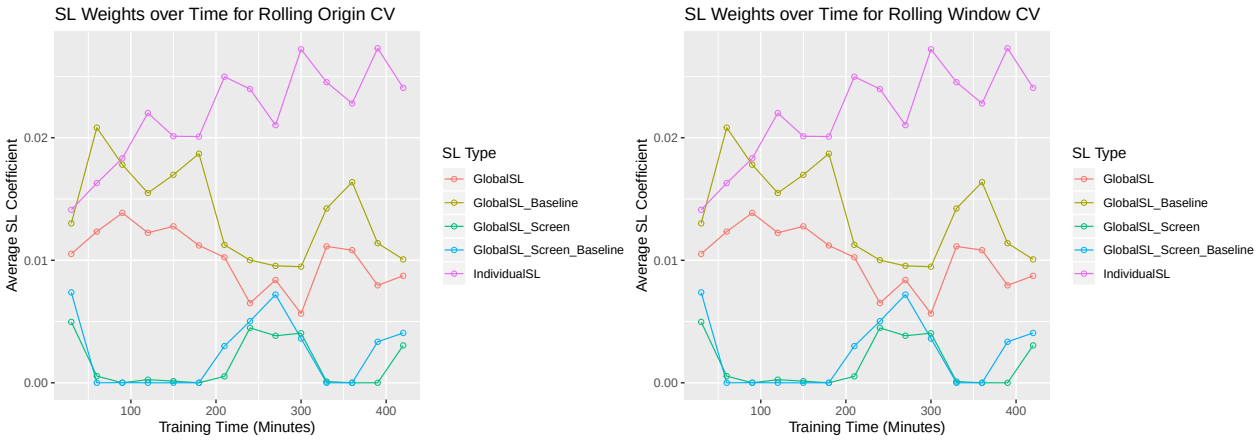
4.2.2 20-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



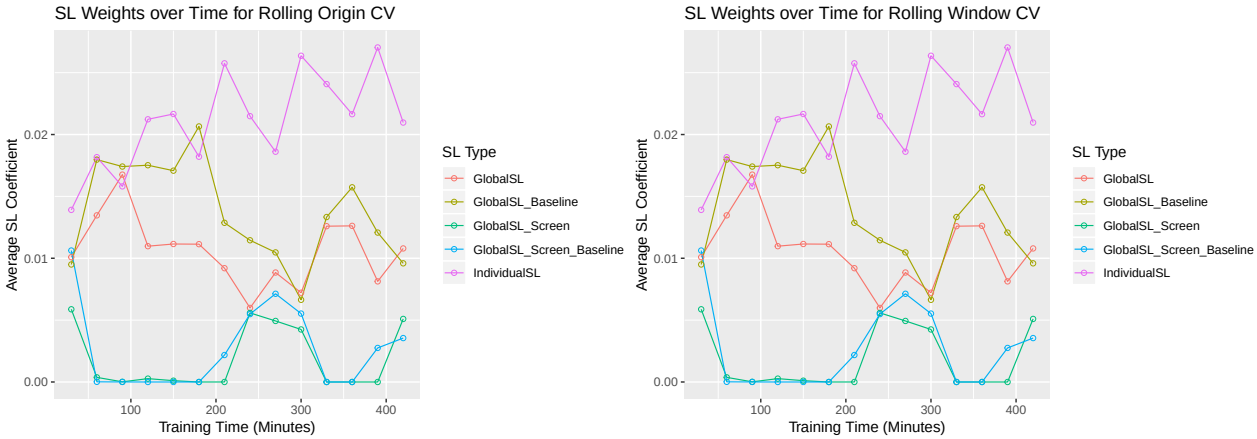
4.2.3 25-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



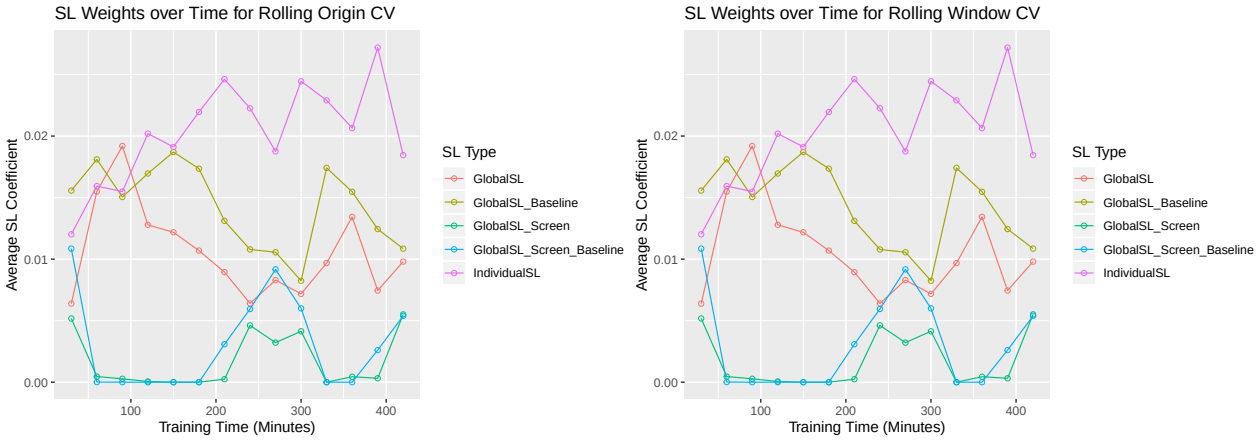
4.2.4 30-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



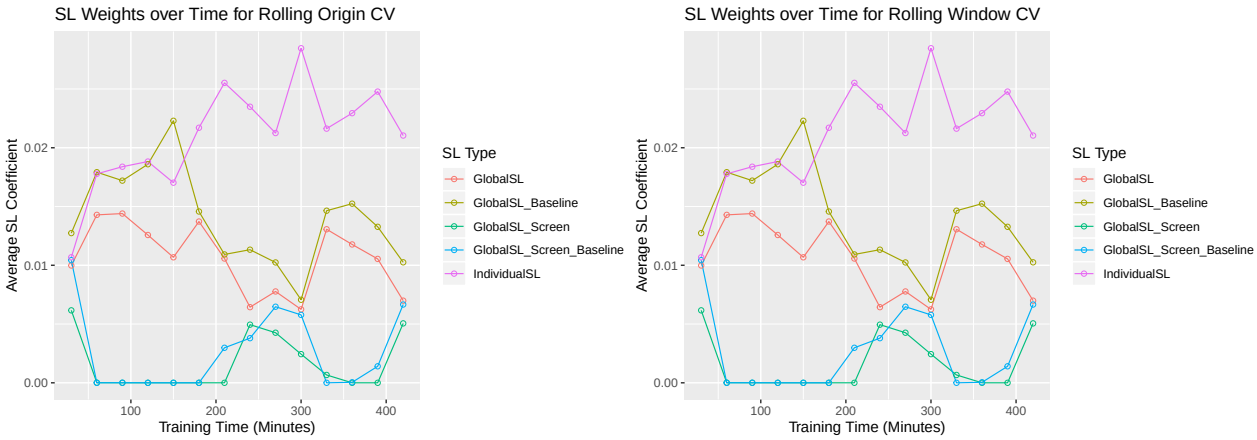
4.2.5 35-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



4.2.6 40-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



4.2.7 45-Minute Gap Between Last Training Time-Point and First Prediction Time-Point



4.3 Loss for the Super Learner

```
## $`15`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.2187609       0.2436004          0.8444522
## 60         0.1772812       0.1922552          0.6397670
## 90         0.1789958       0.1948014          0.5718600
## 120        0.2064540       0.2299704          0.5792879
## 150        0.2269019       0.2417951          0.5232963
## 180        0.2058827       0.2184352          0.5053482
## 210        0.2422732       0.2669676          0.4663630
## 240        0.2077228       0.2293281          0.3686981
## 270        0.1842415       0.2050277          0.3885337
## 300        0.1791525       0.1950574          0.3275296
## 330        0.1897606       0.2104212          0.3504652
## 360        0.2345400       0.2553037          0.3960904
## 390        0.2034191       0.2186174          0.2964325
## 420        0.1489244       0.1749950          0.2238493
##
## $`20`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.2069904       0.2333463          0.7692448
## 60         0.2053216       0.2163418          0.6986879
## 90         0.1614891       0.1864960          0.6259908
## 120        0.2059885       0.2227752          0.5884804
## 150        0.2563148       0.2707940          0.6042140
## 180        0.2246173       0.2328649          0.4693189
## 210        0.2825525       0.3009770          0.4973662
## 240        0.1998845       0.2195410          0.3591567
## 270        0.1947822       0.2161461          0.4045247
## 300        0.1899800       0.2092201          0.3663086
## 330        0.2284978       0.2516511          0.4147225
## 360        0.2360030       0.2586488          0.3744302
## 390        0.1971189       0.2150482          0.3216981
## 420        0.1783979       0.1983697          0.2310786
##
## $`25`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1563823       0.1753178          0.6598575
## 60         0.1986391       0.2140665          0.6920485
## 90         0.1855281       0.2093762          0.6749228
## 120        0.2253682       0.2390871          0.5533808
## 150        0.2763840       0.2943721          0.6167904
## 180        0.2099039       0.2232237          0.4394208
## 210        0.2872256       0.3087400          0.4463472
## 240        0.2052573       0.2281040          0.3410759
## 270        0.2178423       0.2398641          0.4500498
## 300        0.2508194       0.2735960          0.4037771
## 330        0.2247313       0.2451512          0.4062301
## 360        0.2026023       0.2283332          0.3461010
## 390        0.2065599       0.2248876          0.3284415
## 420        0.1991797       0.2193844          0.2743525
##
## $`30`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1735489       0.1932594          0.6686186
## 60         0.2112567       0.2198748          0.7336240
## 90         0.1953064       0.2138494          0.6953606
## 120        0.1944219       0.2117762          0.5040779
## 150        0.2170398       0.2363867          0.5905535
## 180        0.2314777       0.2467217          0.4749451
## 210        0.2046084       0.2343354          0.3991717
## 240        0.2009148       0.2283156          0.3579989
## 270        0.2131899       0.2320571          0.4608735
## 300        0.2421324       0.2636025          0.3928886
## 330        0.2346417       0.2485155          0.3953611
## 360        0.2016030       0.2220347          0.3460379
## 390        0.1565996       0.1777171          0.2719200
## 420        0.2186114       0.2376930          0.3163366
##
## $`35`
```

```
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1783589       0.2039100          0.7211419
## 60         0.2605542       0.2766301          0.8674775
## 90         0.1786867       0.2025277          0.6273539
## 120        0.1940503       0.2126765          0.5172943
## 150        0.2272543       0.2438912          0.5792917
## 180        0.2332918       0.2520836          0.5048434
## 210        0.2093031       0.2367159          0.3781994
## 240        0.1783991       0.1975361          0.3567383
## 270        0.1603917       0.1856626          0.4133231
## 300        0.1992269       0.2229779          0.3393208
## 330        0.2530182       0.2704914          0.4377350
## 360        0.2136275       0.2257003          0.3503225
## 390        0.1758480       0.1984073          0.3182807
## 420        0.1977546       0.2242567          0.3036039
##
## $`40`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1577010       0.1774340          0.7542508
## 60         0.2308862       0.2485542          0.7600303
## 90         0.2017476       0.2163040          0.6581152
## 120        0.1908487       0.2042021          0.5006469
## 150        0.2007051       0.2124511          0.5455165
## 180        0.2329977       0.2588749          0.4826358
## 210        0.2032846       0.2278459          0.3874596
## 240        0.1848535       0.2064029          0.3987519
## 270        0.1792628       0.1973017          0.3871138
## 300        0.1769005       0.1993509          0.2909595
## 330        0.2488298       0.2681789          0.4613815
## 360        0.2132426       0.2198779          0.3387179
## 390        0.1761579       0.1965081          0.2870376
## 420        0.1732511       0.1898715          0.3231218
##
## $`45`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1620517       0.1812471          0.8238108
## 60         0.1802333       0.1915944          0.6558882
## 90         0.2142240       0.2305203          0.6835806
## 120        0.2286077       0.2416597          0.5902841
## 150        0.2075724       0.2189213          0.5477999
## 180        0.2444898       0.2667998          0.5097494
## 210        0.2107143       0.2341754          0.4103842
## 240        0.1793901       0.2053898          0.3848582
## 270        0.1801871       0.2021354          0.3461521
## 300        0.1882994       0.2129674          0.3589323
## 330        0.2316348       0.2550324          0.4106591
## 360        0.2044928       0.2172181          0.3211375
## 390        0.1573585       0.1768810          0.2413511
## 420        0.2172772       0.2458584          0.3473854

## $`15`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.2187609       0.2436004          0.8444522
## 60         0.1772812       0.1922552          0.6397670
## 90         0.1789958       0.1948014          0.5718600
## 120        0.2064540       0.2299704          0.5792879
## 150        0.2269019       0.2417951          0.5232963
## 180        0.2058827       0.2184352          0.5053482
## 210        0.2422732       0.2669676          0.4663630
## 240        0.2077228       0.2293281          0.3686981
## 270        0.1842415       0.2050277          0.3885337
## 300        0.1791525       0.1950574          0.3275296
## 330        0.1897606       0.2104212          0.3504652
## 360        0.2345400       0.2553037          0.3960904
## 390        0.2034191       0.2186174          0.2964325
## 420        0.1489244       0.1749950          0.2238493
##
## $`20`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.2069904       0.2333463          0.7692448
## 60         0.2053216       0.2163418          0.6986879
## 90         0.1614891       0.1864960          0.6259908
## 120        0.2059885       0.2227752          0.5884804
## 150        0.2563148       0.2707940          0.6042140
## 180        0.2246173       0.2328649          0.4693189
## 210        0.2825525       0.3009770          0.4973662
## 240        0.1998845       0.2195410          0.3591567
## 270        0.1947822       0.2161461          0.4045247
## 300        0.1899800       0.2092201          0.3663086
## 330        0.2284978       0.2516511          0.4147225
## 360        0.2360030       0.2586488          0.3744302
## 390        0.1971189       0.2150482          0.3216981
## 420        0.1783979       0.1983697          0.2310786
##
## $`25`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1563823       0.1753178          0.6598575
## 60         0.1986391       0.2140665          0.6920485
## 90         0.1855281       0.2093762          0.6749228
## 120        0.2253682       0.2390871          0.5533808
## 150        0.2763840       0.2943721          0.6167904
## 180        0.2099039       0.2232237          0.4394208
## 210        0.2872256       0.3087400          0.4463472
## 240        0.2052573       0.2281040          0.3410759
## 270        0.2178423       0.2398641          0.4500498
## 300        0.2508194       0.2735960          0.4037771
## 330        0.2247313       0.2451512          0.4062301
## 360        0.2026023       0.2283332          0.3461010
## 390        0.2065599       0.2248876          0.3284415
## 420        0.1991797       0.2193844          0.2743525
##
## $`30`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1735489       0.1932594          0.6686186
## 60         0.2112567       0.2198748          0.7336240
## 90         0.1953064       0.2138494          0.6953606
## 120        0.1944219       0.2117762          0.5040779
```

```
## 150        0.2170398       0.2363867          0.5905535
## 180        0.2314777       0.2467217          0.4749451
## 210        0.2046084       0.2343354          0.3991717
## 240        0.2009148       0.2283156          0.3579989
## 270        0.2131899       0.2320571          0.4608735
## 300        0.2421324       0.2636025          0.3928886
## 330        0.2346417       0.2485155          0.3953611
## 360        0.2016030       0.2220347          0.3460379
## 390        0.1565996       0.1777171          0.2719200
## 420        0.2186114       0.2376930          0.3163366
##
## $`35`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1783589       0.2039100          0.7211419
## 60         0.2605542       0.2766301          0.8674775
## 90         0.1786867       0.2025277          0.6273539
## 120        0.1940503       0.2126765          0.5172943
## 150        0.2272543       0.2438912          0.5792917
## 180        0.2332918       0.2520836          0.5048434
## 210        0.2093031       0.2367159          0.3781994
## 240        0.1783991       0.1975361          0.3567383
## 270        0.1603917       0.1856626          0.4133231
## 300        0.1992269       0.2229779          0.3393208
## 330        0.2530182       0.2704914          0.4377350
## 360        0.2136275       0.2257003          0.3503225
## 390        0.1758480       0.1984073          0.3182807
## 420        0.1977546       0.2242567          0.3036039
##
## $`40`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1577010       0.1774340          0.7542508
## 60         0.2308862       0.2485542          0.7600303
## 90         0.2017476       0.2163040          0.6581152
## 120        0.1908487       0.2042021          0.5006469
## 150        0.2007051       0.2124511          0.5455165
## 180        0.2329977       0.2588749          0.4826358
## 210        0.2032846       0.2278459          0.3874596
## 240        0.1848535       0.2064029          0.3987519
## 270        0.1792628       0.1973017          0.3871138
## 300        0.1769005       0.1993509          0.2909595
## 330        0.2488298       0.2681789          0.4613815
## 360        0.2132426       0.2198779          0.3387179
## 390        0.1761579       0.1965081          0.2870376
## 420        0.1732511       0.1898715          0.3231218
##
## $`45`
##     loss_combined_SL loss_regular_SL loss_individual_SL
## 30         0.1620517       0.1812471          0.8238108
## 60         0.1802333       0.1915944          0.6558882
## 90         0.2142240       0.2305203          0.6835806
## 120        0.2286077       0.2416597          0.5902841
## 150        0.2075724       0.2189213          0.5477999
## 180        0.2444898       0.2667998          0.5097494
## 210        0.2107143       0.2341754          0.4103842
## 240        0.1793901       0.2053898          0.3848582
## 270        0.1801871       0.2021354          0.3461521
## 300        0.1882994       0.2129674          0.3589323
## 330        0.2316348       0.2550324          0.4106591
## 360        0.2044928       0.2172181          0.3211375
## 390        0.1573585       0.1768810          0.2413511
## 420        0.2172772       0.2458584          0.3473854
```