# Demographic Time-Bombs

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# What is a Demographic Time-Bomb?

When the ageing population of a country is exacerbated by declining birth rates, which reduces the number of working age adults.

Demographic Time-Bombs form over years, sometimes decades and are worsened by the increase in life expectancy.

# Why should we care about them?

- Economic contraction
- Country debt
- Higher tax rates
- Shortage of pension/social security-type funds
- Increase in retirement age

# Demographic Time Bomb Risk Model

**Data Sources:**

- World Bank
- Gapminder

**Breakdown:**

- 2000 - 2015
- 163 countries

**Target:**

- Potential Support Ratio (PSR)
- PSR (log) *

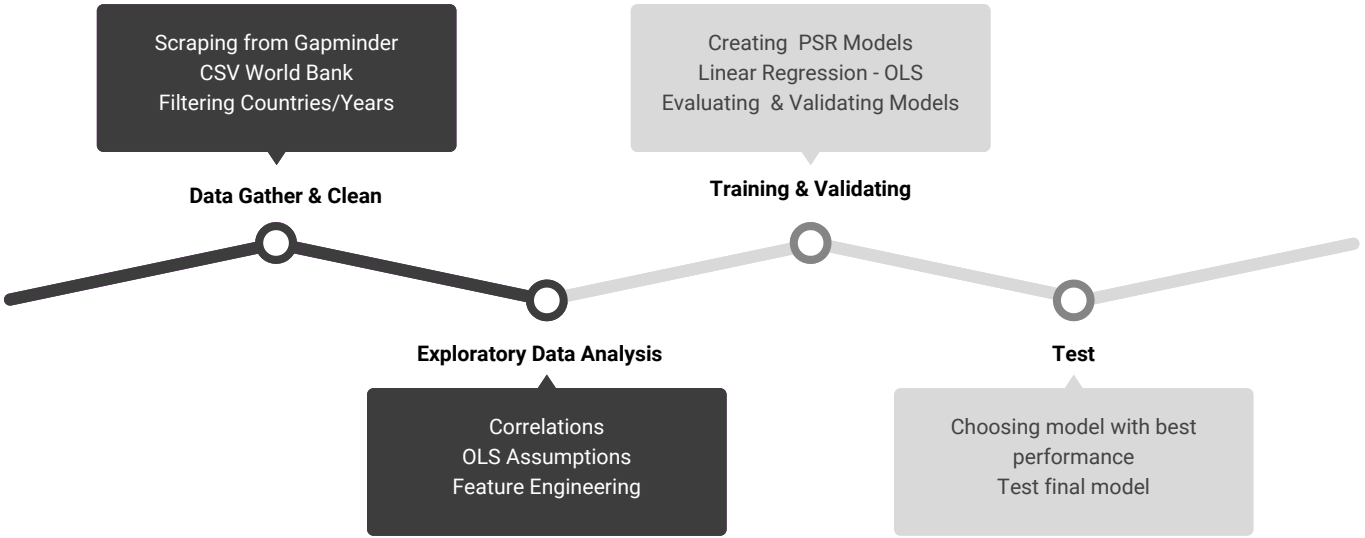
$$\frac{\text{Working-age population}}{\text{Population over 60}}$$

**Features:**

- Fertility
- Birth Rate
- Death Rate
- Life Expectancy
- GDP
- Fertility (log) *
- Death/Birth Rate *
- Death Rate (2) *

* Feature Engineered

# Methodology

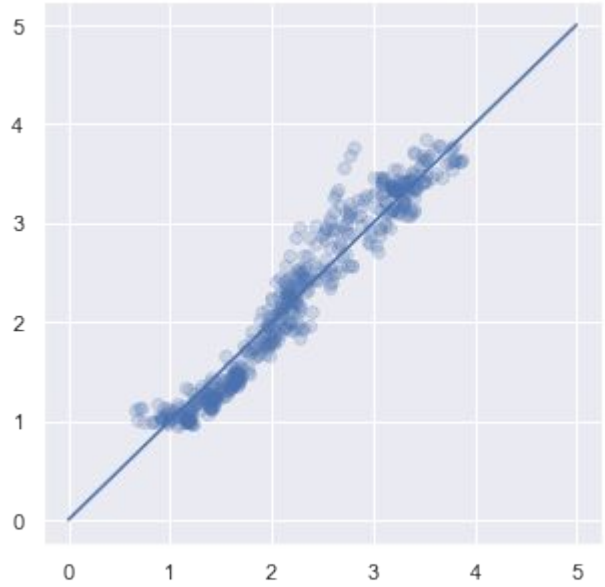


# Model Performance

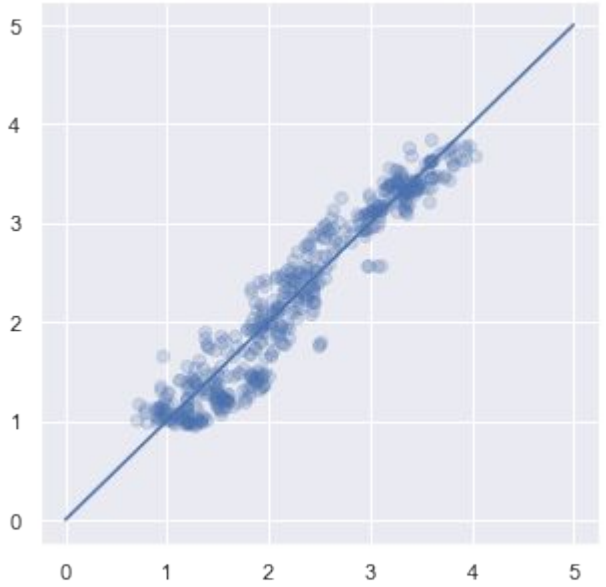
| Model | Root Mean Squared Error (RMSE) | $R^2$ (Validation) |
|---|---|---|
| Model 1 | 2.819 | 0.936 |
| Model 2 | 0.278 | 0.900 |
| Model 3 | 2.766 | 0.938 |
| Model 4 | 0.247 | 0.920 |
| Model 5 (LASSO) | 2.398 | 0.954 |
| Model 6 (LASSO)* | 0.216 | 0.939 |
| Model 7 (Ridge M2) | 0.278 | 0.900 |
| Model 8 (Ridge M4)* | 0.216 | 0.920 |
| Model 9 (Random Forest) | 0.245 | 0.922 |

# Comparing Predictions

Model 6 (LASSO y_log)




Model 8 (Ridge on Model 4)



# Conclusion - Testing Final Model

**Applied Model on Test**

- Select countries representing low, medium, high PSR values
- R2 = 0.937
- RMSE = 0.239

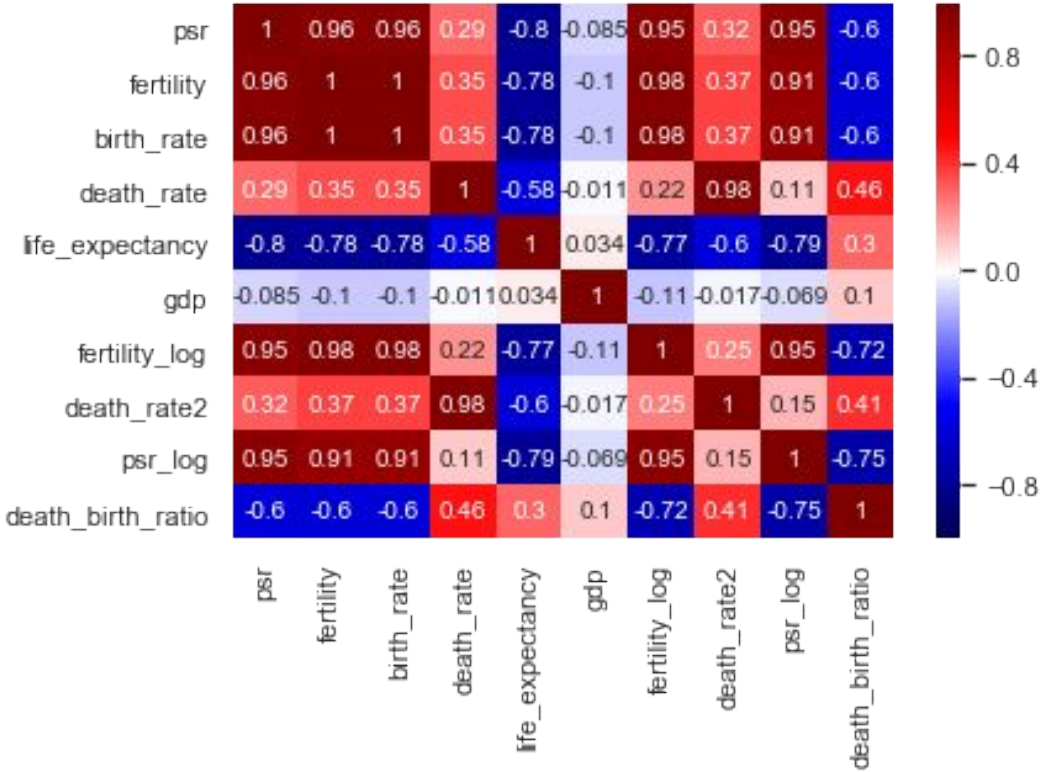
**Features**

- Fertility
- Life Expectancy
- Death Rate (Squared)
- Death/Birth Ratio

# Future Work

- Try model with additional features such as:
  - Men/Women Ratio
  - Unemployment
  - Women Education
  - Immigration

# Appendix


psr 1 0.96 0.96 0.29 -0.8 -0.085 0.95 0.32 0.95 -0.6
fertility 0.96 1 1 0.35 -0.78 -0.1 0.98 0.37 0.91 -0.6
birth_rate 0.96 1 1 0.35 -0.78 -0.1 0.98 0.37 0.91 -0.6
death_rate 0.29 0.35 0.35 1 -0.58 -0.011 0.22 0.98 0.11 0.46
life_expectancy -0.8 -0.78 -0.78 -0.58 1 0.034 -0.77 -0.6 -0.79 0.3
gdp -0.085 -0.1 -0.1 -0.011 0.034 1 -0.11 -0.017 -0.069 0.1
fertility_log 0.95 0.98 0.98 0.22 -0.77 -0.11 1 0.25 0.95 -0.72
death_rate2 0.32 0.37 0.37 0.98 -0.6 -0.017 0.25 1 0.15 0.41
psr_log 0.95 0.91 0.91 0.11 -0.79 -0.069 0.95 0.15 1 -0.75
death_birth_ratio -0.6 -0.6 -0.6 0.46 0.3 0.1 -0.72 0.41 -0.75 1
psr
fertility
birth_rate
death_rate
life_expectancy
gdp
fertility_log
death_rate2
psr_log
death_birth_ratio
0.8
0.4
0.0
−0.4
−0.8

## Model 1

| | | | |
|---|---|---|---|
| **Dep. Variable:** | psr | **R-squared:** | 0.929 |
| **Model:** | OLS | **Adj. R-squared:** | 0.929 |
| **Method:** | Least Squares | **F-statistic:** | 6771. |
| **Date:** | Thu, 24 Jan 2019 | **Prob (F-statistic):** | 0.00 |
| **Time:** | 19:38:44 | **Log-Likelihood:** | -3888.1 |
| **No. Observations:** | 1560 | **AIC:** | 7784. |
| **Df Residuals:** | 1556 | **BIC:** | 7806. |
| **Df Model:** | 3 | | |
| **Covariance Type:** | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | -5.7877 | 0.230 | -25.132 | 0.000 | -6.239 | -5.336 |
| **fertility** | 6.9858 | 0.052 | 134.445 | 0.000 | 6.884 | 7.088 |
| **death_rate** | -0.1508 | 0.025 | -6.108 | 0.000 | -0.199 | -0.102 |
| **gdp** | 0.0361 | 0.013 | 2.680 | 0.007 | 0.010 | 0.063 |

| | | | |
|---|---|---|---|
| **Omnibus:** | 185.843 | **Durbin-Watson:** | 2.082 |
| **Prob(Omnibus):** | 0.000 | **Jarque-Bera (JB):** | 641.375 |
| **Skew:** | 0.566 | **Prob(JB):** | 5.34e-140 |
| **Kurtosis:** | 5.930 | **Cond. No.** | 31.8 |

## Model 2

| | | | |
|---|---|---|---|
| **Dep. Variable:** | psr_log | **R-squared:** | 0.871 |
| **Model:** | OLS | **Adj. R-squared:** | 0.871 |
| **Method:** | Least Squares | **F-statistic:** | 3502. |
| **Date:** | Thu, 24 Jan 2019 | **Prob (F-statistic):** | 0.00 |
| **Time:** | 19:38:45 | **Log-Likelihood:** | -382.34 |
| **No. Observations:** | 1560 | **AIC:** | 772.7 |
| **Df Residuals:** | 1556 | **BIC:** | 794.1 |
| **Df Model:** | 3 | | |
| **Covariance Type:** | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | 1.1375 | 0.024 | 46.735 | 0.000 | 1.090 | 1.185 |
| **fertility** | 0.5560 | 0.005 | 101.252 | 0.000 | 0.545 | 0.567 |
| **death_rate** | -0.0614 | 0.003 | -23.537 | 0.000 | -0.067 | -0.056 |
| **gdp** | 0.0050 | 0.001 | 3.510 | 0.000 | 0.002 | 0.008 |

| | | | |
|---|---|---|---|
| **Omnibus:** | 40.533 | **Durbin-Watson:** | 2.017 |
| **Prob(Omnibus):** | 0.000 | **Jarque-Bera (JB):** | 48.042 |
| **Skew:** | 0.332 | **Prob(JB):** | 3.70e-11 |
| **Kurtosis:** | 3.546 | **Cond. No.** | 31.8 |

## Model 3

| | | | |
|---|---|---|---|
| **Dep. Variable:** | psr | **R-squared:** | 0.930 |
| **Model:** | OLS | **Adj. R-squared:** | 0.930 |
| **Method:** | Least Squares | **F-statistic:** | 5159. |
| **Date:** | Thu, 24 Jan 2019 | **Prob (F-statistic):** | 0.00 |
| **Time:** | 19:38:45 | **Log-Likelihood:** | -3876.2 |
| **No. Observations:** | 1560 | **AIC:** | 7762. |
| **Df Residuals:** | 1555 | **BIC:** | 7789. |
| **Df Model:** | 4 | | |
| **Covariance Type:** | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | -8.4058 | 0.446 | -18.834 | 0.000 | -9.281 | -7.530 |
| **fertility** | 7.4748 | 0.114 | 65.485 | 0.000 | 7.251 | 7.699 |
| **gdp** | 0.0313 | 0.013 | 2.329 | 0.020 | 0.005 | 0.058 |
| **death_birth_ratio** | 0.3680 | 0.078 | 4.702 | 0.000 | 0.214 | 0.521 |
| **death_rate2** | -0.0171 | 0.002 | -7.288 | 0.000 | -0.022 | -0.012 |

| | | | |
|---|---|---|---|
| **Omnibus:** | 188.823 | **Durbin-Watson:** | 2.063 |
| **Prob(Omnibus):** | 0.000 | **Jarque-Bera (JB):** | 583.764 |
| **Skew:** | 0.610 | **Prob(JB):** | 1.73e-127 |
| **Kurtosis:** | 5.737 | **Cond. No.** | 677. |

## Model 4

| | | | |
|---|---|---|---|
| **Dep. Variable:** | psr_log | **R-squared:** | 0.915 |
| **Model:** | OLS | **Adj. R-squared:** | 0.915 |
| **Method:** | Least Squares | **F-statistic:** | 5575. |
| **Date:** | Thu, 24 Jan 2019 | **Prob (F-statistic):** | 0.00 |
| **Time:** | 19:38:46 | **Log-Likelihood:** | -58.003 |
| **No. Observations:** | 1560 | **AIC:** | 124.0 |
| **Df Residuals:** | 1556 | **BIC:** | 145.4 |
| **Df Model:** | 3 | | |
| **Covariance Type:** | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | 0.9627 | 0.031 | 31.111 | 0.000 | 0.902 | 1.023 |
| **fertility_log** | 1.5230 | 0.019 | 81.624 | 0.000 | 1.486 | 1.560 |
| **gdp** | 0.0068 | 0.001 | 5.878 | 0.000 | 0.005 | 0.009 |
| **death_birth_ratio** | -0.0491 | 0.004 | -12.242 | 0.000 | -0.057 | -0.041 |

| | | | |
|---|---|---|---|
| **Omnibus:** | 12.609 | **Durbin-Watson:** | 2.059 |
| **Prob(Omnibus):** | 0.002 | **Jarque-Bera (JB):** | 12.791 |
| **Skew:** | -0.201 | **Prob(JB):** | 0.00167 |
| **Kurtosis:** | 3.188 | **Cond. No.** | 37.1 |

# For more information visit:

https://github.com/bmirandab/Demographic_TimeBomb