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# Introduction

The ATUS dataset [1] used is based on research carried out as part of the American Time Use Survey [2] from 2003 to 2017, containing time use data for 431 different activities grouped into 17 over-arching categories.

**Aim:** Hypothesise, validate and present long-term trends based on the data

## Approach:

- ▶ EDA
  - ▶ The dataset was split and the even months were used for exploration and model training (July excluded and used for validation);
- ▶ Validation using left out “unseen” data
  - ▶ Formal hypothesis tests on the initial beliefs from the EDA using the odd months (including July) as the validation data;
- ▶ Summary plots of findings

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# Tidying and Structuring the Data

- ▶ Missing values were confined to 9 columns of factor variables so these were removed
- ▶ The 17 categories were built from the activity data
- ▶ As the aim is to present long-term trends, weighted means for **each year** were calculated
  - ▶ This allows for comparisons and ensures that each group is correctly represented in the population

The weighted means are then calculated using

$$\overline{T}_j = \frac{\sum_i weight_i T_{ij}}{\sum_i weight_i}$$

where  $i$  corresponds to the individual, and  $j$  corresponds to the type of individual

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## Observation 1:

# Participation in Caring for & Helping Non-HH Members

## Exploratory Data Analysis

- ▶ Activities with % change larger than 10% and variance greater than 0.5

Table 1: Change in Participation of Activities

Measure	tu04	tu08	tu13	tu14	tu16
Variance	2.54	0.89	1.44	0.60	1.93
% Change	-32.11	-26.46	10.17	12.32	-24.08

- ▶ Fitting a linear model and performing best subsets regression with Year forced in as an explanatory variable gives Sex and Number of Household Children
- ▶ Fit a more complex model: glm with log link and multiplicative errors  
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  - ▶ Use natural cubic splines to show fluctuations
  - ▶  $tu04participation \sim -1 + Sex + Sex : ns(Year, knots = 2003, 2005, \dots, 2017)$
- ▶ Performing an  $F$ -test on the model shows this is a significant improvement on  
 $tu04participation \sim -1 + ns(Year, knots = 2003, 2005, \dots, 2017)$

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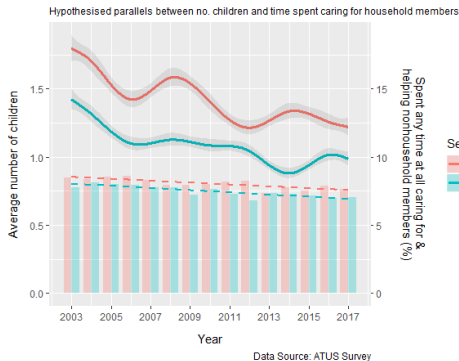
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# Observation 1:



- ▶ The plot indicates that over the period, the participation in 'tu04' has decreased for both men and women
- ▶ Changes in the 'average no. of household children' seem to follow the trend in participation, however the link is weak (correlations of 0.65 for Men and 0.49 for Women)

A one-sided  $t$ -test on a linear model simplification of the generalised linear model without splines -  
( $tu04participation \sim Year + Sex$ ) - gives a  $p$ -value of  
**5.7e-09**  $<< 0.05$

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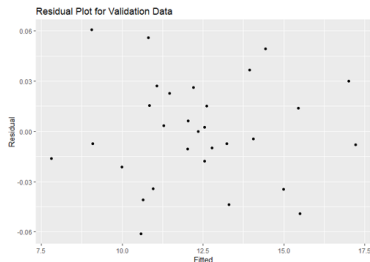
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# Validation

Formal one-sided  $t$ -test on linear model build on *validation data* gives a  $p$ -value of  **$1.4\text{e-}07 < 0.05$**



- ▶ To test the suitability of the model on the validation dataset a residual plot was created
- ▶ The errors:
  - ▶ Are uncorrelated
  - ▶ Have mostly equal variance
  - ▶ Seem to have mean 0

Performing a formal  $t$ -test when average number of household children is added confirms that this has a significant effect on participation in caring for & helping non-household children

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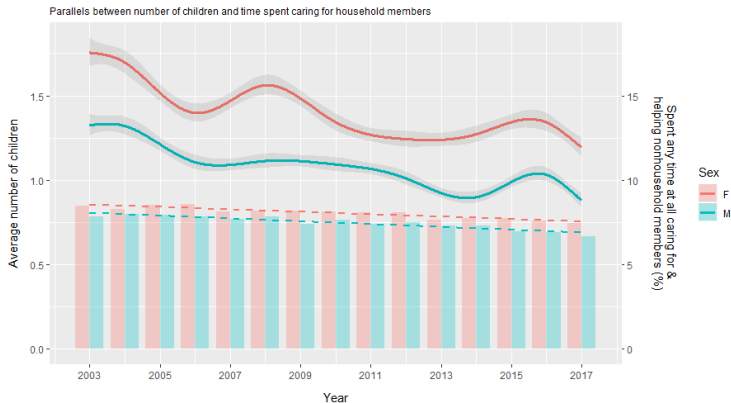
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# Final Plot Built On All Data Excluding July



Data Source: ATUS Survey

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## Observation 2:

# How Time Spent on Traditionally Gendered Activities has Changed as Gender Roles have Broken Down?

Table 2: Traditionalist Gender Activities

Male Activities	Female Activities
Working	Housework
House Maintenance	Cooking
Vehicle Maintenance	Childcare

Table 3: Generations

Generation	Birth Years
Silent Generation	1928 - 1945
Baby Boomers	1946 - 1964
Generation X	1965 - 1980
Millennials	1981 - 1996

- ▶ Table 2 is a simplified version of Talcott Parsons' [3] study on gender roles
- ▶ Table 3 shows how to break down the respondents into different generational groups [4]
- ▶ Division between genders in terms of societal roles is consistently featured in the news; evident in the “#MeToo” movement amongst others
- ▶ The report aimed to investigate how this division changed over the given period through investigating long-term trends in each of the traditional gender activities

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# Exploratory Data Analysis

- ▶ The first stage of the analysis looked at participation rates at a total population level for the different activities to check they were popular enough for comparison
- ▶ Following this initial check, general linear models were developed for all suitable activities and different parameters were checked including:
  - ▶ Sex
  - ▶ Year
  - ▶ Generation
  - ▶ Region
- ▶ After performing formal F-tests and comparing simpler models, the following model was settled upon for all activities

$Activity \sim -1 + ns(Year) + Sex + Sex : ns(Year, knots = 2003, 2005, \dots, 2017) +$   
 $Generation + Generation : ns(Year, knots = 2003, 2005, \dots, 2017)$

- ▶ The simpler models were variants of this model, but without sex or generational information

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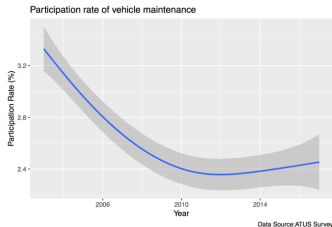
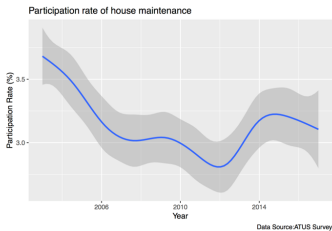
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# House Maintenance and Vehicle Maintenance (Males)

- ▶ The participation rate was too low to warrant deeper analysis
- ▶ Whilst the findings represented that there existed a separation in gender, the participation rates of around 3% for both reflected that these were more uncommon activities
- ▶ It was decided that there was not enough data to reflect the time spent on these activities in a suitable linear model



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# Validation

- ▶ **Males:** Working, House Maintenance and Vehicle Maintenance;
- ▶ **Females:** Housework, Cooking and Childcare
- ▶ The models shown on the following slides showcase the results of the analysis, plotting all of the data with the exception of July as required
- ▶ Despite using 11 months of the data here, it is critical to reiterate that all of the EDA and validation was carried out on entirely separate 6 month subsets of each year to ensure validity of the conclusions and testing
- ▶ Formal one-sided  $t$ -test were performed on the simple linear model below for each activity, using weighted yearly averages for the data

*Gender time difference  $\sim$  Year*

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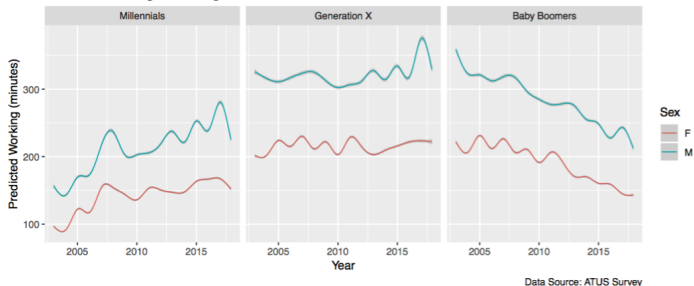
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# Validation - Working

Trends in working for each generation



- ▶ The plots show the changes in working patterns between 3 generations. There's an increase in working time for *Millennials* as this generation begin to work. Likewise, there's a decrease in time for *Baby Boomers* as many of this generation begin to retire.
- ▶ *Generation X* shows that there is an increase in women working time and for the first 13 years, a decrease in time working for men. There is a slight uptick for men working in 2016, however, this begins to return to previous lower levels in 2017.
- ▶ The  $t$ -test on a population level for this gave a  $p$ -value of  $0.047 < 0.05$
- ▶ The  $F$ -test is shown below

Model	Residual DF	Residual Deviance	DF drop	Deviance drop	F	p-value
1	98098	56241.17				
2	98068	52250.68	30	3990.49	733.51	$< 2.2\text{e-}16$
3	98020	23983.07	48	28267.62	3247.51	$< 2.2\text{e-}16$

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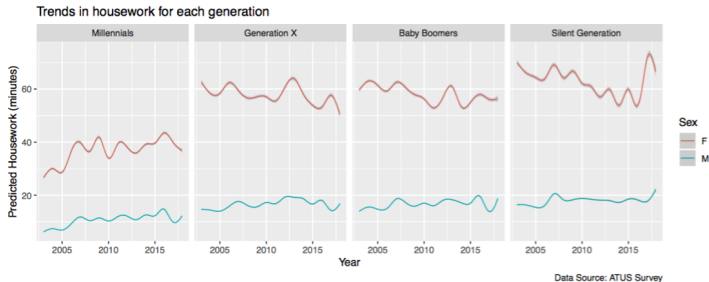
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# Validation - Housework



- ▶ Except for *Millennials*, all generations have the decrease in time spent on housework. But the decrease for women is sharper than any *increase* for men, which is clear through observation of *Generation X*.
- ▶ On the other hand, the gap seems to have increased slightly for *Millennials* - both sexes are increasing the amount of time spent on housework, there is a confounding effect of increased time due to age / moving out.
- ▶ Notably, *Millennials* also spend less time doing housework than the others.
- ▶ The  $t$ -test on a population level for this gave  $p$ -value of  $6.8e-05 \ll 0.05$
- ▶ The  $F$ -test is shown below

Model	Residual DF	Residual Deviance	DF drop	Deviance drop	F	p-value
1	98098	66513.61				
2	98068	30837.95	30	35675.66	4231.51	$< 2.2e-16$
3	98020	27722.58	48	3115.37	230.95	$< 2.2e-16$

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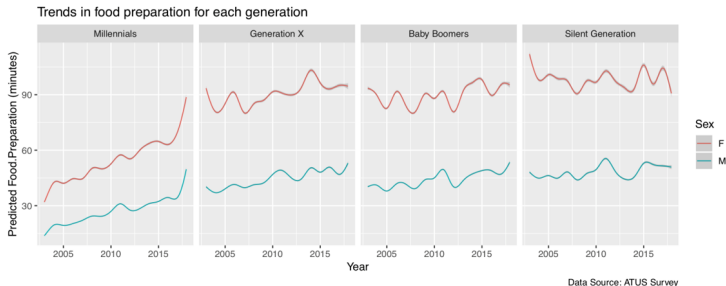
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# Validation - Cooking



- ▶ Both genders from all the generations other than the *Silent Generation* are actually spending more time than previously on food preparation
- ▶ For men, there is a sharper increase than in time spent by women which is evidence of erosion in this particular gender stereotype
- ▶ Notably, *Millennials* spend more and more time on cooking and the nearly same increasing rate of both gender leads to the small gap
- ▶ The  $t$ -test on a population level for this gave  $p$ -value of  $0.0054 < 0.05$
- ▶ The  $F$ -test is shown below

Model	Residual DF	Residual Deviance	DF drop	Deviance drop	F	p-value
1	98098	30146.10				
2	98068	17578.80	30	12567.29	2889.4	$< 2.2\text{e-}16$
3	98020	13478.53	48	4100.28	589.2	$< 2.2\text{e-}16$

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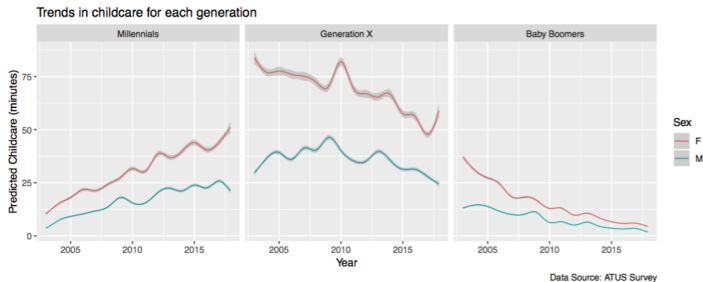
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# Validation - Childcare



- Note that the drop off for women is sharper than it is for men, leading to a convergence in the weighted means for both.
- The  $t$ -test on a population level for this gave a  $p$ -value of  $0.037 < 0.05$
- The  $F$ -test is shown below

Model	Residual DF	Residual Deviance	DF drop	Deviance drop	F	p-value
1	98098	176671.00				
2	98068	162588.37	30	14082.63	298.72	$< 2.2\text{e-}16$
3	98020	59257.72	48	103330.65	1369.92	$< 2.2\text{e-}16$

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# Conclusions

# Limitations of the Data

- ▶ 15 years is a relatively short period within which to observe long term trends
- ▶ Sporadic subset sizes due to the filtering and sub-setting required
- ▶ The reliance on people to remember the way in which they spend their time (i.e. They could forget smaller tasks and focus on more memorable or time-consuming ones)

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# Conclusion

- ▶ Embarking upon EDA from multiple perspectives highlighted the scale and number of potential trends present in the data
- ▶ Both of the main observations were validated successfully through robust statistical methodology
- ▶ Generating demographics and utilising the weights provided in the dataset allowed for more focused analysis
- ▶ There have been societal changes over this period are reflected in the trends observed

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[1] “ATUS datasets.”

[https://www.bls.gov/tus/datafiles\\_0317.htm](https://www.bls.gov/tus/datafiles_0317.htm).

[2] Bureau of Labor Statistics, “The american time use survey.” <https://www.bls.gov/tus/>, 2017.

[3] T. Parsons, “Age and sex in the social structure of the united states,” *American Sociological Review*, vol. 7, no. 5, pp. 604–616, 1942 [Online]. Available: <http://www.jstor.org/stable/2085686>

[4] “Millennials projected to overtake baby boomers as america’s largest generation.” <http://www.pewresearch.org/fact-tank/2018/03/01/millennials-overtake-baby-boomers/>.

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