

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

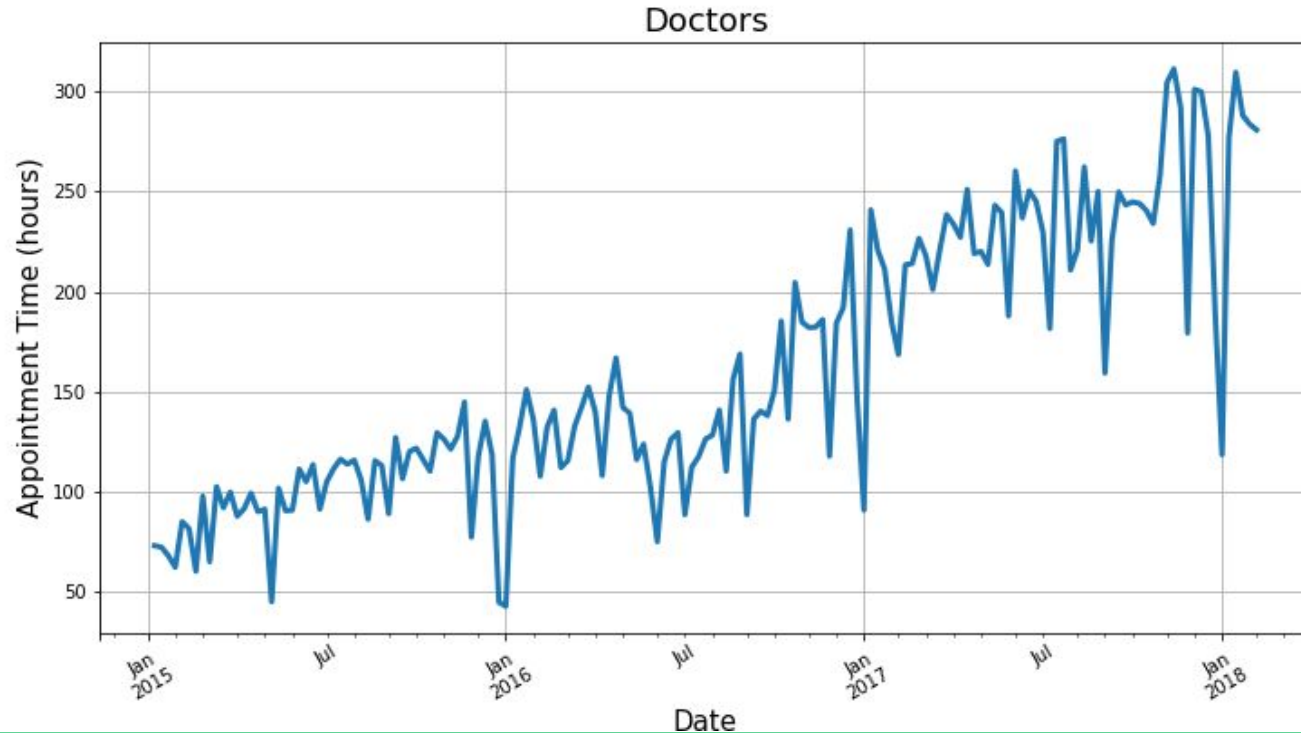


Step 1: Model Demand

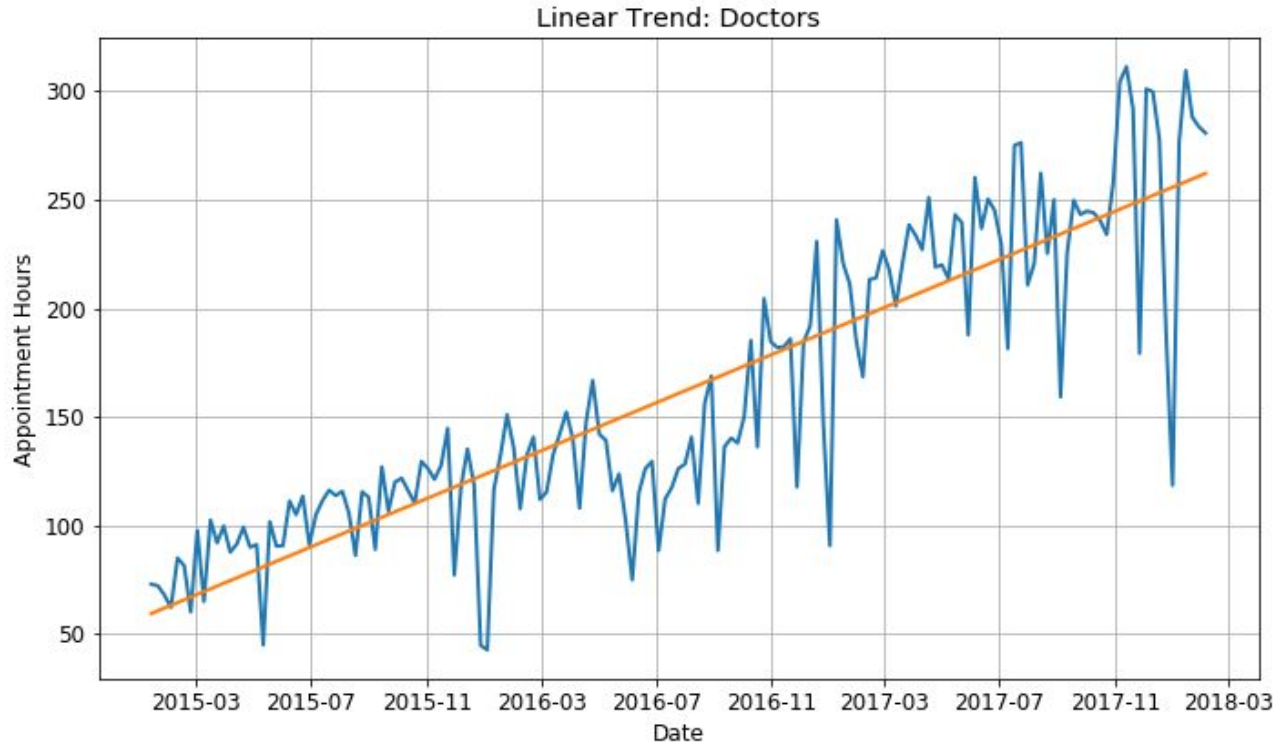
Step 2: Determine the number of providers needed to meet that demand

Modeling Demand:

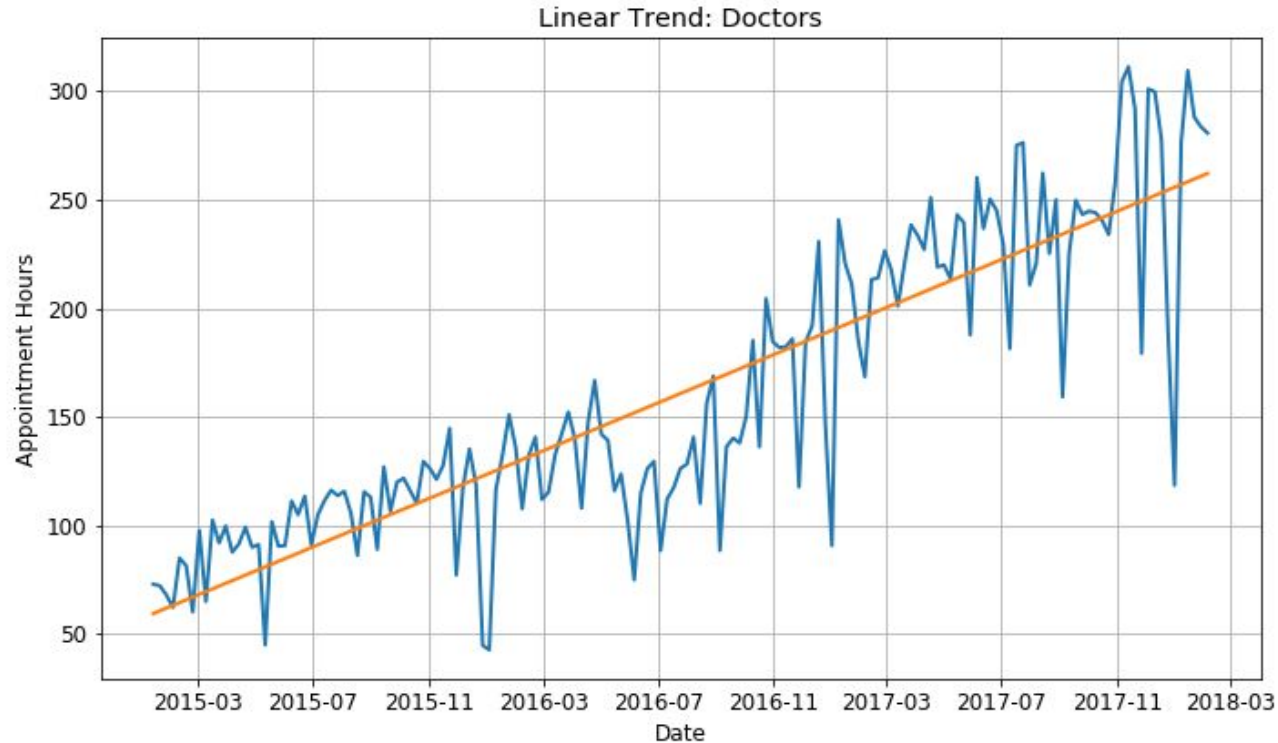
How much time (Appointment Hours) will be needed?



A Simple Model: Linear Regression

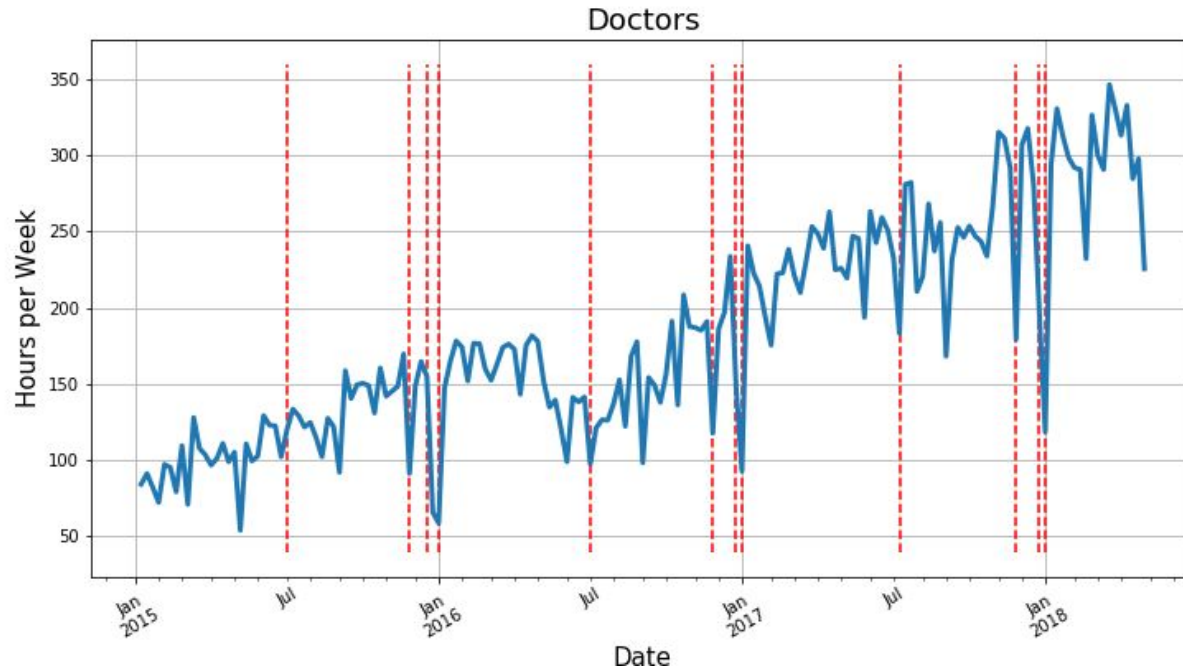


Simple Model: Linear Regression



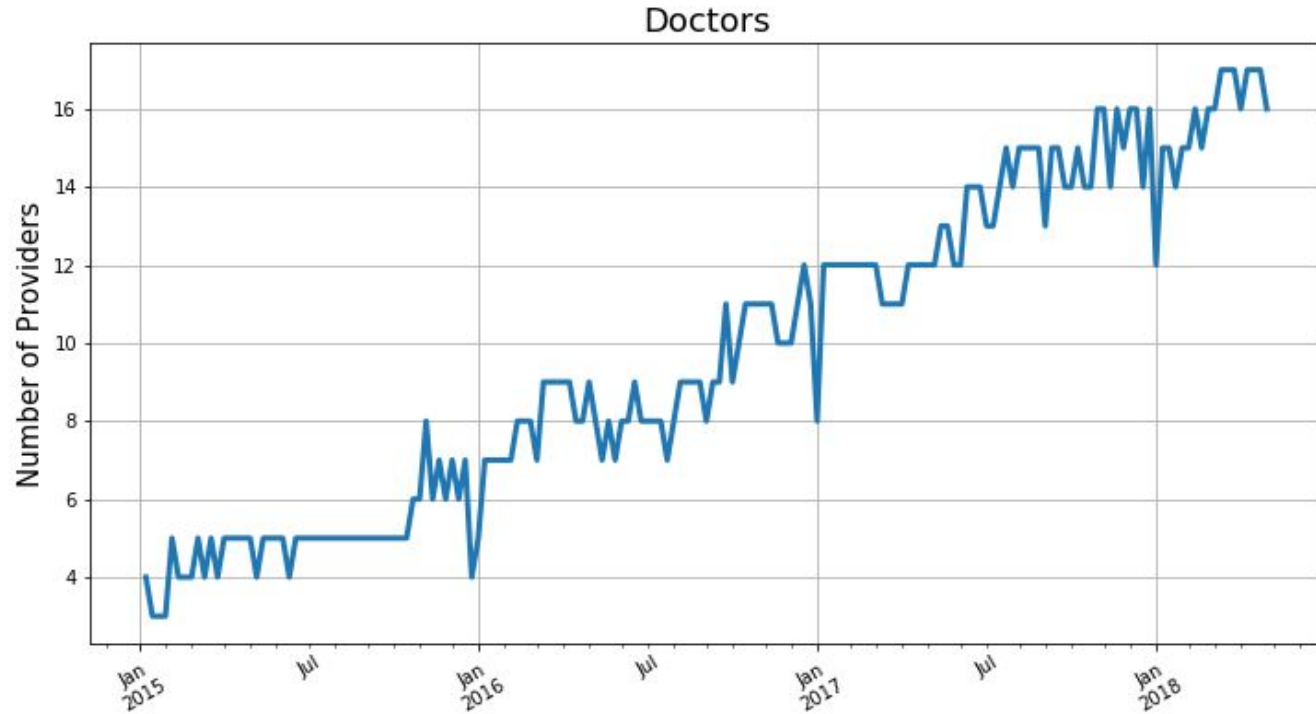
Not a good fit!!!

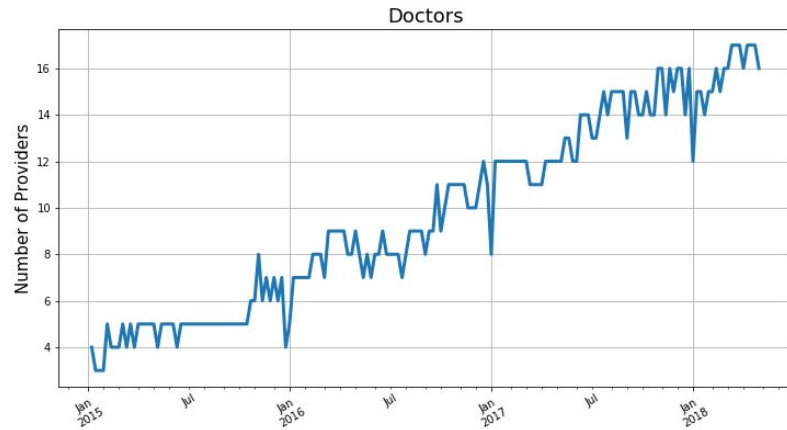
Variation Due to Time of Year



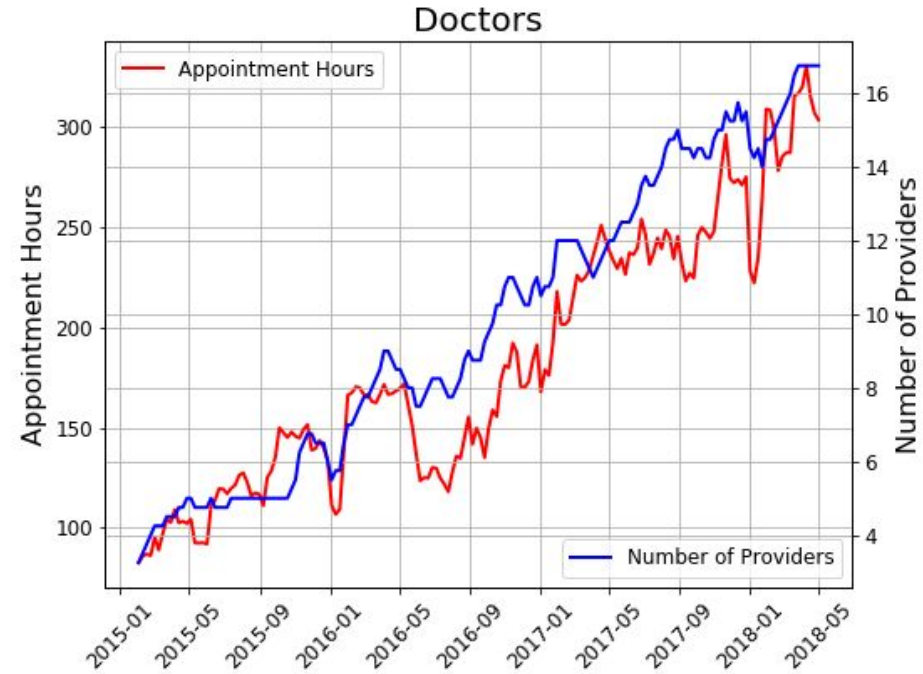
Example: Major Holidays

Modeling Supply

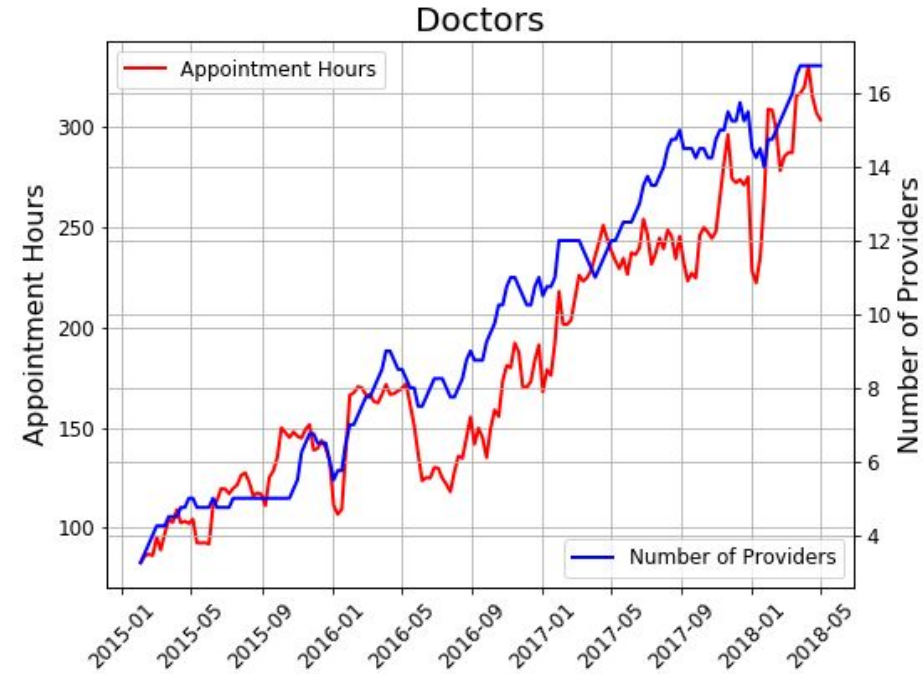
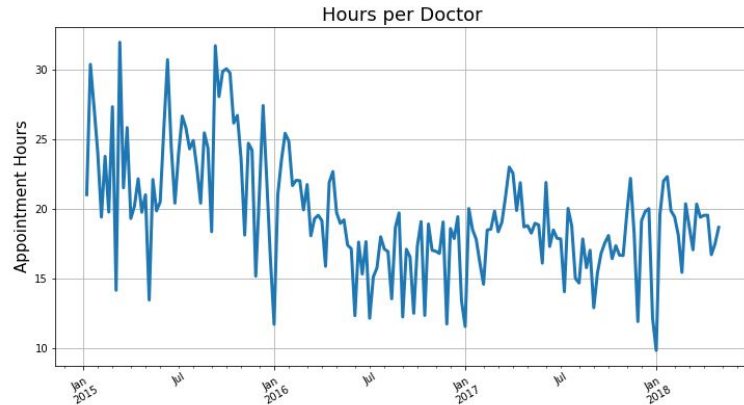
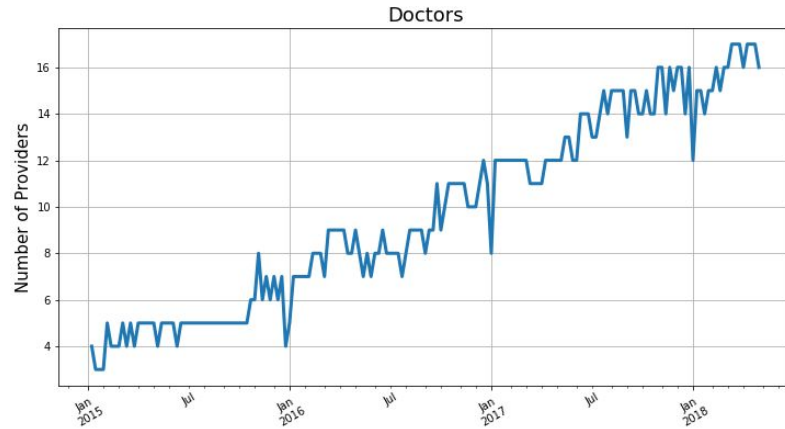




Supply and Demand



Supply and Demand



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

Modeling Weekly Demand for Psychiatrists

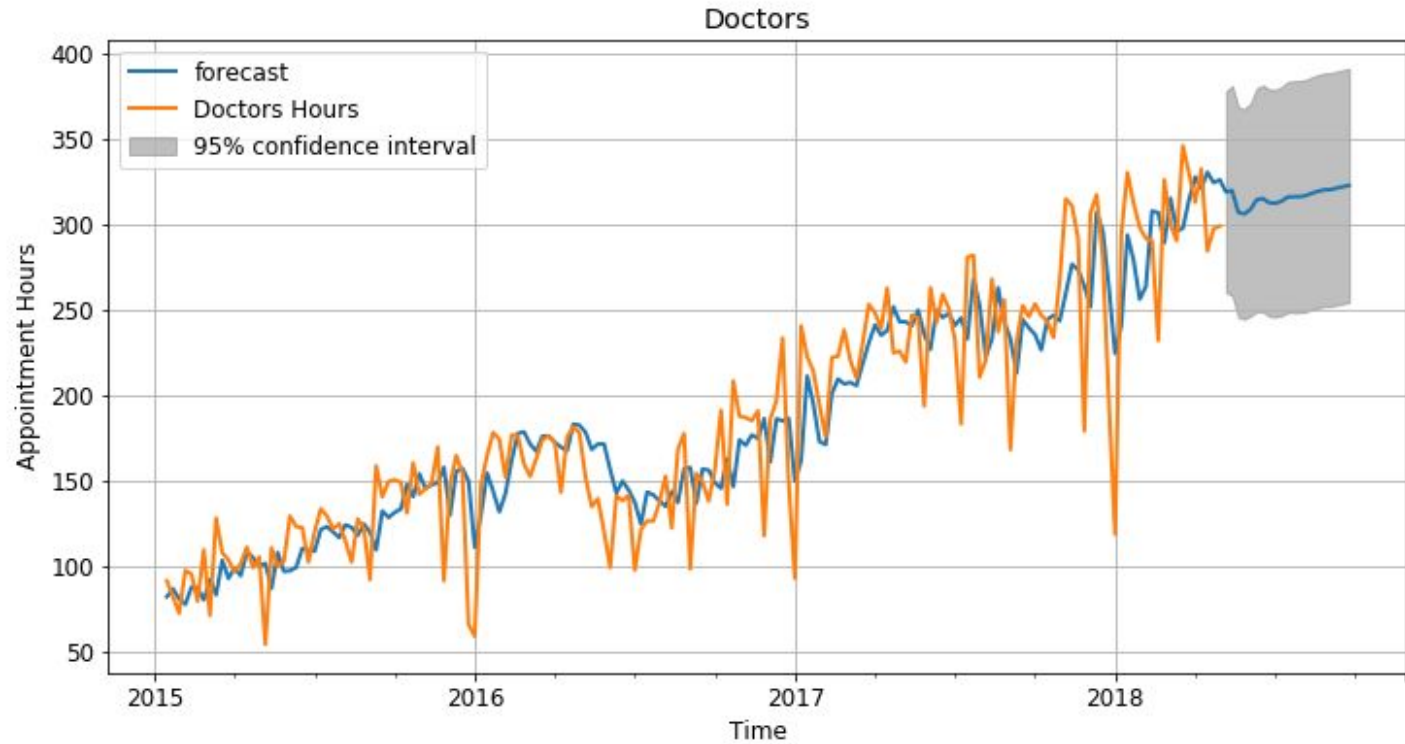
Linear Regression (not good)

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

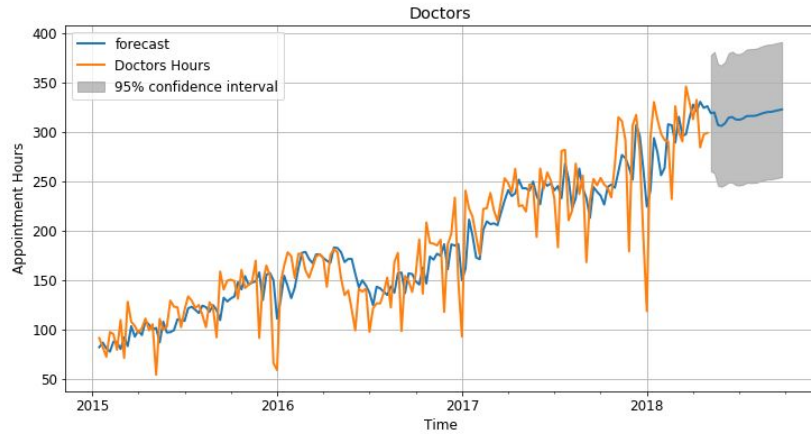
ARIMA/ARIMAX: AutoRegressive Integrated Moving Average/with Explanatory Variable

Prophet: new forecasting library from Facebook

ARIMAX



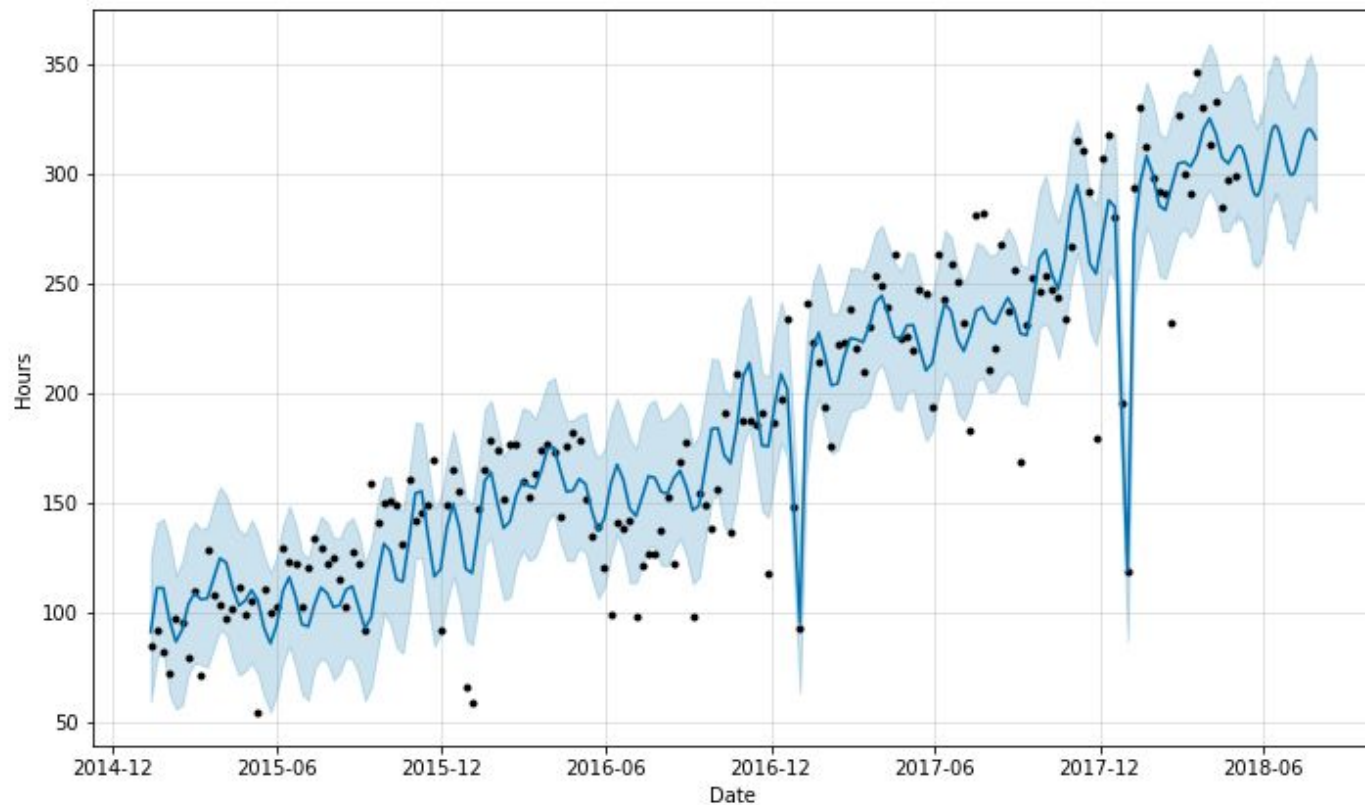
ARIMAX



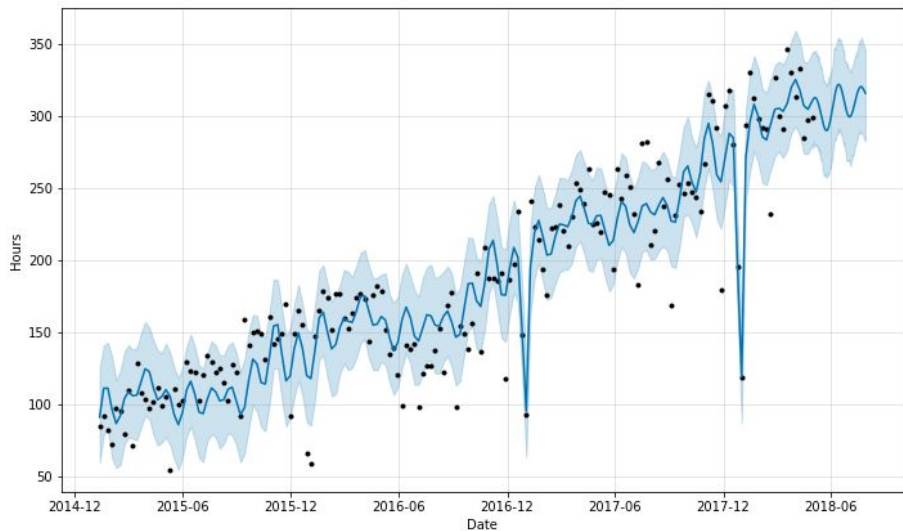
	Predicted_Hours	Predicted_Num_Providers
2018-06-25	313.0	16.0
2018-07-02	313.0	16.0
2018-07-09	314.0	16.0
2018-07-16	316.0	16.0
2018-07-23	317.0	16.0
2018-07-30	317.0	16.0
2018-08-06	317.0	16.0
2018-08-13	319.0	16.0
2018-08-20	320.0	16.0

8-16 week forecast

Prophet



Prophet



	Predicted_Hours	Est_Num_Providers
8	307.0	16.0
9	305.0	16.0
10	303.0	15.0
11	302.0	15.0
12	300.0	15.0
13	298.0	15.0
14	296.0	15.0
15	295.0	15.0
16	293.0	15.0

8-16 week forecast

Conclusions

ARIMAX Predictions: 16 psychiatrists needed 8 to 16 weeks in the future

Prophet Predictions: 15-16 psychiatrists over the same interval

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Which model is better?

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Which model is better?

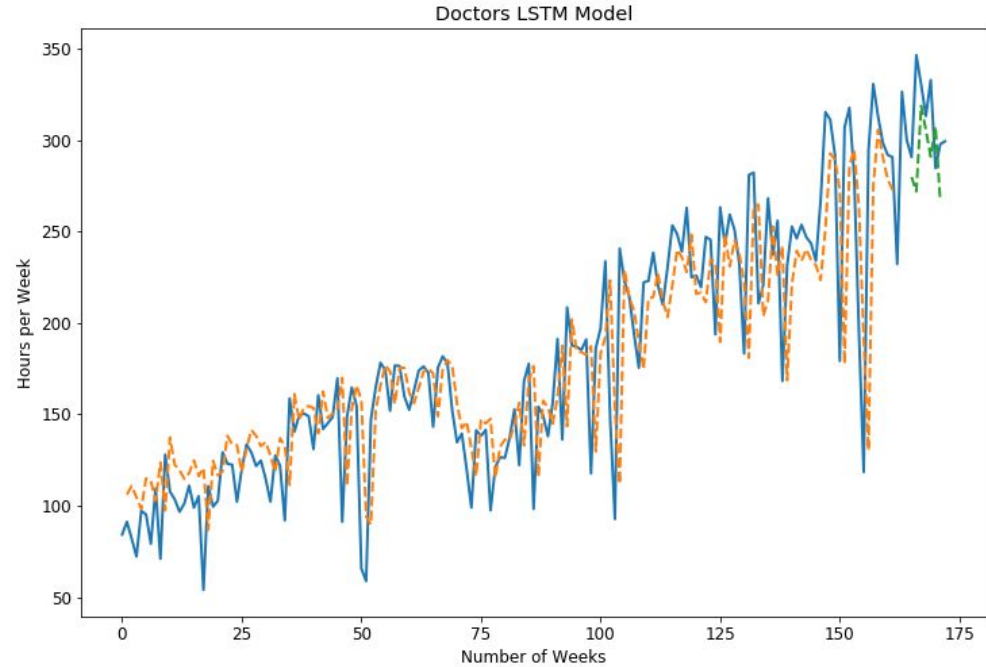
Mean squared error for test data (March & April 2018) was lower for Prophet model than ARIMAX

Next Steps

- LSTM: Long Short-Term Memory
Recurrent Neural Network

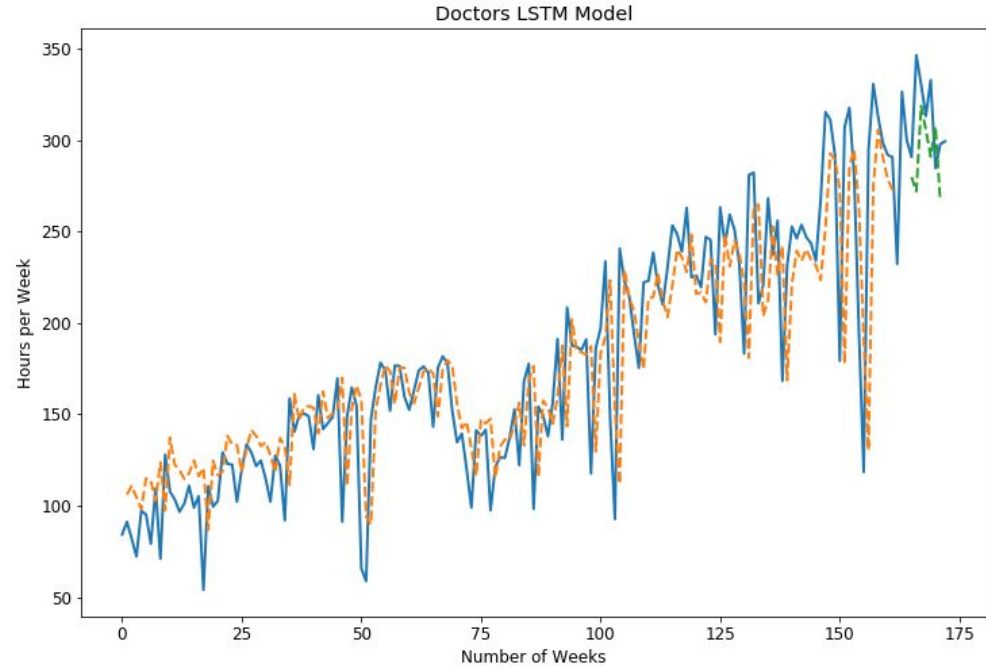
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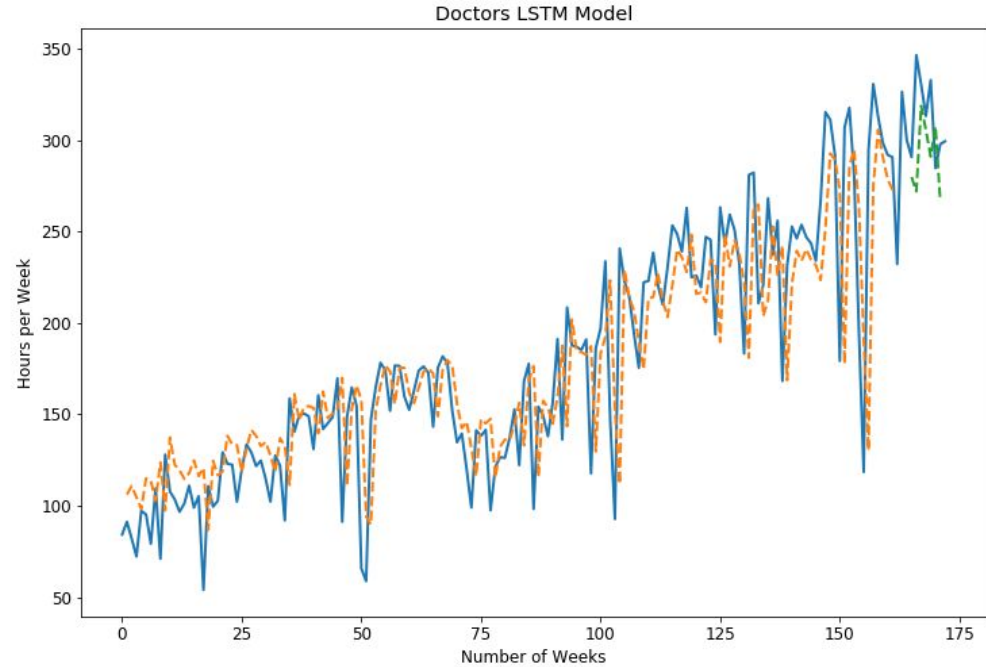
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- Add additional features/variables to existing models



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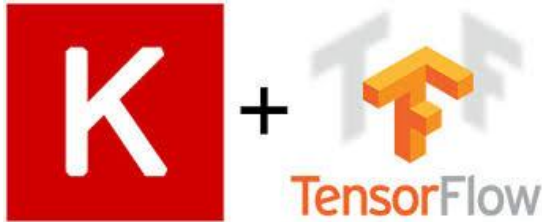
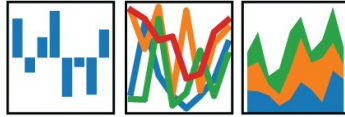
- LSTM: Long Short-Term Memory Recurrent Neural Network
- Add additional features/variables to existing models
- Breakdown by different types appointments



Tools/Libraries Used



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



matplotlib



Machine Learning with Scikit-Learn

Thank you!!!!

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<https://github.com/nicolemhfarley>

