

NICU Case Study

1 Problem

The case presents the problem of efficiently allocating functions in the NICU. Since the planned renovations started, factors of decreasing census and profits have raised the question of whether these changes are long-term. If they were, the remaining budget could be redirected to renovate the rest of the Children's Hospital instead.

The US Births dataset presents 66 entries of numerical values of monthly births from January 2007 to June 2012. Its analysis with the NICU dataset will provide recommendations of whether to continue with planned bed increases.

2 Understanding and Preparing Data

R code

```
births.df$Year = as.integer(substr(as.character(births.df$Yr_Mo),1,4))
births.df$Month = as.integer(substr(as.character(births.df$Yr_Mo),5,6))
births.df$Date =
  as.Date(
    paste(substr(as.character(births.df$Yr_Mo),1,4),
          substr(as.character(births.df$Yr_Mo),5,6), "01", sep="-"),
    format="%Y-%m-%d")
```

Tableau code

`INT(RIGHT(STR([Yr Mo]), 2))`

`INT(LEFT(STR([Yr Mo]),4))`

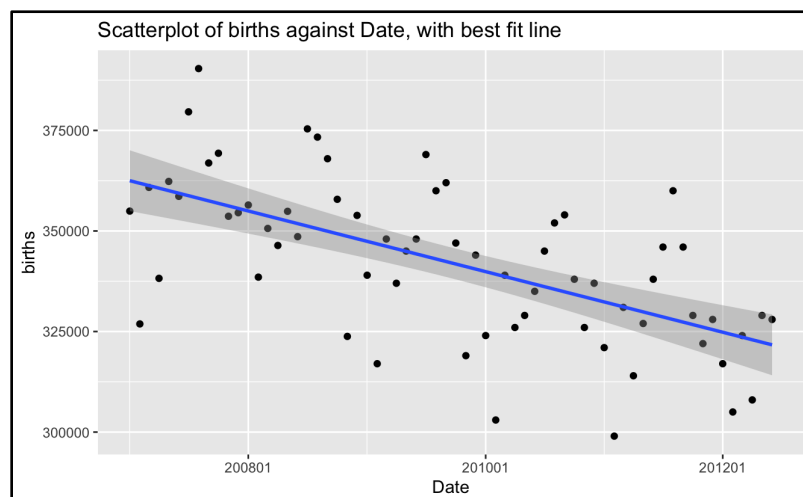


Figure 1: Scatterplot of live births against Date with line of best fit

The scatter plot and best-fit line shows a decreasing trend in births from 2007 to 2012. This can be attributed to economic factors, such as the 2008 financial crisis (WEF, 2022) and social factors such as women's postponement of marriage and greater workforce participation (PRB, 2021)

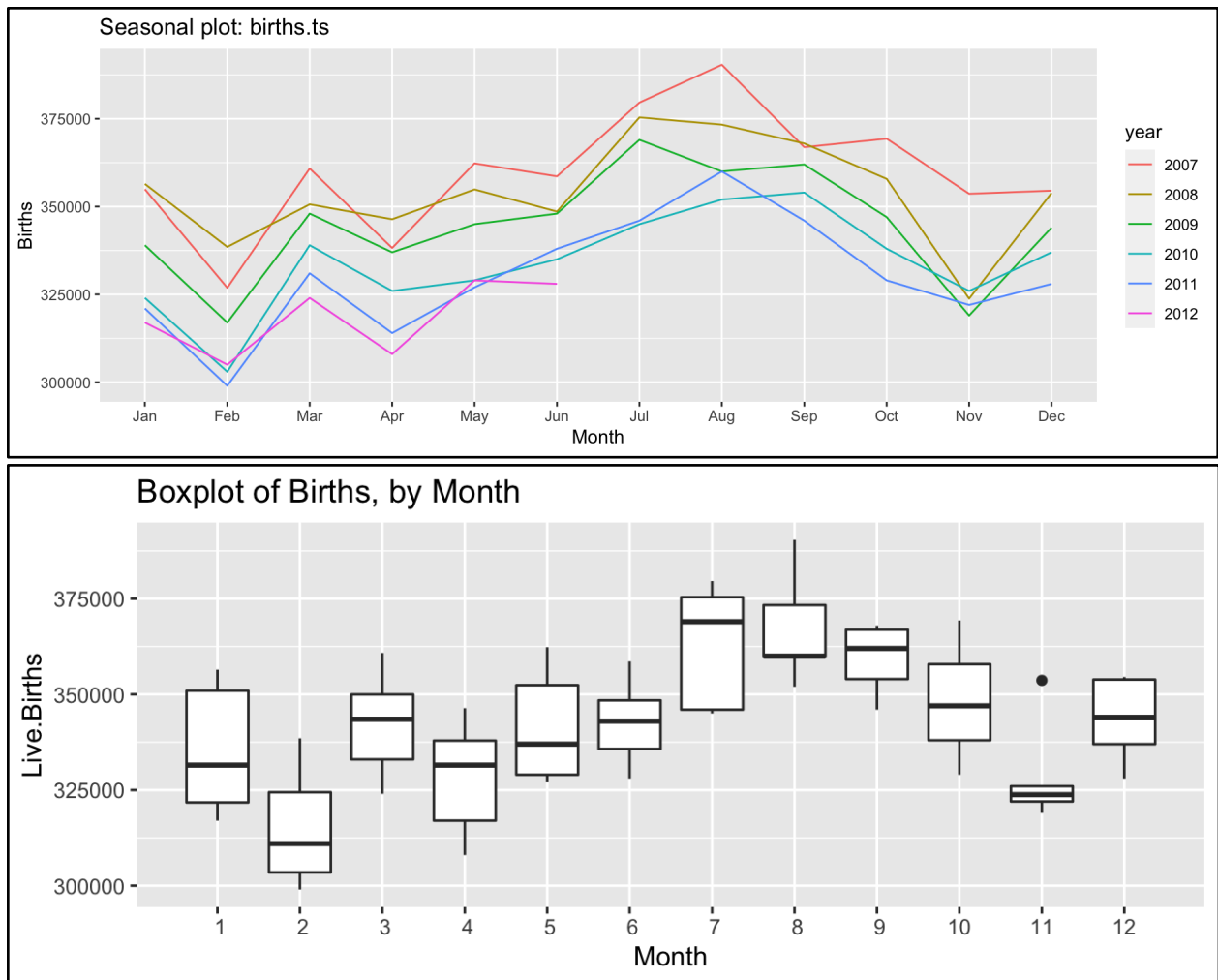


Figure 2: Seasonality of Births

Figure 2 presents seasonality patterns of births. Births increase in April-August, peaking in July-September. February has the lowest births.

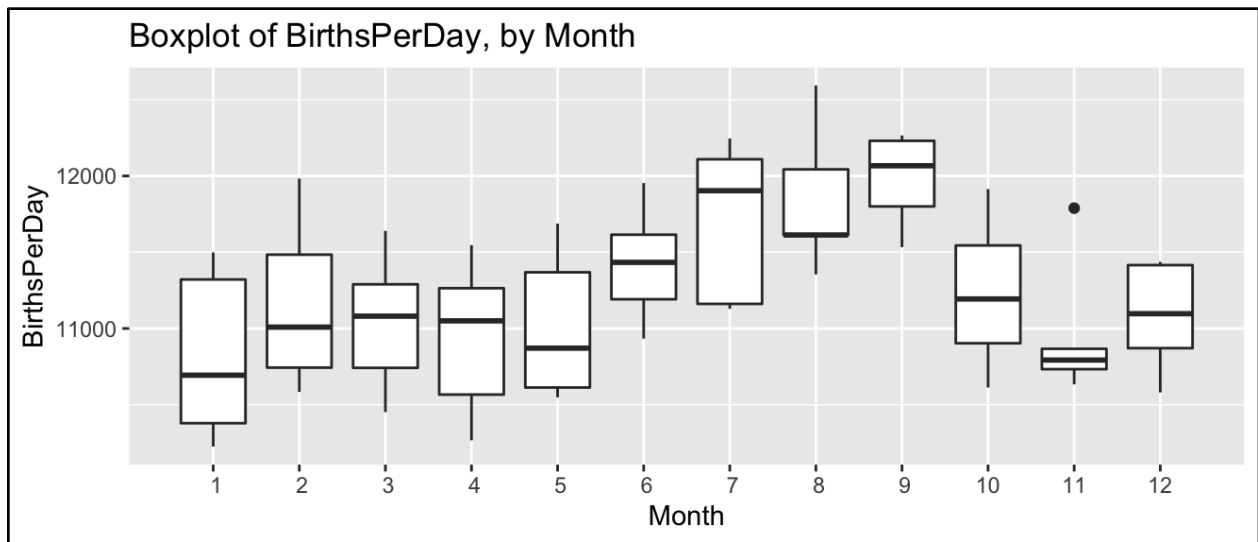


Figure 3: Seasonality of BirthsPerDay

Lowest births in February could be explained by February having the least number of days as median BirthsPerDay for February is comparable to adjacent months. (see Figure 3).

Higher births in summer (June-September) can be associated with increased conception in winter months (December-February), resulting in high births 9 months later. Decreased sperm quality in summer months also resulted in lower winter births (WHO, 2022).

This suggests that there is both trend and seasonality in births.

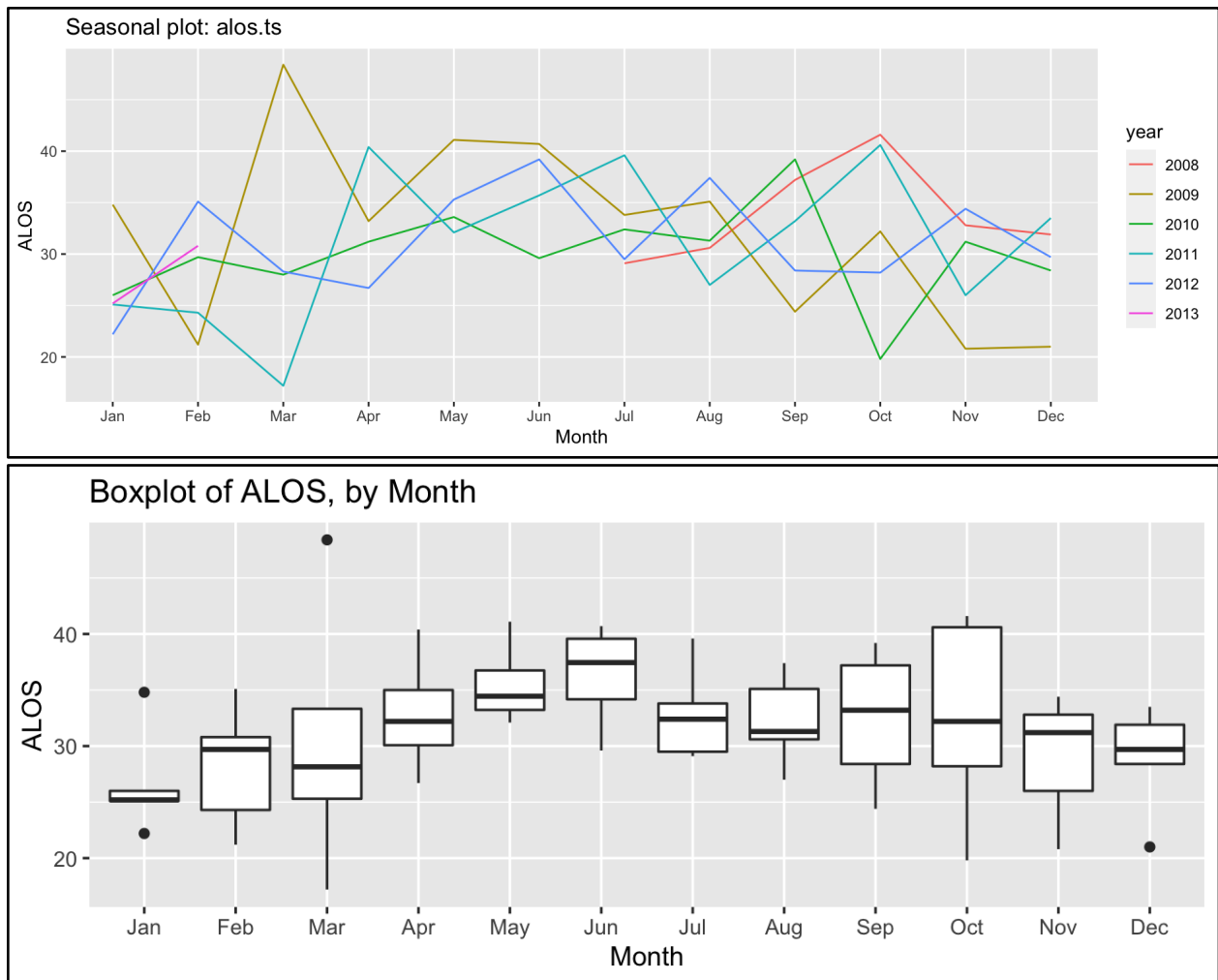


Figure 4: Seasonality of ALOS

Lowest ALOS in December-February and highest in April-July coincide with lower births in winter and higher births in summer (see Figure 2&4). Thus, there is likely also seasonality in ALOS. Advancements in medical technology also led to a decrease in ALOS from 2008-2012.

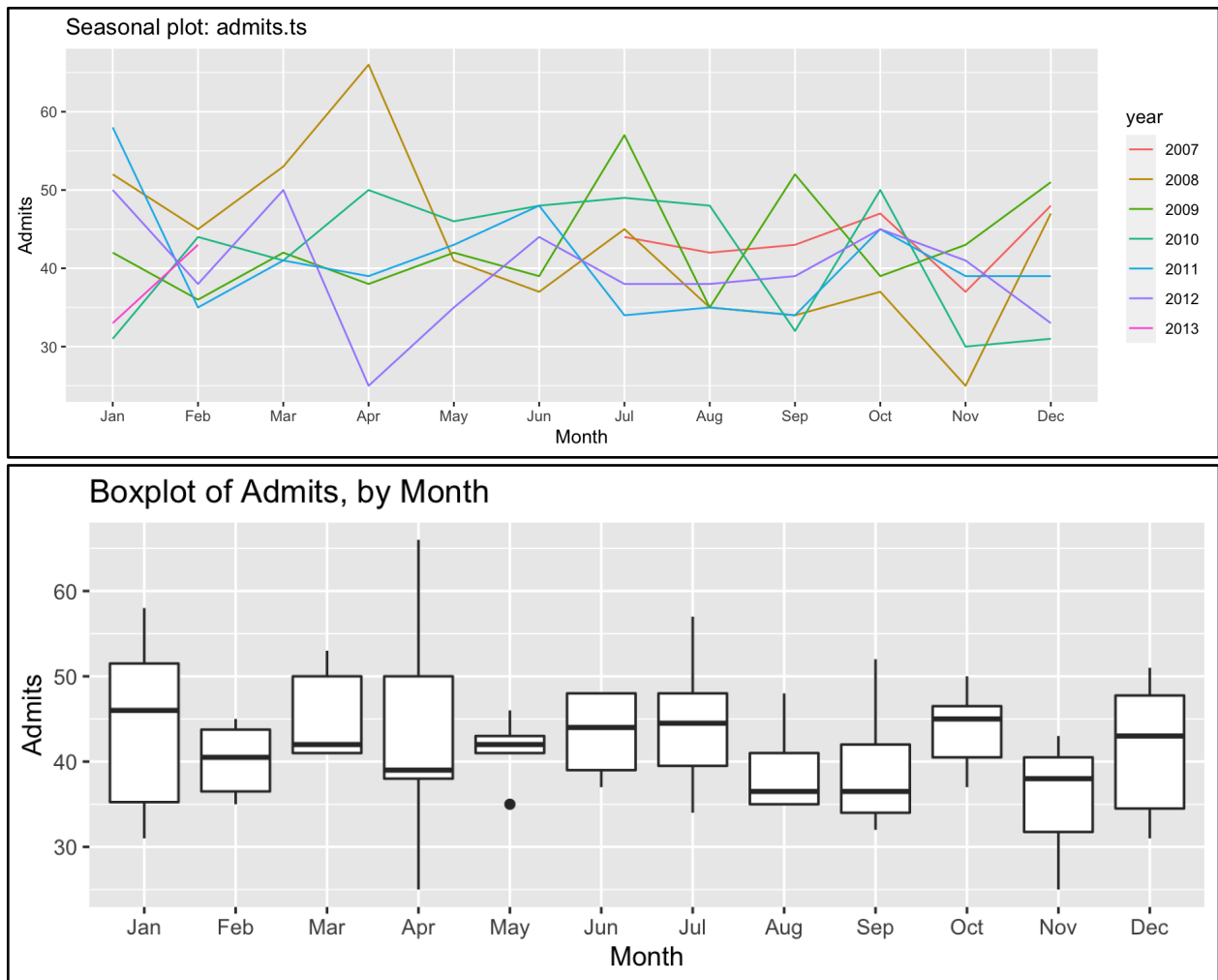


Figure 5: Seasonality of Admits

On average, August-November presented lowest NICU admits while June-July had higher admits (see Figure 5). However, Admits has no seasonality with unpredictable fluctuation throughout the year, thus, there is likely no link with births. This may be as Admits is derived from GHSC's NICU, thus weakly representative of the US population and births.

3 Understanding and Preparing Data

Dataset Generation

A time series object was created for LiveBirths. This was split 75:25 by the number of records. The training dataset hence contains births up until February 2011.

Models Analysis

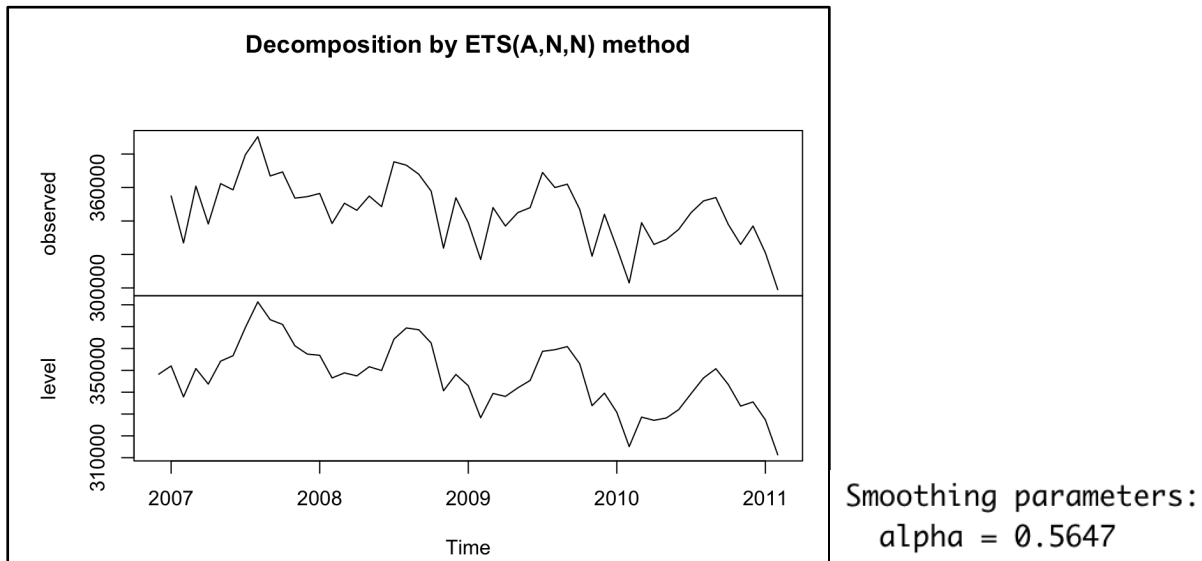
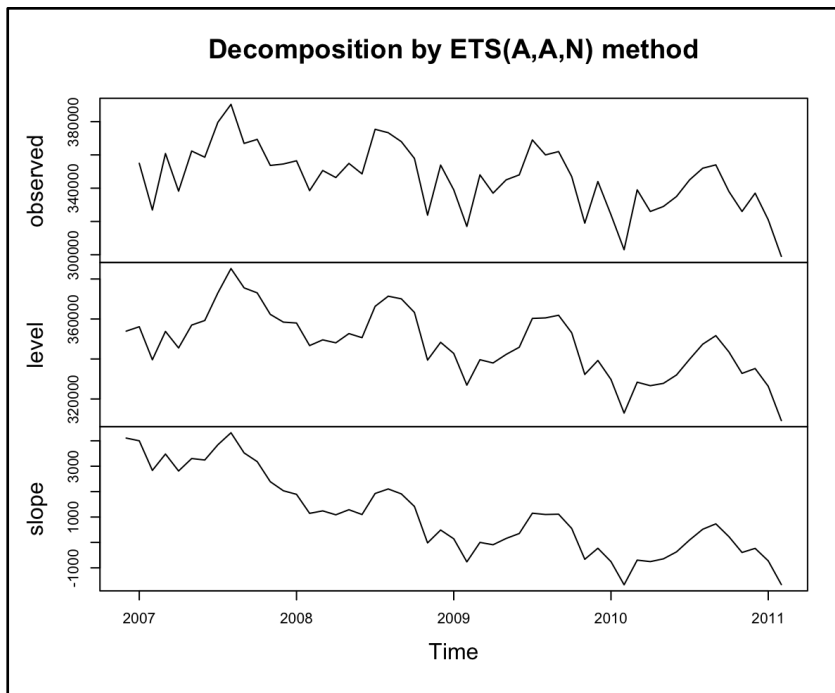


Figure 6: Decomposition of Simple Exponential Smoothing (SES)

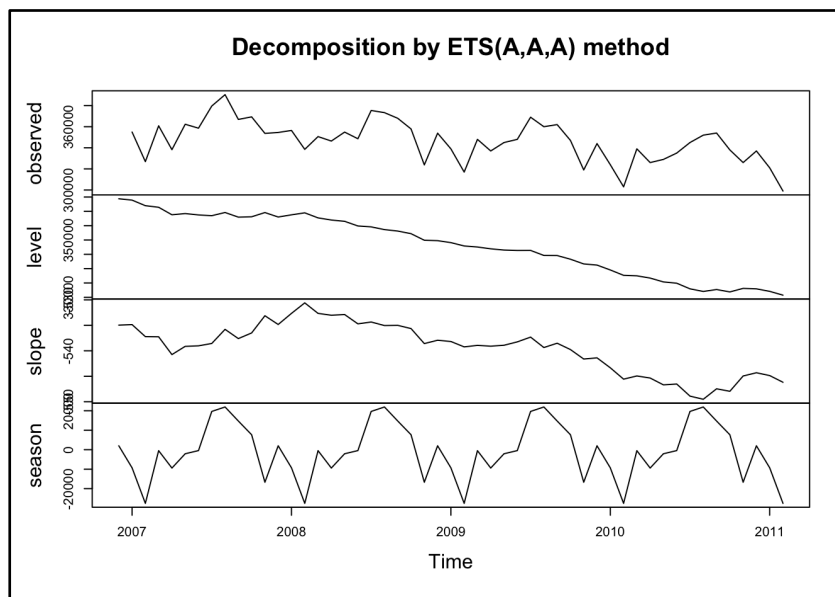
SES resulted in a relatively high alpha because there is a clear trend and seasonality meaning fluctuations are not a result of randomness. Level is therefore closely dependent on the births attribute, producing a level plot shaped similarly with observed births (see Figure 6).



Smoothing parameters:
 $\alpha = 0.6172$
 $\beta = 0.035$

Figure 7: Decomposition of Holt's linear model

Holt's linear model produced a small beta, meaning trend is heavily weighted on past levels; alpha was similar to SES.



Smoothing parameters:
 $\alpha = 0.157$
 $\beta = 3e-04$
 $\gamma = 2e-04$

Figure 8: Decomposition of Holt-Winters seasonality model

Holt-Winters model has very low beta and gamma. There is a clear seasonality representation, and the trend (slope) is well-reflected to be downwards-sloping.

```
> forecast::accuracy(births.ets.ANN.pred, test.ts)
```

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-1307.57	16113.47	13106.61	-0.5579377	3.842864	1.331727	-0.04599095	NA
Test set	16917.65	21880.80	18125.74	4.9866513	5.381415	1.841707	0.55523775	1.564617

```
>
```

```
> forecast::accuracy(births.ets.AAN.pred, test.ts)
```

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-3289.923	16723.51	13663.97	-1.105559	4.013121	1.388359	-0.08148855	NA
Test set	33143.743	35664.66	33143.74	9.974315	9.974315	3.367645	0.45836614	2.635609

```
>
```

```
> forecast::accuracy(births.ets.AAA.pred, test.ts)
```

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-850.5261	5868.993	4584.923	-0.2833848	1.337625	0.4658615	-0.1695469	NA
Test set	2922.6837	6538.180	5258.065	0.8699006	1.602711	0.5342577	-0.3178919	0.4932989

Figure 9: Model accuracy

Holt-Winters produced lowest errors across every metric as births contain trend and seasonality, making Holt-Winters model best at predicting births.

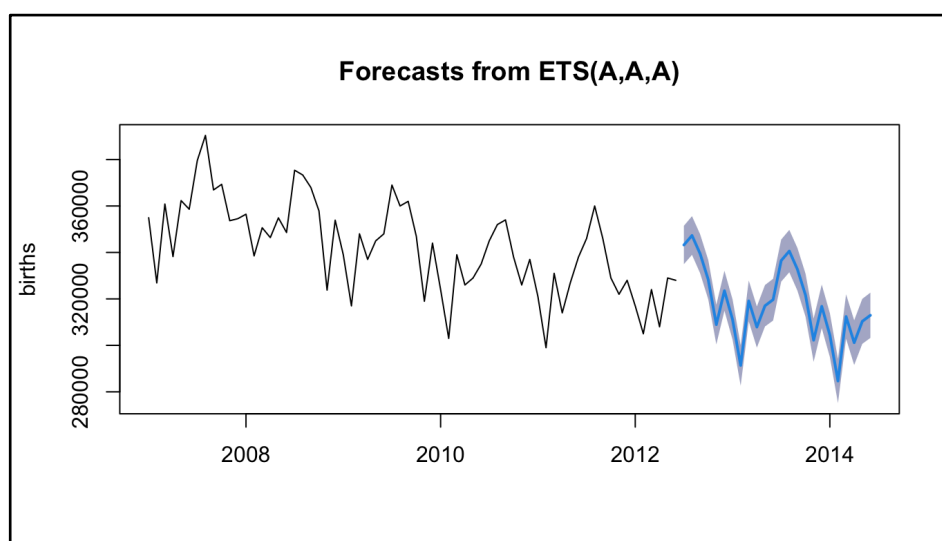


Figure 10: US births forecasted with 80% confidence level

Hence, we expect the model to predict a continually decreasing trend with seasonality into July 2014 (see Figure 9).

4 Conclusions & Recommendations

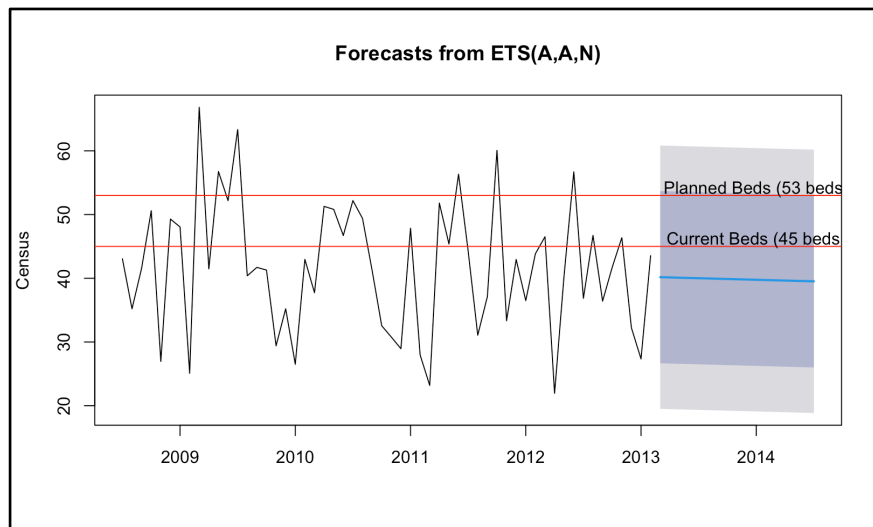


Figure 11: Forecasts from Holt's linear model

Census forecasts show that only 40 beds are required by July 2014 (see Figure 10). This is below the current bed count of 45. As birth is forecasted to decline into 2014 and beyond, there is no evidence that there is a need for more beds. Therefore, we advise the COO of GCH to stop production of beds since it is likely that the current beds would be able to accommodate future census.

References

What does the global decline of the fertility rate look like? World Economic Forum.

(2022, June). Retrieved February 17, 2023, from

<https://www.weforum.org/agenda/2022/06/global-decline-of-fertility-rates-visualised>

Why is the U.S. birth rate declining? PRB. (2021, May). Retrieved February 17, 2023,

from <https://www.prb.org/resources/why-is-the-u-s-birth-rate-declining/>

World Health Organization. (2021, November). *Preterm birth*. World Health

Organization. Retrieved February 17, 2023, from <https://www.who.int/news-room/fact-sheets/detail/preterm-birth>