Predicting Business Needs Through Time Series Analysis

Nicole-Marie Farley, Ph.D.

About Me

Biomedical Background

- B.A. Neuroscience
- Ph.D. Cellular and Molecular Biology

Interested in using data science to improve healthcare

The Problem

WellPsyche: provider of mental health services

- *Thanks to Vincent Serpico

Given historical data, can we anticipate future demand for mental healthcare providers?

Project Objective: predict the number of providers in each category that will be needed to meet future demand with 3 months lead time.

- Provider categories: doctors/psychiatrists, RN/PAs, therapists

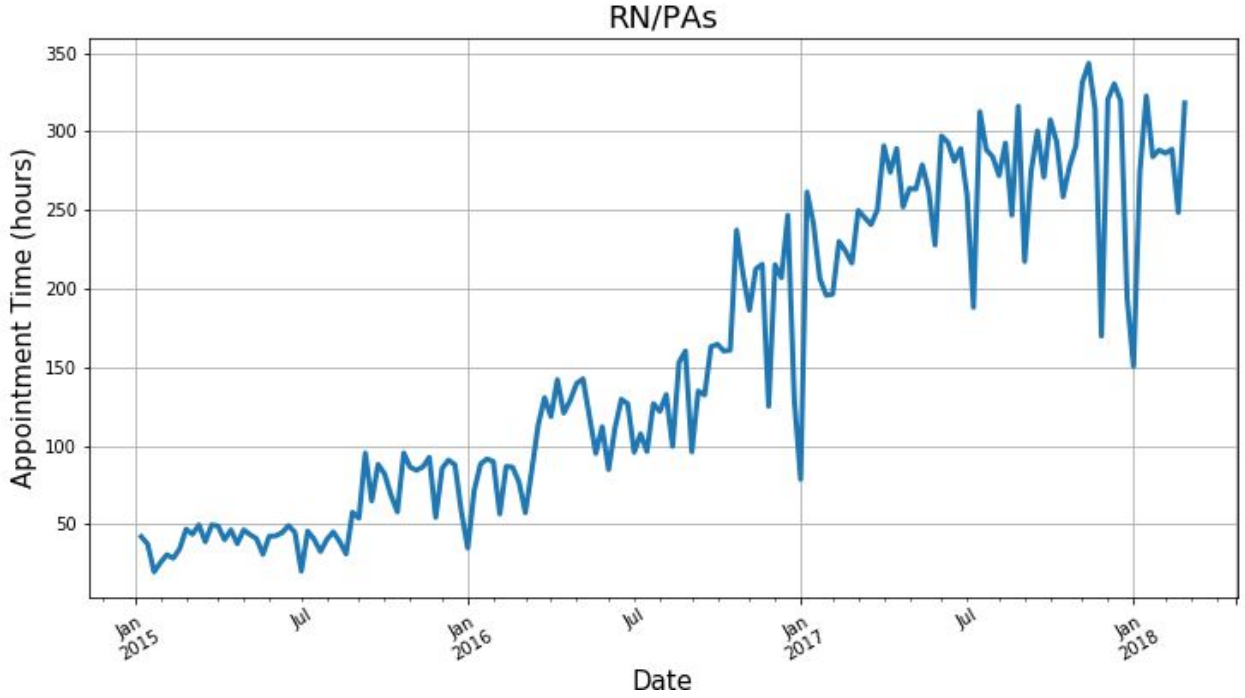
Approach

Step 1: Model Demand

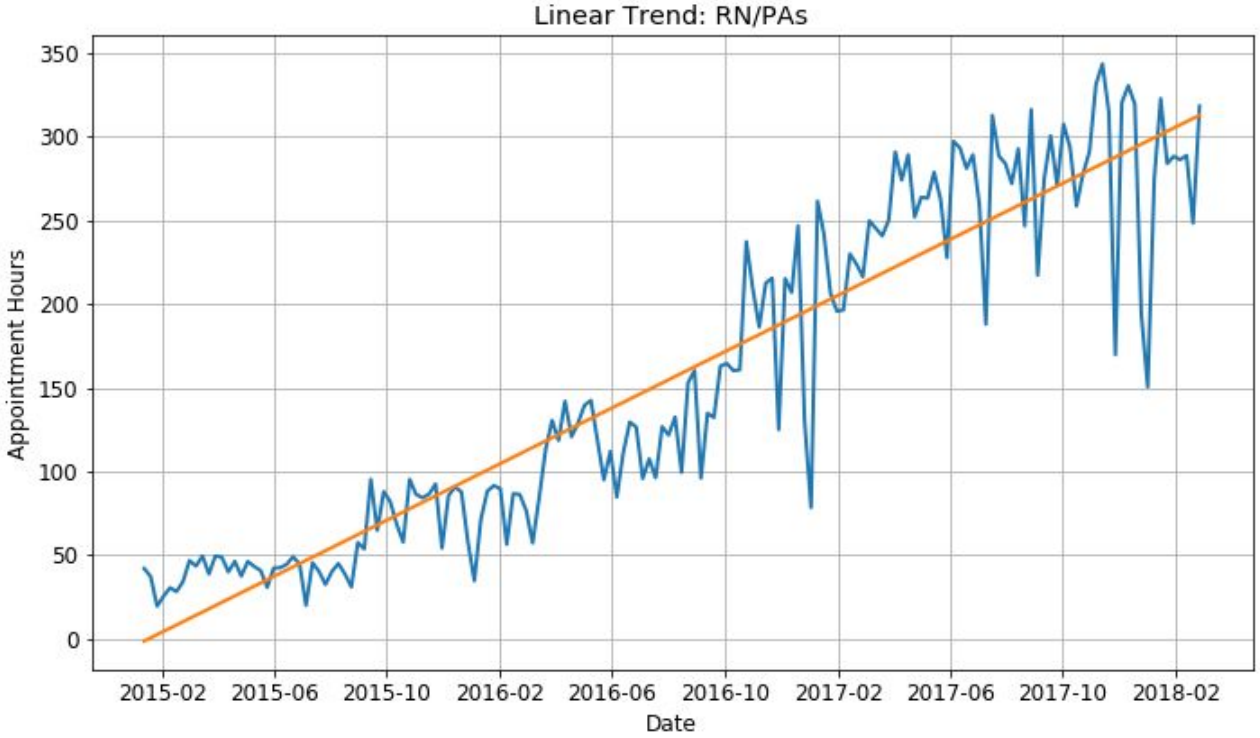
Step 2: Determine the number of providers needed to meet that demand

Modeling Demand:

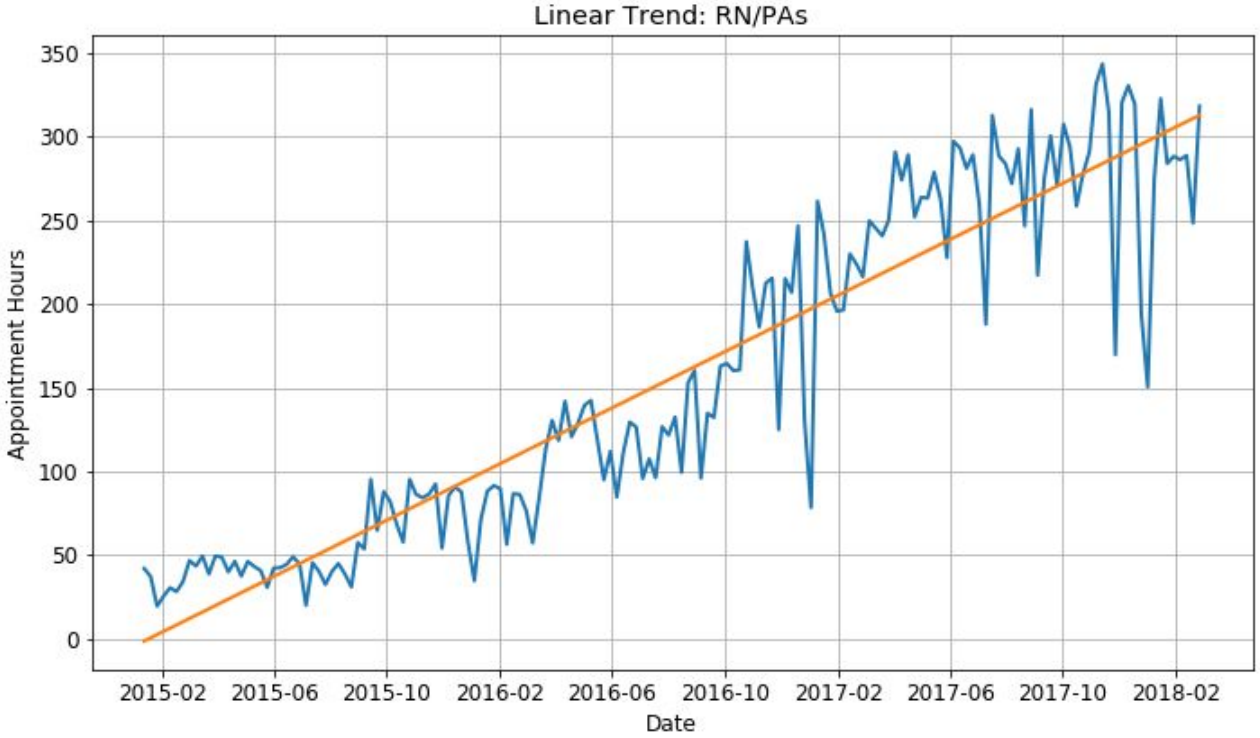
How much time (Appointment Hours) will be needed?



Simple Model: Linear Regression

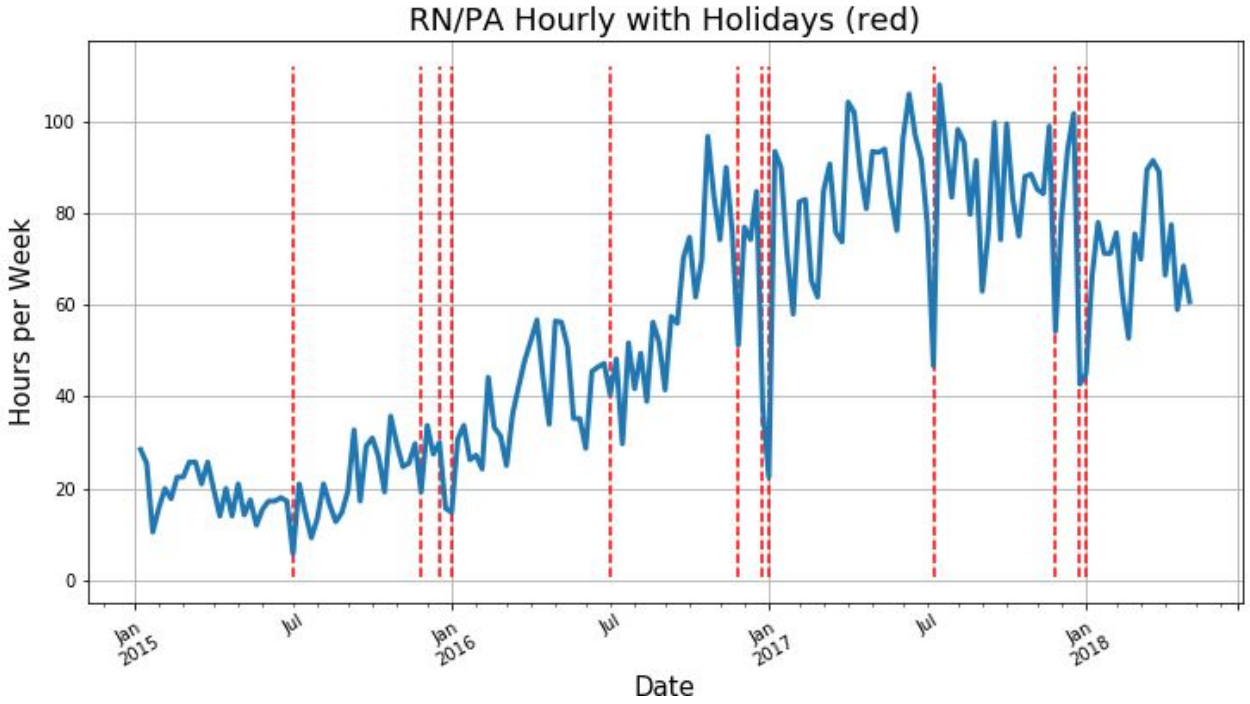


Simple Model: Linear Regression



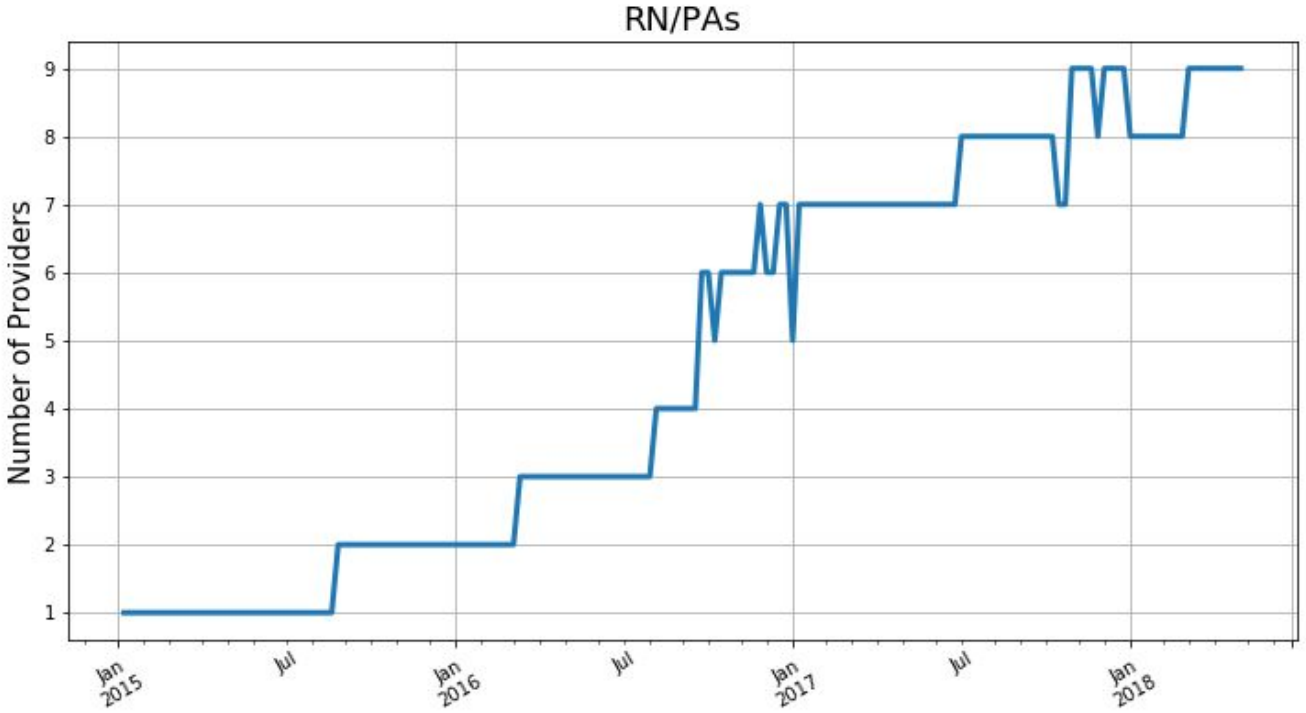
Not a good fit!!!

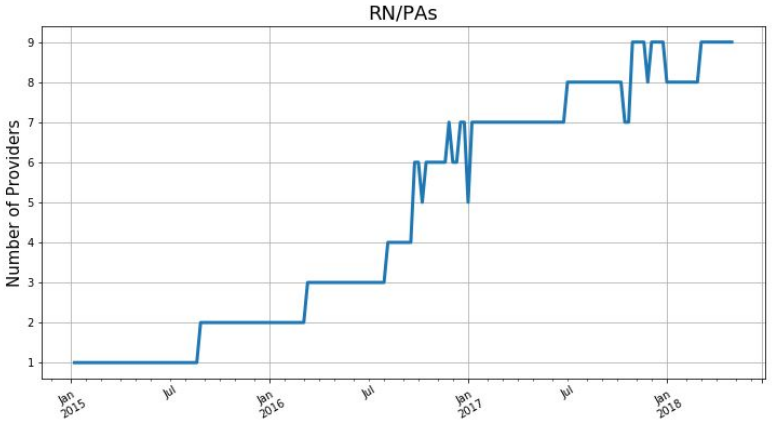
Variation Due to Time of Year



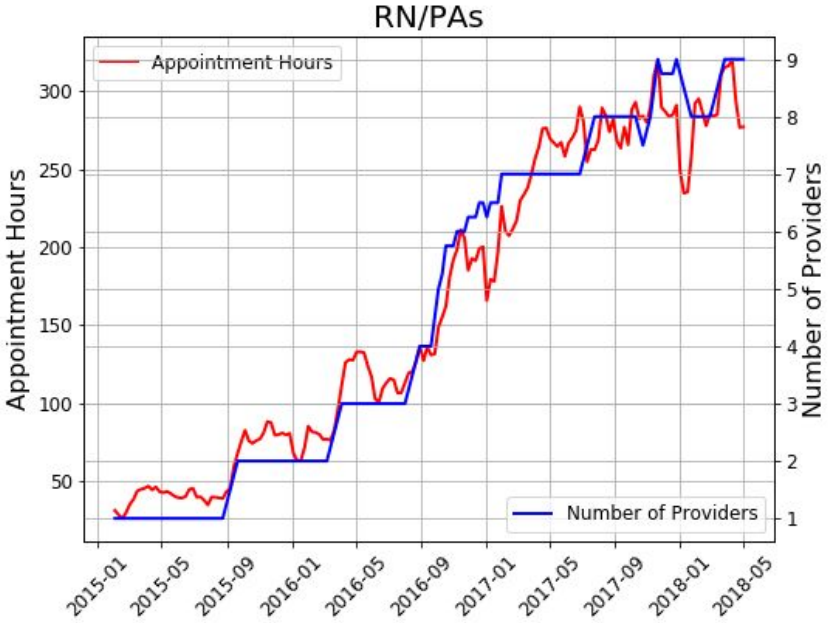
Example: Major Holidays

Modeling Supply

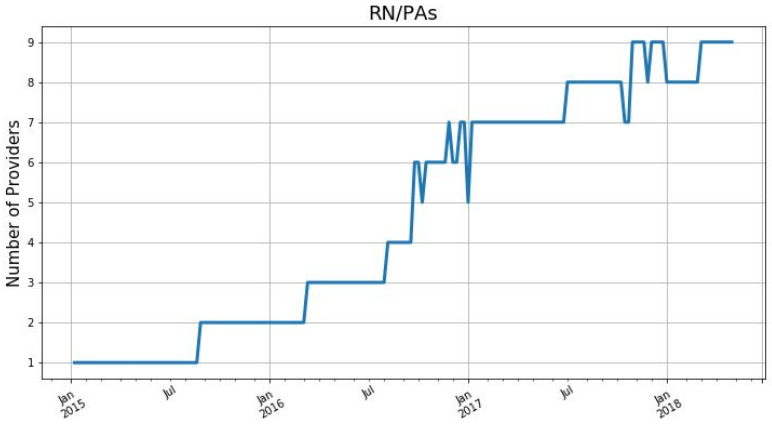


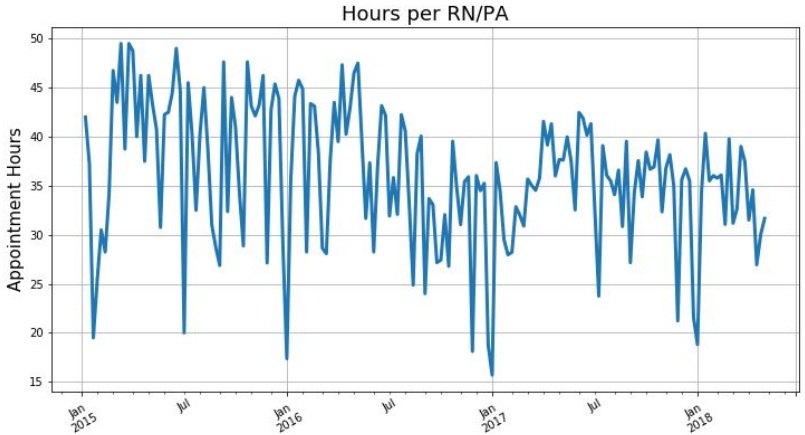


Supply and Demand

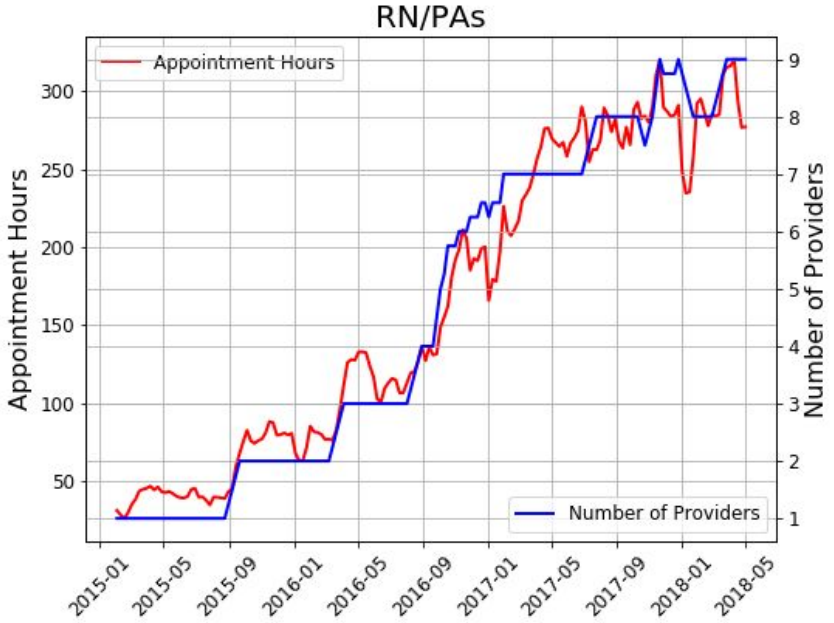


Number of providers needed = Predicted number of hours (demand) / average hours per provider (supply)





Supply and Demand



Number of providers needed = Predicted number of hours (demand) / average hours per provider (supply)

Modeling Weekly Demand for Psychiatrists

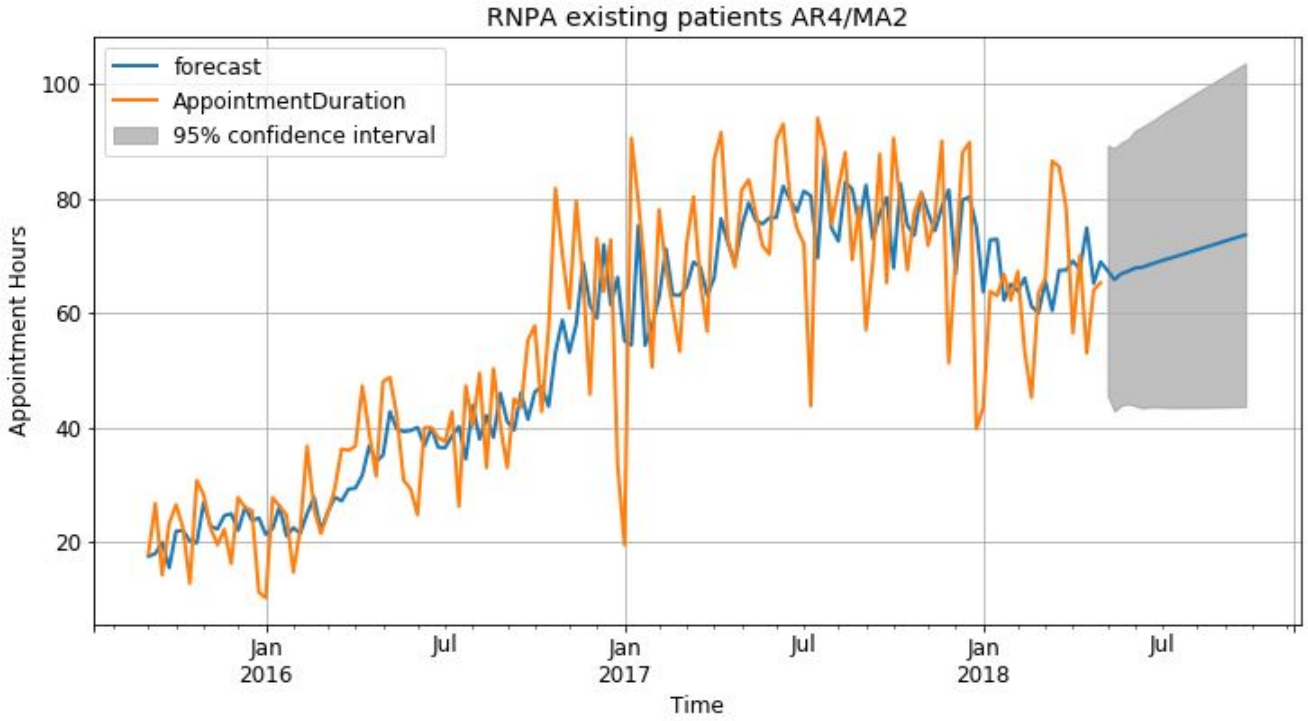
Linear Regression (not good)

AR: AutoRegressive / MA: Moving Average (getting better)

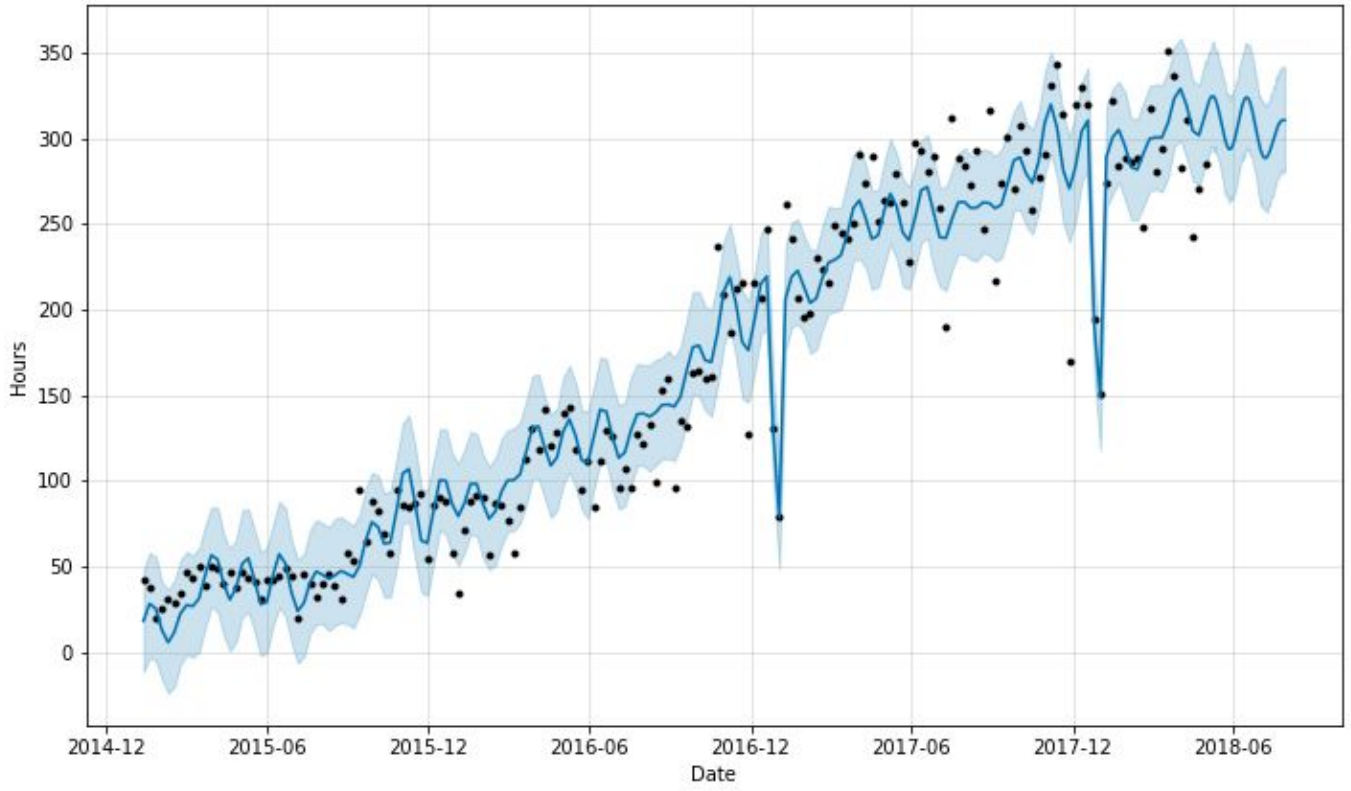
ARIMA/ARIMAX: AutoRegressive Integrated Moving Average/with Explanatory Variable

Prophet: new forecasting library from Facebook

ARIMAX


RNPA existing patients AR4/MA2
forecast
AppointmentDuration
95% confidence interval
Appointment Hours
100
80
60
40
20
Jan
2016
Jul
Jan
2017
Jul
Jan
2018
Jul
Time

Prophet


Hours
350
300
250
200
150
100
50
0
2014-12
2015-06
2015-12
2016-06
2016-12
2017-06
2017-12
2018-06
Date

Conclusions

ARIMAX Predictions: 8-10 RN/PAs needed May 2018 - July 2018

Prophet Predictions: 8-9 RN/PAs needed May 2018 - July 2018

Next Steps

- LSTM: Long Short-Term Memory Recurrent Neural Network

Next Steps

- LSTM: Long Short-Term Memory Recurrent Neural Network
- Add additional features/variables to existing models

Next Steps

- LSTM: Long Short-Term Memory Recurrent Neural Network
- Add additional features/variables to existing models
- Breakdown by different types of appointments and new vs. existing patients

Tools/Libraries Used

jupyter

python

NumPy

SM StatsModels
Statistics in Python

pandas
$y_i t = \beta' x_{it} + \mu_i + \epsilon_{it}$

PROPHET
Forecasting at scale.

K + TensorFlow

matplotlib

scikit learn

Machine Learning with Scikit-Learn

Thank you!!!!

nicole.m.h.farley@gmail.com

https://www.linkedin.com/in/nicole-farley-ph-d/

https://github.com/nicolemhfarley