# City of Boston Earnings Analysis

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# Introduction

- City of Boston publishes detailed earnings for city employees
  - How is the $1.7B payroll being spent?
  - Are employees paid fairly (equally)?
  - Is there evidence for wealth segregation?


Earnings categories

| name | department | title | regular | retro | other | overtime | injured | detail | quinn | total | zip | year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Menino,Thomas M. | Mayor's Office | Mayor | 175000.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175000.00 | 02136 | 2011 |
| Menino,Thomas M. | Mayor's Office | Mayor | 175000.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175000.02 | 02136 | 2012 |
| Menino,Thomas M. | Mayor's Office | Mayor | 175000.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175000.02 | 02136 | 2013 |
| Menino,Thomas M. | Mayor's Office | Mayor | 10769.23 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10769.23 | 02136 | 2014 |
| Walsh,Martin J. | Mayor's Office | Mayor | 164903.87 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 164903.87 | 02125 | 2014 |
| Walsh,Martin J. | Mayor's Office | Mayor | 181730.79 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 181730.79 | 02125 | 2015 |
| Walsh,Martin J. | Mayor's Office | Mayor | 175000.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175000.02 | 02124 | 2016 |
| Walsh,Martin J. | Mayor's Office | Mayor | 175000.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 175000.02 | 02124 | 2017 |

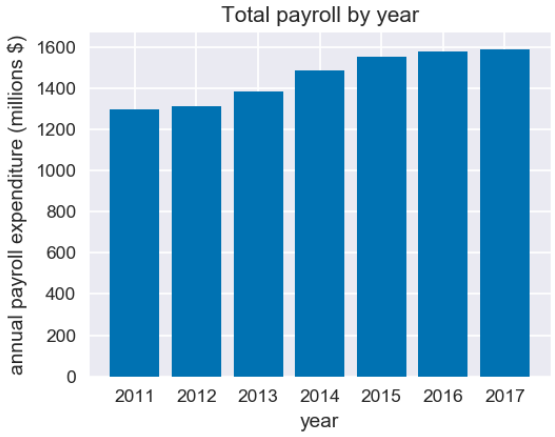
~ 20,000 employees per year

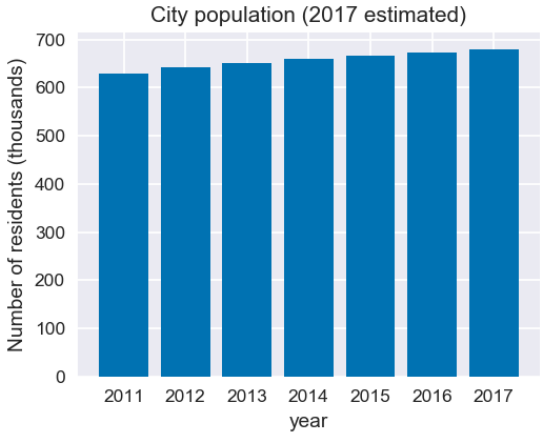
Years 2011 through 2017

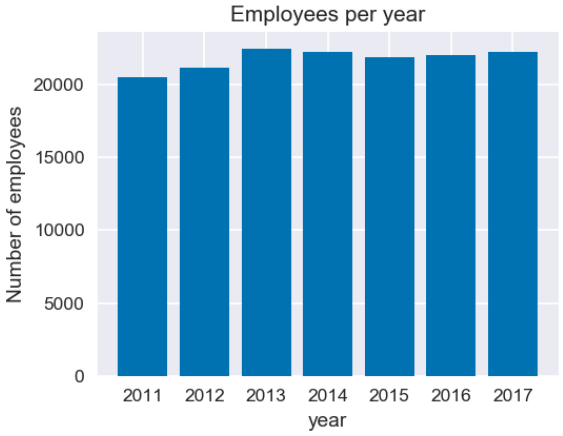
- Additionally, individual schools are listed for select years
- Data cleaning was needed for a few items:
  - Some departments consolidated and/or changed names
  - Titles are spelled out in various ways
  - Some employees list work place zip code or wrong/missing zip code

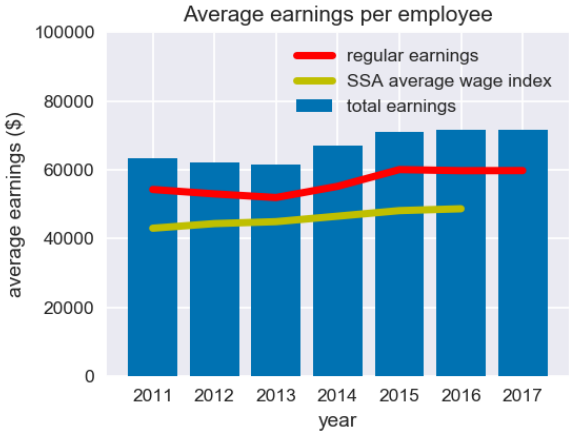
# General Trends

- Biggest increase in total payroll between 2013 and 2014
- Number of employees decreased during same period
- Significant growth in average earnings per employee



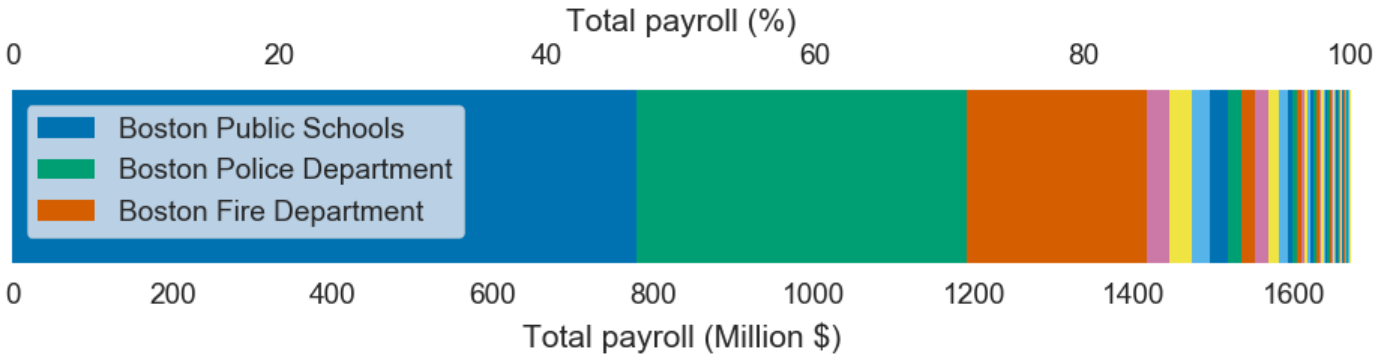



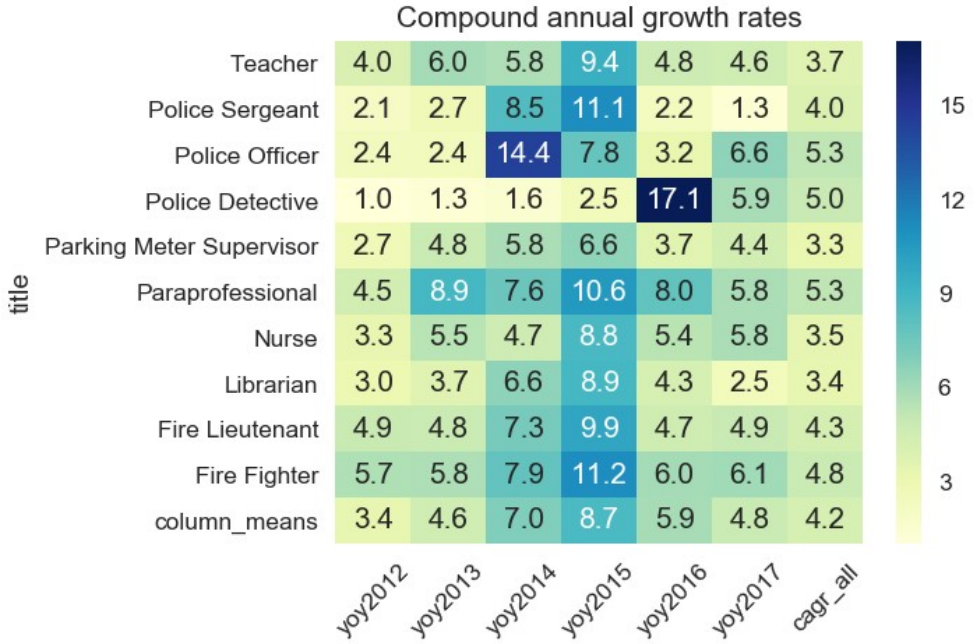

Slower growth than SSA average wage index in recent years

# Where is the money spent?

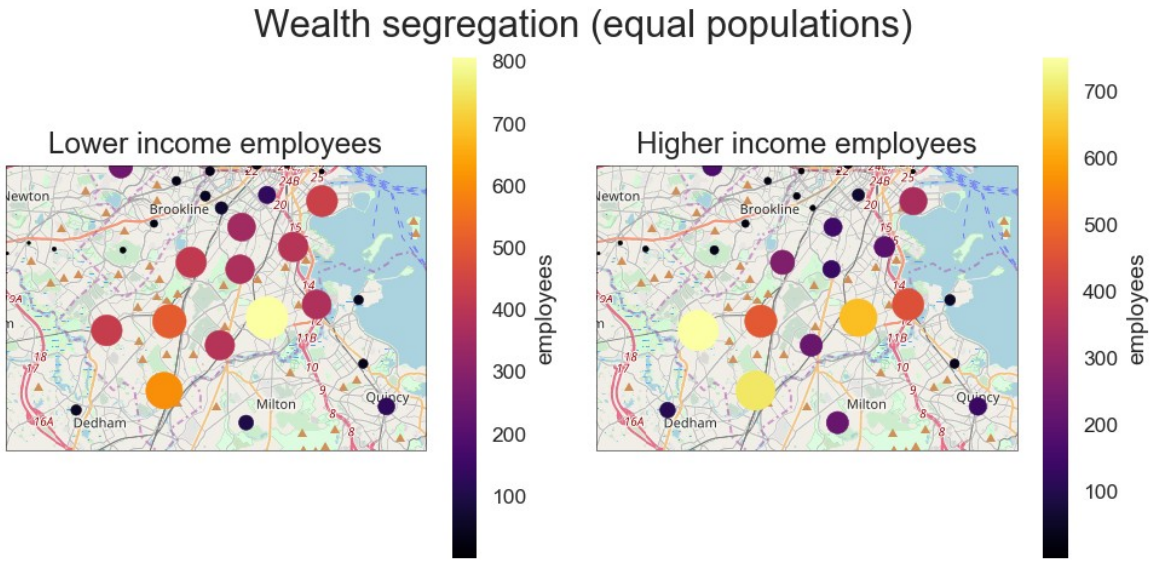
- Largest 3 departments account for 84% of payroll




- Pay increases for the 10 most common job titles (excluding partial year employees)
- Increases are uneven over the years
- Growth tends to even out in the long run ("cagr_all")
- Largest mean growth in 2015



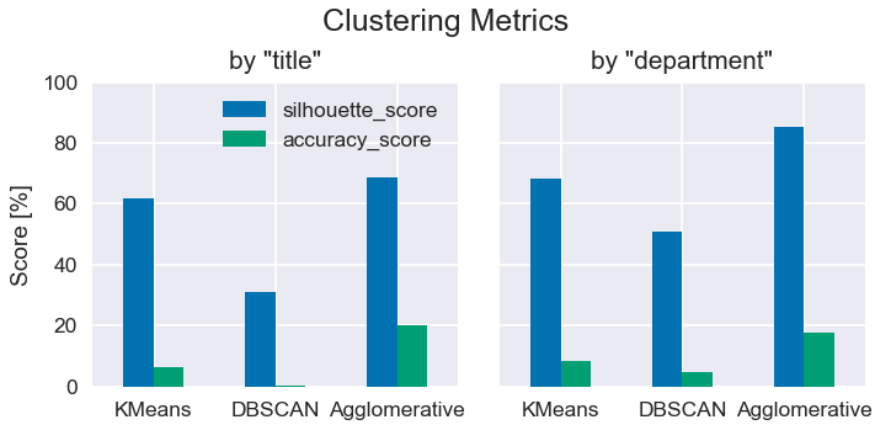
# Wealth Segregation

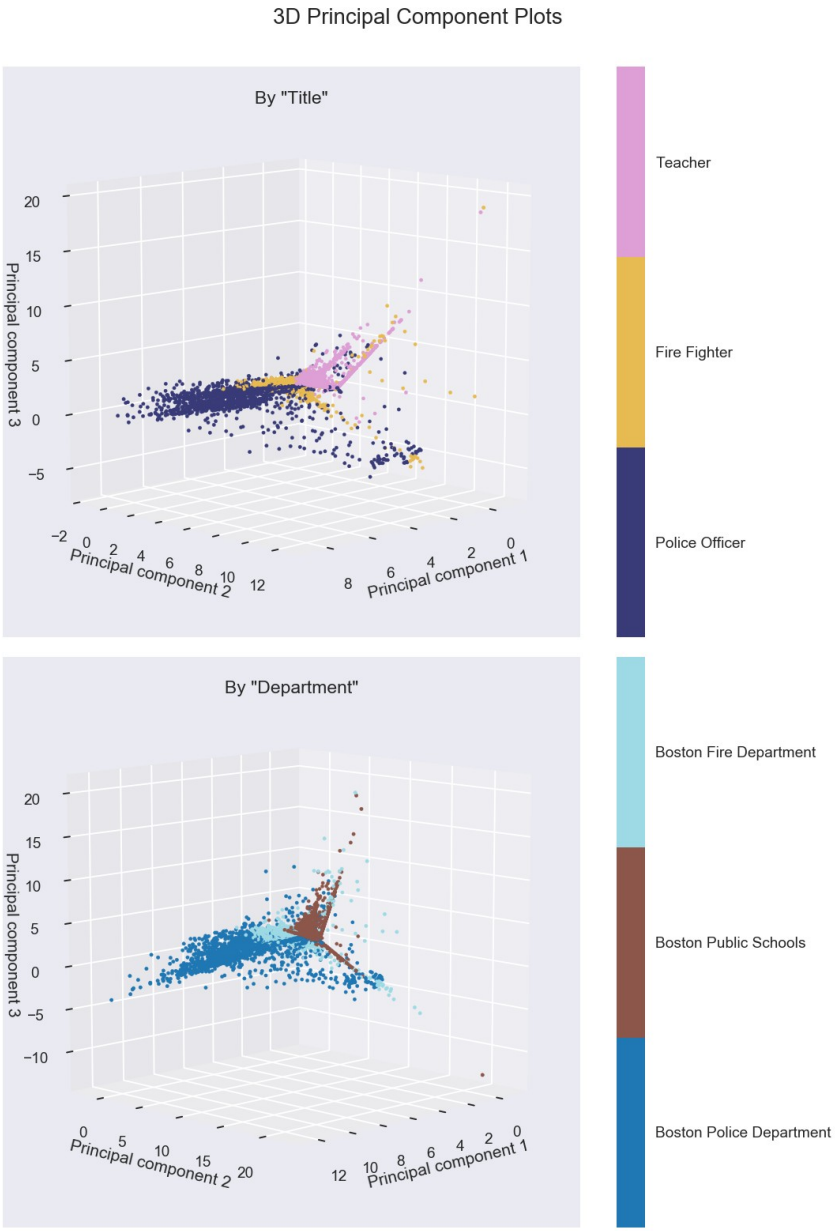



- Wealth segregation can be demonstrated for city employees
- "Zillow Home Value Index" is used as measure of "wealth" per zip code
- Correlation is very weak for all zip codes, but strong for locally well-known extreme cases


# Pay Discrepancy?

- Can machine learning algorithms predict top 3 job titles or departments?
- Success would indicate significant pay discrepancy
- Unsupervised clustering (cluster analysis) works best with agglomerative clustering algorithm
- Clustering fails to show meaningful structure or prediction accuracy (score)

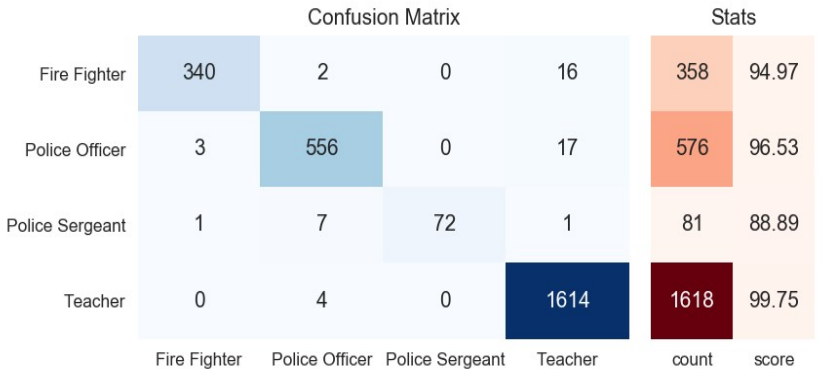


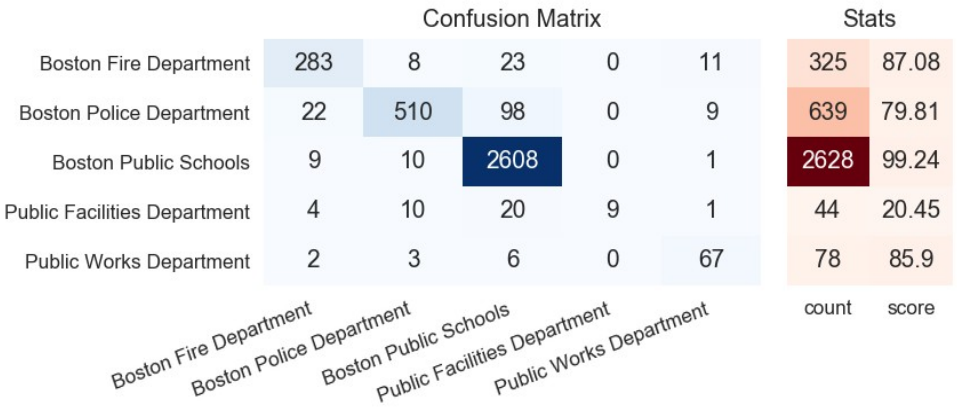
# Pay Discrepancy?

- Supervised machine learning becomes a challenging multi-class classification problem.
- Random Forrest and Support Vector Classifiers work reasonably well if only the most frequent titles or departments are considered.
- Insufficient features (earnings categories) for general classification (all titles/departments)
- “Police Sergeant” is the most misclassified title due to similarity to “Police Officer” and low observation count.
- “Public Facilities Department” is the most misclassified department due to low count in test set and part-time workers.

## Classification by Job Title

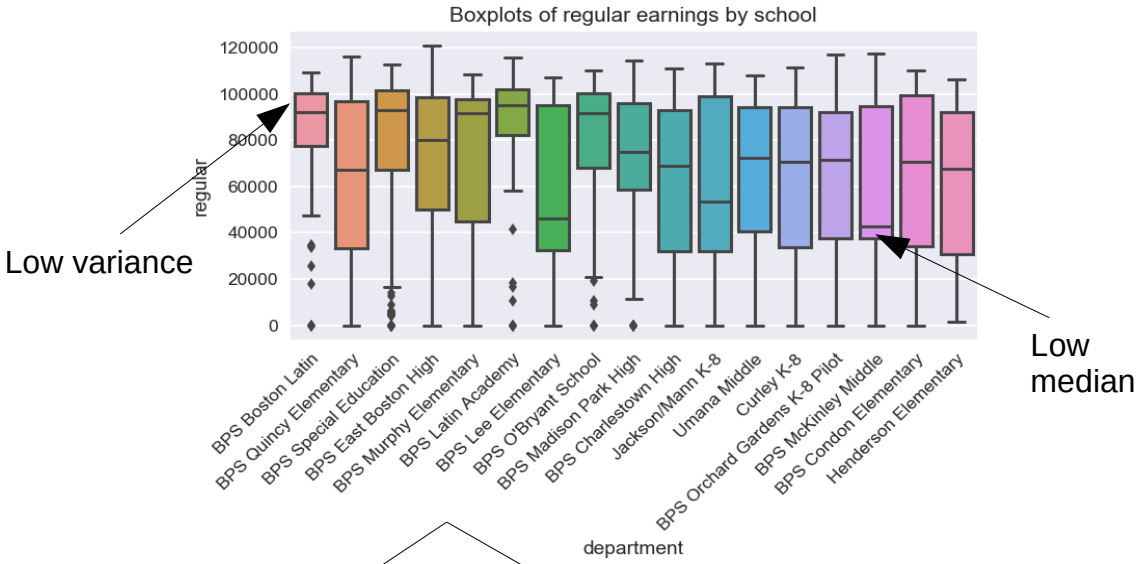



## Classification by Department

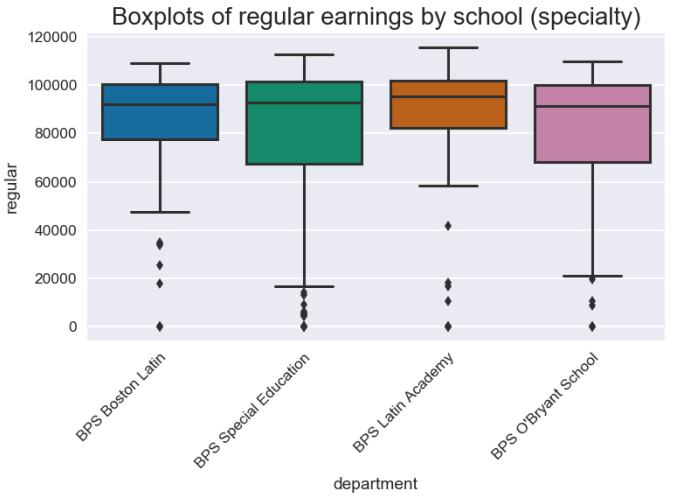


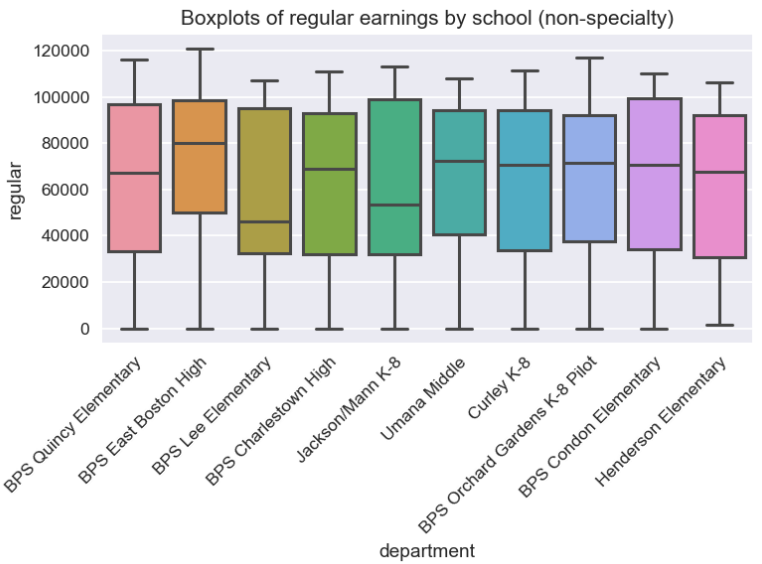
# Are Teachers Paid Equally?

- KNN classification of teacher regular earnings returns an average F1 score of only 14%
  - Poor classification results imply no difference in earnings
  - Multi-class classification perhaps not the best tool for the job




- Splitting schools into specialty and non-specialty categories returns very similar distributions within each group



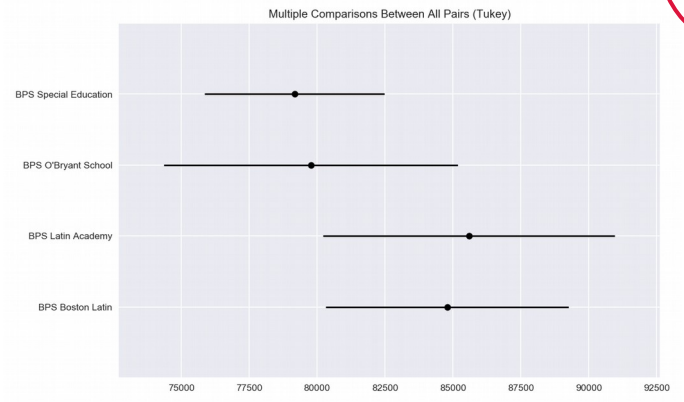



# Are Teachers Paid Equally?

- ANOVA is a useful tool for comparison of means
- Null hypothesis (equal means) is not rejected (reject = False)

Multiple Comparison of Means - Tukey HSD,FWER=0.05

| group1 | group2 | meandiff | lower | upper | reject |
|---|---|---|---|---|---|
| BPS Boston Latin | BPS Latin Academy | 799.5256 | -9073.7494 | 10672.8005 | False |
| BPS Boston Latin | BPS O'Bryant School | -5020.1532 | -14924.7595 | 4884.453 | False |
| BPS Boston Latin | BPS Special Education | -5618.4619 | -13321.7146 | 2084.7908 | False |
| BPS Latin Academy | BPS O'Bryant School | -5819.6788 | -16526.6053 | 4887.2477 | False |
| BPS Latin Academy | BPS Special Education | -6417.9875 | -15128.7367 | 2292.7617 | False |
| BPS O'Bryant School | BPS Special Education | -598.3087 | -9344.5546 | 8147.9373 | False |

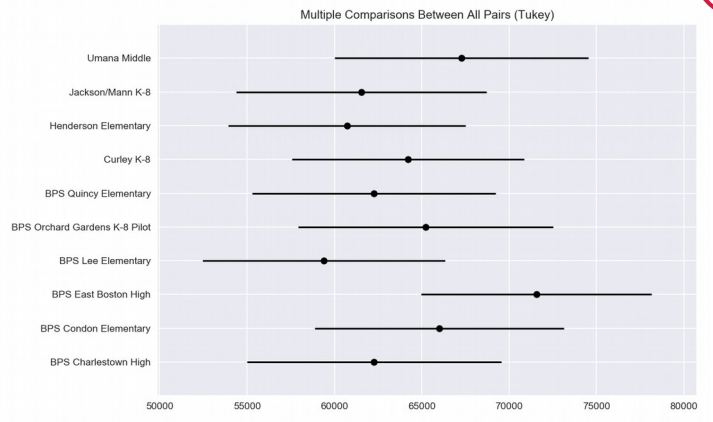



Specialty

Non-specialty

Multiple Comparison of Means - Tukey HSD,FWER=0.05

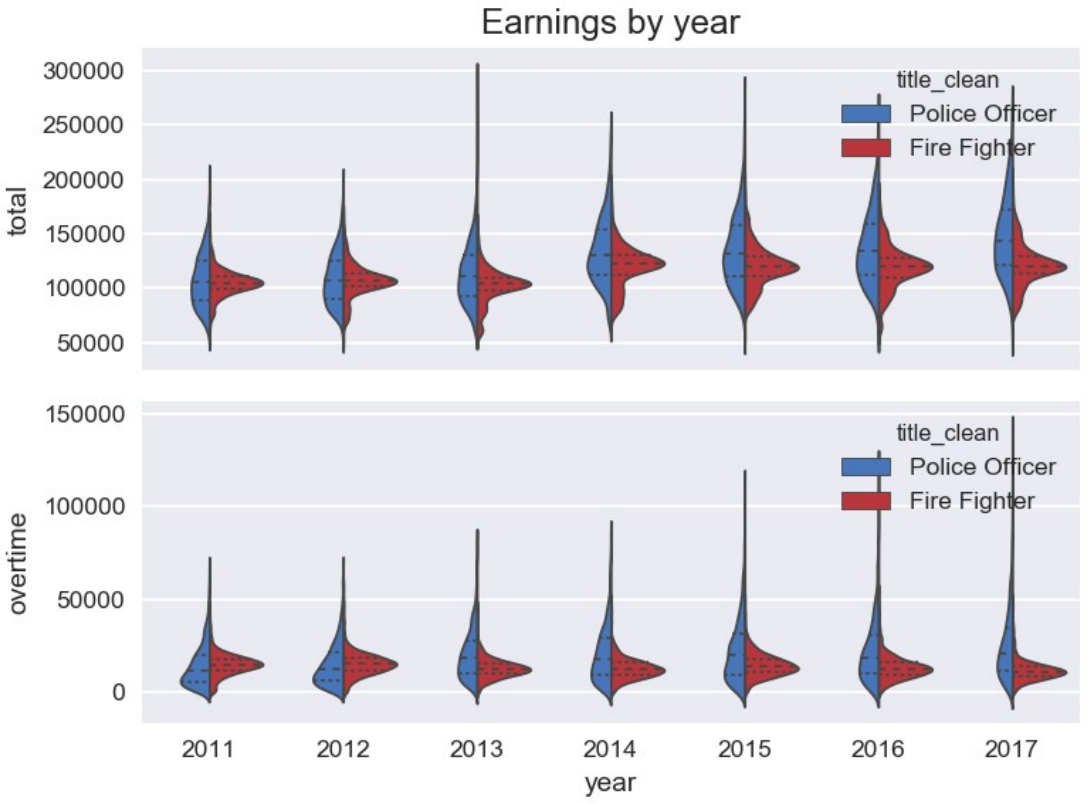
| group1 | group2 | meandiff | lower | upper | reject |
|---|---|---|---|---|---|
| BPS Charlestown High | BPS Condon Elementary | 3747.849 | -10647.9868 | 18143.6849 | False |
| BPS Charlestown High | BPS East Boston High | 9295.4976 | -4578.4972 | 23169.4924 | False |
| BPS Charlestown High | BPS Lee Elementary | -2879.9703 | -17085.454 | 11325.5134 | False |
| BPS Charlestown High | BPS Orchard Gardens K-8 Pilot | 2953.1201 | -11616.408 | 17522.6481 | False |
| BPS Charlestown High | BPS Quincy Elementary | -19.7135 | -14255.6638 | 14216.2368 | False |
| BPS Charlestown High | Curley K-8 | 1951.0158 | -11974.2099 | 15876.2416 | False |
| BPS Charlestown High | Henderson Elementary | -1542.2513 | -15602.3146 | 12517.812 | False |
| BPS Charlestown High | Jackson/Mann K-8 | -710.4463 | -15139.8597 | 13718.967 | False |
| BPS Charlestown High | Umana Middle | 5001.2926 | -9532.3055 | 19534.8908 | False |




- Magnet schools and other specialty schools have lower variance
- Low variance could be result of lower turnover
  - More desirable workplace
  - Specialized education or job description
  - Higher pay, but not necessarily
- Key information to measure turnover is missing from the dataset

# Police Officers and Firefighters

- In 2011, firefighters have slightly higher median total earnings
- By 2017 police officers earn more
- Biggest change is overtime pay

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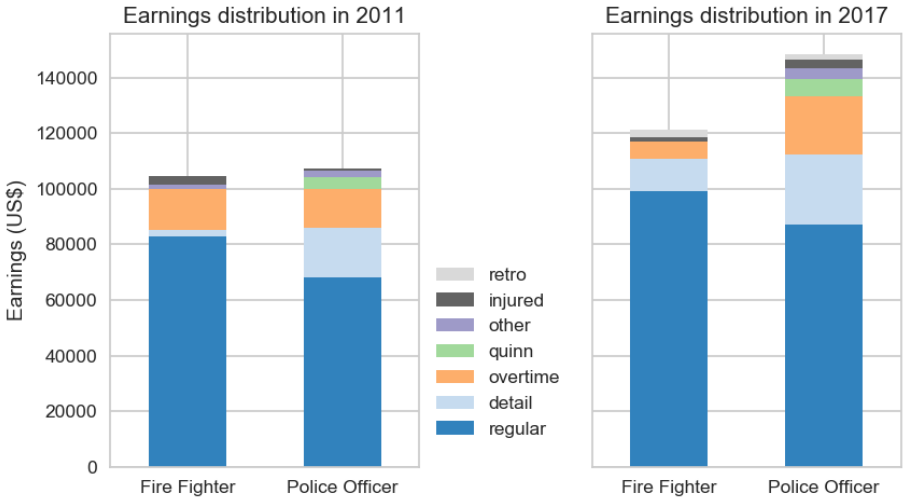
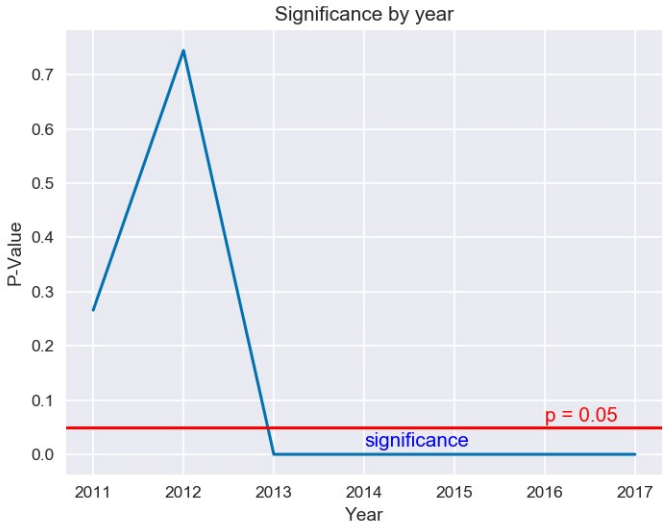
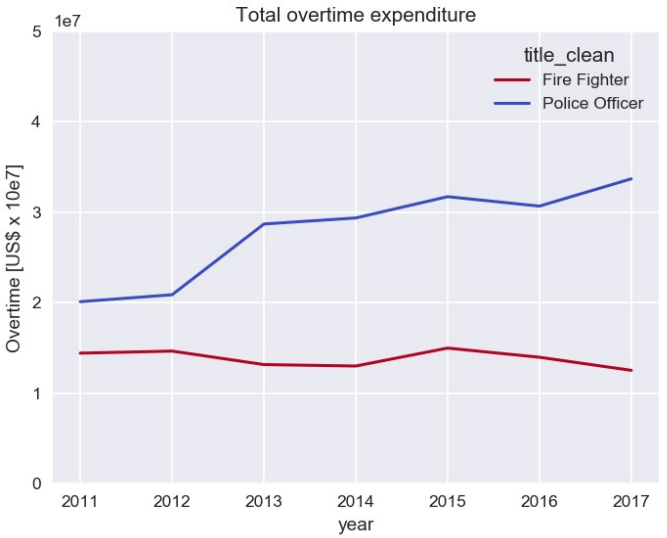



- In 2011 and 2012, there was no measurable difference in mean overtime pay between firefighters and police officers
- Total overtime pay for police officers is $13 million above 2011 level
- Slight decrease in overtime for firefighters



# Conclusions

- No convincing evidence of pay inequality for same or similar titles
- Total payroll increase is driven by increased overtime, in particular from police department
- Wealth segregation is evident, but mitigated by a variety of factors beyond the reach of the earnings database.
- Better conclusions could be drawn if additional information were available:
  - Employment start date
  - End date
  - Promotion date
  - Annual salary or expected earnings

# References


- Main dataset:
  - https://data.boston.gov/dataset/employee-earnings-report
- Boston public schools department
  - https://www.bostonpublicschools.org/
- Zillow Home Value Index:
  - https://www.zillow.com/research/data/
- Social Security Average Wage Index:
  - https://www.ssa.gov/oact/cola/awidevelop.html
- Population Census:
  - https://www.census.gov/quickfacts/fact/table/bostoncitymassachusetts/PST045216
  - 2017 data is extrapolated from 2011-2016 data
- Commentary on police department overtime hours:
  - https://www.bostonglobe.com/metro/2018/02/16/bpd-captain-was-city-top-earner