Proceedings of ICFTBA 2025 Symposium: Financial Framework's Role in Economics and Management of Human-Centered Development
DOI: 10.54254/2754-1169/2025.GL28672

Study on the Fertility Rate of Estonian Women

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Abstract. To address Estonia's rapidly declining population, the government introduced the "mother's salaries" policy in 2004, offering generous financial compensation to new mothers. This study investigates the policy's association with fertility rates among Estonian women aged 20–24 and 30–34 using time series analysis, including AutoRegressive Integrated Moving Average (ARIMA) modeling and Interrupted Time Series (ITS) regression. The results indicate that fertility rates among women aged 30–34 rose significantly after 2004, as evidenced by a notable trend reversal and positive level change ($p < 0.001$). However, for women aged 20–24, the decline in fertility continued, and no statistically significant change was observed. These findings highlight that while the "mother's salaries" policy coincided with increased fertility among older women, the relationship is correlational. Broader economic and cultural changes may also explain the age-specific divergence. Forecasting suggests continued decline among younger women, underscoring the need for structural policies that support early family formation without compromising education and careers.

Keywords: Total Fertility Rate (TFR), Estonia, Fertility Trends, Public Health Demography

1. Introduction

Declining fertility rates have become a pressing demographic concern across Europe, particularly in post-Soviet states such as Estonia. Since independence in 1991, Estonia has experienced persistent sub-replacement fertility, shaped by delayed marriage, economic restructuring, rising education, and shifting cultural norms. Policymakers feared shrinking population, labor shortages, and intergenerational imbalances. In 2004, Estonia introduced the "mother's salaries" policy, a generous parental benefit scheme providing income-based payments for up to 14 months following childbirth. The intention was to reduce the financial burden of parenthood and encourage childbirth. Prior research on pronatalist policies across Europe has produced mixed findings, often noting that financial incentives alone may not overcome deeper structural barriers [1, 2]. Few studies, however, have investigated whether such policies affect age cohorts differently amid shifting childbearing timelines.

This study focuses on two key age groups—women aged 20–24 and 30–34—whose fertility trajectories diverged markedly in the early 21st century. The primary research question is whether the 2004 "mother's salaries" policy influenced fertility rates differently across these cohorts. Specifically, I investigate: (1) whether the policy produced significant changes in fertility trends and

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levels, and (2) whether these changes persisted over time. To address these questions, I apply Interrupted Time Series (ITS) regression to detect level and slope changes after the policy's introduction, and AutoRegressive Integrated Moving Average (ARIMA) models to forecast future fertility trends. By providing age-specific policy impact analysis, this study offers insights for designing more targeted demographic interventions and contributes to the broader discourse on fertility policy effectiveness in post-transition societies.

2. Methodology

This study uses annual age-specific fertility rate data, measured as the number of live births per 1,000 women, for two cohorts: women aged 20–24 and 30–34 in Estonia. Data covering the period from 1970 to 2024 were obtained from the Global Health Data Exchange (IHME, 2024) and cross-verified with official statistics from Statistics Estonia. The dataset provides a continuous, nationally representative time series, allowing for long-term trend analysis. Before analysis, the data were reviewed for missing values and inconsistencies; no imputation was necessary. To ensure comparability across years, the data were used in their standardized form, and where necessary, differencing was applied to achieve stationarity for time series modeling.

The analytical framework combines Interrupted Time Series (ITS) regression and AutoRegressive Integrated Moving Average (ARIMA) modeling. ITS was selected because it is a well-established quasi-experimental method for evaluating the impact of policy interventions over time, allowing for the estimation of both immediate (level) and gradual (trend) changes. ARIMA modeling was employed for its suitability in capturing temporal dependencies and forecasting univariate time series data. Model selection for ARIMA was guided by the Akaike Information Criterion (AIC), residual diagnostics, and autocorrelation function (ACF/PACF) analysis. While ARIMA models were fitted to the 20–24 age group due to strong autocorrelation patterns in residuals from linear trend models, the 30–34 group's ITS results were sufficiently robust to capture policy impact, and ARIMA forecasting was not prioritized for that cohort.

The analysis proceeded in three stages. First, descriptive statistics and visual trend plots were generated to identify long-term patterns and potential inflection points in fertility rates. Second, ITS regression was applied to detect statistically significant changes in levels and slopes following the 2004 "mother's salaries" policy. Third, ARIMA models were constructed for the 20–24 age group to forecast post-2024 fertility trajectories and evaluate predictive performance. All analyses were conducted in R (version 4.3.1), with results validated through residual diagnostics and model fit statistics to ensure robustness.

3. Results

Long-term fertility trends for Estonian women in the 20–24 and 30–34 age groups from 1970 to 2024 reveal distinct patterns (Figure 1). Women aged 20–24 experienced a steady decline in fertility rates from the 1970s onward, reflecting broader European trends of delayed motherhood. In contrast, fertility among women aged 30–34 began to rise in the early 2000s, with the two age group trajectories intersecting around 2008. From that point onward, fertility rates for women in their early thirties surpassed those of women in their early twenties, indicating a generational shift in the timing of childbearing.

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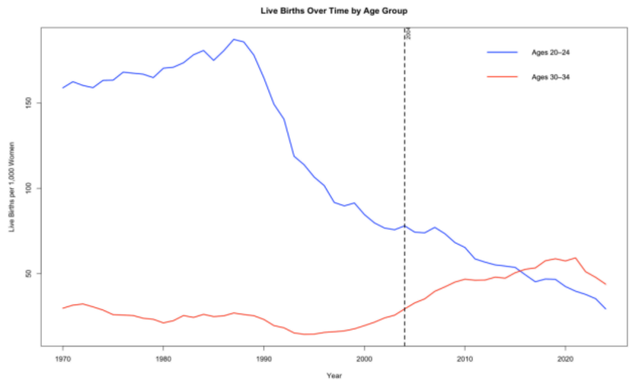

Figure 1. Age-specific fertility rates for Estonian women aged 20–24 (blue) and 30–34 (red), 1970–2024.ing

The ITS analysis confirmed these visual observations. For women aged 20–24, the pre-policy slope was significantly negative ($\beta = -2.93$, $p < 0.001$), and neither the level change ($p = 0.184$) nor the slope change ($p = 0.451$) after the 2004 policy was statistically significant (Figure 2). This indicates that the “mother’s salaries” policy did not reverse the declining fertility trend among younger women. In contrast, women aged 30–34 experienced a significant positive level change ($\beta = 20.12$, $p < 0.001$) and a significant upward slope change ($\beta = 1.38$, $p < 0.001$) after the policy (Figure 3). These results suggest that the policy successfully stimulated fertility growth in this older cohort.

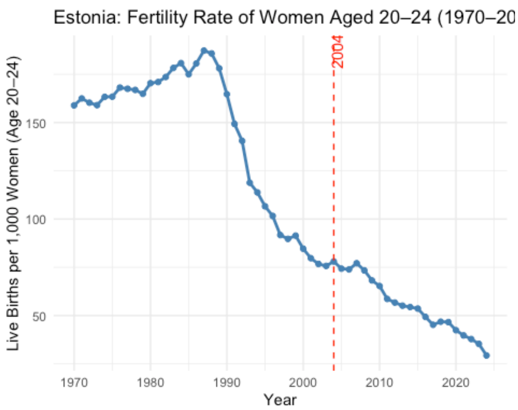

Figure 2. ITS regression results for women aged 20–24, before and after the 2004 policy

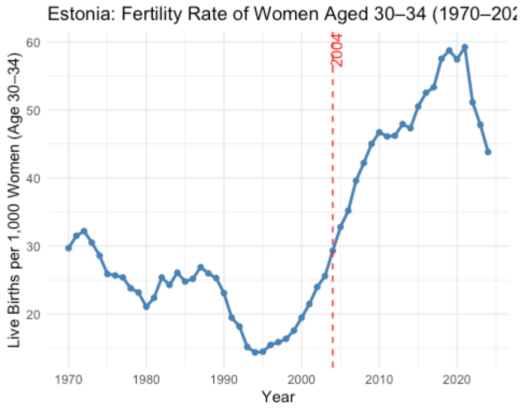

Figure 3. ITS regression results for women aged 30–34, before and after the 2004 policy

For the 20–24 cohort, a simple linear trend model confirmed the strong downward trajectory ($p < 0.001$) but failed to fully capture the time series structure, as residual autocorrelation remained high. The ACF showed a slow decay, indicating non-stationarity, while the PACF displayed a strong spike at lag 1, consistent with AR(1)-type processes. This justified the use of ARIMA modeling for more accurate forecasting.

```
##
## Call:
## lm(formula = live_birth ~ time + post_policy + time_since_policy,
## data = data)
##
## Residuals:
## Min 1Q Median 3Q Max
## -33.603 -13.530 -1.219 4.659 46.065
##
## Coefficients:
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 5967.6277 658.3237 9.065 3.28e-12 ***
## time -2.9315 0.3314 -8.846 7.10e-12 ***
## post_policy -13.9980 10.3919 -1.347 0.184
## time_since_policy 0.5769 0.7593 0.760 0.451
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 18.96 on 51 degrees of freedom
## Multiple R-squared: 0.8804, Adjusted R-squared: 0.8733
## F-statistic: 125.1 on 3 and 51 DF, p-value: < 2.2e-16
```

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For women aged 30–34: The ITS analysis revealed a significant positive level change ($p < 0.001$) and trend reversal ($p < 0.001$) after 2004. This indicates that the “mother’s salaries” policy was effective for older generations.

```
##
## Call:
## lm(formula = live_birth ~ time + post_policy + time_since_policy,
## data = data2)
##
## Residuals:
## Min 1Q Median 3Q Max
## -13.531 -2.615 1.054 3.021 8.403
##
## Coefficients:
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 732.00325 149.92512 4.882 1.07e-05 ***
## time -0.35687 0.07547 -4.729 1.82e-05 ***
## post_policy 20.12440 2.36663 8.503 2.39e-11 ***
## time_since_policy 1.37518 0.17293 7.952 1.72e-10 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.317 on 51 degrees of freedom
## Multiple R-squared: 0.9018, Adjusted R-squared: 0.896
## F-statistic: 156.1 on 3 and 51 DF, p-value: < 2.2e-16
```

Linear trend models is fitted to the fertility data for Estonian women aged 20-24 years old. The negative trends is highly statistically significant with relatively high R squared.

```
##
## Call:
## lm(formula = live_birth ~ time, data = data)
##
## Residuals:
## Min 1Q Median 3Q Max
## -35.318 -11.369 -2.914 5.683 47.588
##
## Coefficients:
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 6323.7896 321.3141 19.68 <2e-16 ***
## time -3.1115 0.1609 -19.34 <2e-16 ***
```

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```
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 18.94 on 53 degrees of freedom
## Multiple R-squared: 0.8759, Adjusted R-squared: 0.8735
## F-statistic: 374 on 1 and 53 DF, p-value: < 2.2e-16
```

I checked whether the errors from your linear trend models (for both age groups) still contain time dependence. Because residuals are autocorrelated, it means the regression model is not fully adequate for time series data, and you may need ARIMA/ITS modeling process.

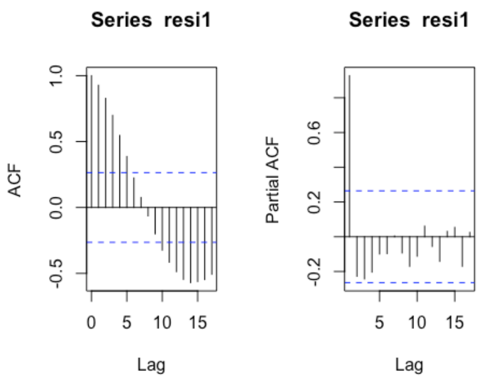

Figure 4. ACF and PACF of fertility rates of women aged 20-24

I differenced both fertility time series to stabilize the mean (remove trends). Then I checked ACF and PACF of the differenced data to see if the resulting series looks stationary and ready for ARIMA modeling.

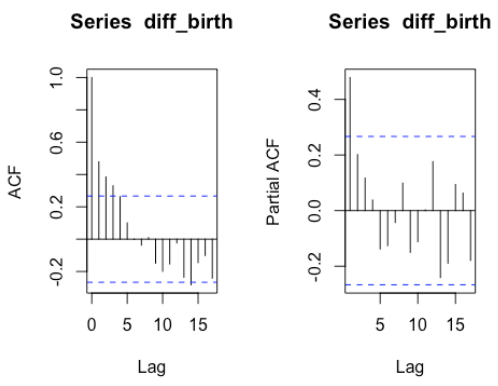

Figure 5. ACF and PACF of differenced fertility rates of women aged 20-24

After consideration, ARIMA(1,1,0) is built for women aged 20-24. In ARIMA(1,1,0) model, the AR(1) term is significant, showing some short-term autocorrelation. Residuals show no strong autocorrelation (ACF1 ≈ 0), indicating good model fit. There is moderate error metrics; MASE < 1 means it's better than a naive forecast.

In ARIMA(2,1,0), AR(1) and AR(2) terms are both significant, suggesting a more complex autocorrelation structure. It has very low residual variance, indicating good model accuracy.

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Residuals are nearly uncorrelated,which means it is a well-specified model. MASE < 1 again shows predictive performance above the baseline.

```
Call:
arima(x = data$live_birth, order = c(1, 1, 0))

Coefficients:
         ar1
      0.5743
s.e.  0.1106

sigma^2 estimated as 22.15:  log likelihood = -160.47,  aic = 324.94

Training set error measures:
                    ME     RMSE      MAE       MPE     MAPE      MASE
Training set -1.074815 4.663844 3.486395 -1.492765 3.646373 0.8221194
                    ACF1
Training set -0.1910517
```

Figure 6. ARIMA(1,1,0) forecast of fertility rates for women aged 20–24, 2025–2029

Forecast() is used to predict the future pattern of fertility rate of women in 20-24 years old. Autoplot is used to visualize the pattern.

Table 1. Prediction intervals (80% and 95%) for fertility rates of women aged 20–24, 2025–2029

Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
25.85441	19.822428	31.88639	16.629289	35.07953
23.87573	12.625942	35.12551	6.670666	41.08079
22.73944	6.662538	38.81634	-1.848059	47.32694
22.08691	1.643796	42.53002	-9.178134	53.35195
21.71218	-2.667580	46.09194	-15.573446	58.99781

Overall, these results demonstrate that the 2004 “mother’s salaries” policy significantly benefited women in their early thirties but had no measurable effect on those in their early twenties, reinforcing the need for age-specific approaches to fertility policy.

4. Discussion

The results reveal age-specific associations between fertility and the “mother’s salaries” policy. Fertility among women aged 30–34 rose significantly after 2004, while women aged 20–24 continued declining. These findings suggest that financial incentives may align more effectively with the life circumstances of older women, who are more economically stable and positioned to respond to benefits. The income-based design may have further advantaged older women with higher pre-birth earnings.

By contrast, younger women face structural barriers—economic precarity, prolonged education, housing challenges, and career concerns—that likely outweigh short-term financial incentives [3-5]. These results align with European studies showing that cash benefits alone rarely reverse fertility declines among the youngest cohorts [6, 7].

However, the relationship observed here is correlational. Other contemporaneous factors—such as broader economic recovery, cultural shifts toward delayed parenthood, or parallel policy reforms—could also explain the fertility reversal among women aged 30–34 [8]. Caution is warranted in attributing observed changes solely to the 2004 reform.

Policy implications include the need for multidimensional interventions that address the unique constraints of younger cohorts [3, 9]. Measures could include subsidized housing, childcare expansion, flexible education paths, and workplace reforms that support parenting earlier in the life course. Public health campaigns promoting fertility awareness could also help individuals align reproductive intentions with biological timelines [3, 4].

5. Conclusion

This study investigated the impact of Estonia's 2004 "mother's salaries" policy on fertility rates among women aged 20–24 and 30–34 by applying Interrupted Time Series (ITS) regression and ARIMA modeling to annual birth data from 1970 to 2024. The findings demonstrate that the policy was highly correlated with fertility rate of woman aged 30-34, with statistically significant level and slope changes following the policy's introduction. However, no significant effect was observed among women aged 20–24, whose fertility rates continued to decline, suggesting that the policy failed to address the unique challenges faced by younger women. The analysis highlights the importance of age-targeted social policies in influencing reproductive behavior. Younger women may be less responsive to financial incentives due to concerns about economic stability, educational attainment, and career aspirations. These results suggest that broader structural supports—such as affordable housing, childcare services, and career-flexible parenting—are necessary to promote early family formation. Limitations of this study include the exclusion of other age groups and contextual policy changes that may have influenced fertility independently of the 2004 intervention. Future research should expand the analysis to additional cohorts and comparative case studies with other post-socialist countries to assess the replicability of Estonia's experience and inform long-term demographic policy strategies across Europe.

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