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Demographic Challenges in Poland: Understanding Low Fertility

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Abstract

Research background: The phenomenon of low fertility in Poland is a vital subject of demographic analysis. In recent years, not only have there been changes in procreative and family models, but also in the age structure of society. This is particularly significant in the context of population ageing, which is becoming increasingly evident and brings numerous challenges such as increased burden on healthcare systems, a decrease in the active workforce, and the need to secure adequate retirement funds. Despite the desire to have children, many individuals refrain from making such a decision, and the reasons for this choice are diverse. Therefore, it was essential to conduct an analysis of the factors determining fertility in Poland, considering both the economic and social aspects. Understanding how the economic situation, labour market conditions, and changes in social structure impact on the decision-making process regarding childbearing is essential.

Purpose of the paper: The objective of this article was to analyse fertility rates in Poland for the period 2004-2020. The conducted research identified the factors influencing the observed state of low generational replacement and determining their intensity.

Methodology/Methods/Data sources: The data used in this article were sourced from the Central Statistical Office and covered the years 2004-2020. The study was based on literature concerning

demography and econometrics. Three statistical methods were applied in the analysis of fertility in Poland: the Classical Method of Least Squares (CMLS) model, the Fixed Effects (FE) estimator, and the Random Effects (RE) estimator. Fertility analysis was conducted at regional level by dividing Poland into 16 administrative units (voivodeships). A panel model was employed for the analysis, and the results were subjected to Wald, Breusch-Pagan, and Hausman tests to compare the outcomes obtained from different models.

Findings: The results of the analysis indicate that the economic situation and the labour market significantly influence the decision to have children in Poland. The trend of low fertility, although showing some increase, is still characteristic of the country compared to other EU nations. The analysis of the factors determining fertility is vital for understanding the decisions of young generations of Poles regarding parenthood.

Keywords: ertility, population ageing, demographic analysis, total fertility rate (TFR)

1. Introduction

The phenomenon of low fertility in Poland is an essential subject of demographic analysis (Mishtal, 2009). In recent years, not only have there been changes in procreative and family patterns, but also in the age structure of society. Several modern trends have been highlighted as affecting the population's reproductive habits. These include a trend for later marriages (Billari and Kohler, 2004) and a decreasing focus on marriage itself, as well as a noticeable movement between cohabitation and non-cohabitational partnerships (Duncan and Phillips, 2012; Jansen et al., 2009). Furthermore, there has been an increase in the rates of separation and divorce (Flowerdew and Al-Hammad, 2004), as well as an increase in the number of children born outside of marriage. Moreover, there has been a shift in traditional family and household structures (Bengtson, 2001), a decrease in the number of unplanned births (Macintyre and Cunningham-Burley, 1993; Westoff, 1976), and an increase in the number of people who prefer to be childless (Gillespie, 2000). While previous studies have highlighted the changes in procreative and family patterns, as well as the implications of an aging society (Kotowska et al., 2008; Matysiak, 2009; Walford and Kurek, 2016) there remains a research gap pertaining to the comprehensive analysis of fertility trends during a specific time frame, notably the period 2004-2020. An ageing society presents numerous challenges, such as an increased burden on healthcare systems, a decrease in the active labour force, and the need to secure adequate resources for retirement (Robbins, 2020; Sobczak et al., 2020).

Therefore, it was important to perform a study of the variables influencing fertility in Poland, taking into consideration economic, political, and social issues. Understanding how the economy, labour market conditions, and changes in social structure impact childbearing decisions is critical (Karbownik and Myck, 2016; Kotowska et al., 2008). Identifying the variables that lead to low fertility rates might help guide the creation of tailored policies and initiatives to solve this demographic issue. The purpose of this work was to fill this knowledge gap by examining fertility patterns in Poland between 2004 and 2020. By meeting this aim, the research contributes to the scientific understanding of fertility dynamics in Poland and provides valuable insights for policymakers and researchers in devising effective strategies to address the demographic challenges posed by low fertility rates and population ageing. The research question at the heart of this paper is: "What are the determinants of low fertility levels in Poland during the studied period, and are they changing over time?" The study explores the plethora of factors that may have impacted on the fertility decisions of individuals and couples in Poland during this time period. Understanding these characteristics is critical for understanding wider demographic trends and directing policy measures that might successfully address these concerns.

The papers starts with an overview of the problem of the demographic decline in Poland and a description of the determinants of the fertility rate (Section 2) and a presentation of the research

methodology (Section 3). The empirical approach is presented in Section 4, while Section 5 reports the findings. Finally, Section 6 provides the conclusions drawn from the study.

2. Demographic Decline in Poland

A concerning social issue in Poland and other EU countries is the growing demographic crisis (Szczudlińska-Kanoś, 2020). The total fertility rate is a significant component in population estimates; it is the average number of children a woman would have if she lived to the end of her reproductive age range, experiencing the age-specific fertility rates of that time at each age (Alkema et al., 2011). Low total fertility rates have been noted in Poland since the late 1990s, with a systematic decline in the fertility rate among women of reproductive age (Kotowska et al., 2008). In 2020, the lowest rate in many years was recorded at 1.378. The fertility rate is the measure that describes the frequency of births in the population of women of reproductive age (in Poland, this age range is from 15 to 49 years), expressed as the ratio of the number of live births to the number of women of reproductive age in a given population, multiplied by 1000.

$$fertility\ rate = \frac{births}{no.\ of\ women} \cdot 1000, \tag{1}$$

where: births – the number of live births during a given period (usually a year), no. of women – the number of women of reproductive age (between 15 and 49 years old).

The total fertility rate (TFR), also known as the total fertility coefficient, is the sum of the previously mentioned fertility rate for successive age cohorts of women aged 15 to 49 years. It indicates the average number of children a woman could give birth to during her reproductive period.

$$total\ fertility\ rate = \sum_{x=15}^{49} fertility\ rate(x). \tag{2}$$

It is generally accepted that if the total fertility rate ranges between 2.10 and 2.15, it indicates a phenomenon known as replacement-level fertility. This leads to the optimal future of the population, as each woman, on average, gives birth to more than two children. In Figure 1, it can be observed that in Poland, for many years, this rate did not exceed 1.50. This situation was slightly improved by the introduction of the government benefit programme 'Family 500+' which resulted in a sudden increase in the total fertility rate between 2015 and 2017. A low total fertility rate may lead to a significant population decline in Poland in the future (Cook et al., 2023).

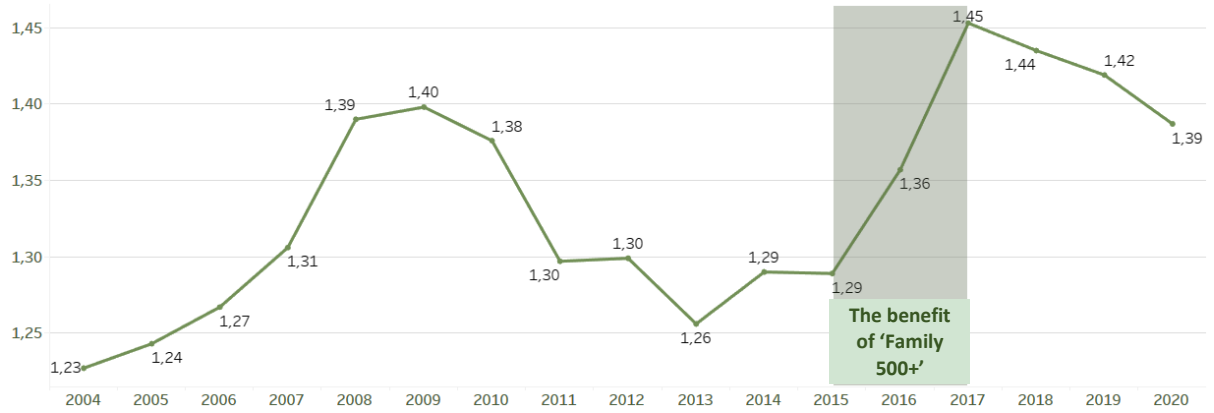

Fig. 1. Total fertility rate in Poland from 2004 to 2020
Source: own work.

The decline in births in Poland began in the mid-1980s. Previously, Poland had a high natural population growth, typically adding around 350,000 persons annually. However, since the 1990s, a systematic decline in fertility has been observed, and in 1999, for the first time since the post-war period, the rate of natural population growth became negative. Over the years, women's attitudes towards motherhood have changed as more and more women are choosing to have children later, often after the age of 35. Delayed family planning also reduces the chances of further procreation. There is a noticeable tendency in Poland toward the preponderance of childless couples or families with two parents and a single child, known as the 2+1 model. This pattern has become more common over the years. Large families made up 16.9% of all households in 2004, but this proportion dropped to 12% by 2011, showing a significant shift in family structure. The reduction in the proportion of families with three or more children is directly related to the country's low overall fertility rate. One of the immediate implications is an increased financial burden on the state as a result of increasing expenditures related with pension payments for retired people. Increased government investment on pension plans is required as the retired population grows. These demographic and economic trends are cause for worry among policymakers and stakeholders, as they need careful study and suitable actions to safeguard the nation's economy and the social systems' long-term development and well--being. Many Poles chose to move to England (Gołata, 2016); statistics show that Polish women residing in the United Kingdom gave birth to an average of 2.13 children there, while in Poland, the average was only 1.30 children. This means that each Polish woman gave birth to over 60% more children in the UK than in their home country.

Over the years, from 2004 to 2020, the total fertility rate (see Figure 1) in Poland fluctuated between 1.227 and 1.453. This was a result of economic, social, and political changes. Economic fluctuations in the country, expressed through periods of stability and crises, have had a direct impact on families' decisions regarding fertility. The lack of financial independence and uncertainty about the future could discourage parenthood, yet changes in the labour market towards greater flexibility and financial stability may create favorable conditions for starting a family. Therefore, understanding the complex and interconnected influences of these economic factors on fertility is crucial for an effective public policy.

During the period of 2004-2020, social transformation, including changes in the stability of relationships and the rise of informal unions, along with the shift in the age of marriage, contributed to delaying decisions to start a family (Kotowska et al., 2008). At the same time, the expansion of educational opportunities for women, as a fundamental step towards gender equality, undoubtedly influenced the delay in choosing motherhood, thus contributing to the overall declining trend in the fertility rate (Snopkowski et al., 2016). These complex social factors and their mutual interactions had a significant impact on the dynamics of fertility in Poland during the analysed period.

3. Research Methodology

The study of fertility within a socio-economic context presents a subject of considerable complexity that necessitates the application of advanced statistical analysis methods (Bollen et al., 2001). Among the tools that enable the effective examination of such issues, Panel Data Modelling emerges as a prominent approach. It is also referred to as Panel Data Analysis, and constitutes an advanced statistical technique employed to investigate the influence of independent variables on a dependent variable using datasets structured in a panel format. Panel data encompasses multiple observational units, such as households, firms, or countries, over a specified period of time. Panel analysis facilitates the consideration of unit heterogeneity and temporal dynamics, which holds critical significance in various research domains and economic practices (Hsiao, 2022). By conducting panel analysis, it becomes feasible to account for fixed and random effects that may impact the dependent variable but are not directly observable. The adoption of panel modelling enables the examination of dynamic effects, such as delays or accelerations in the interaction between variables and the dependent

variable, thereby proving invaluable in the analysis of economic, social, or political processes. Furthermore, this approach offers valuable insights in addressing concerns related to endogeneity and heteroskedasticity that may arise in regression models.

Various estimation methods for panel models have been presented in the literature, including FE estimation, RE estimation, and generalised method of moments (GMM), which can be applied depending on the data specificity and the phenomena under investigation. In this paper, the validity of employing FE estimation and RE estimation methods were examined.

According to the assumptions, the RE estimator assumes that it is not possible to estimate individual effects for each observation, hence they are incorporated as part of the random component of the model, given by:

$$y_i = c\beta_0 + X_i\,\beta + v_i, \tag{3}$$

where: y_i – dependent variable for observation i at time t, c – vector of one coefficients, β – vector of coefficients for the independent variables, β_0 – idiosyncratic error term, X_i – vector of independent variables for observation i at time t, v_i – individual-specific random effect for observation i.

Due to the inability to estimate individual random effects, the following assumptions should be considered:

1. $E(\beta) = 0\ for\ i = 1, \dots, N.$
2. $E(\beta, \beta) = 0.$

$$E\left(\beta_i, \beta_j\right) = \begin{cases} 0\ for\ i \neq j \\ \sigma_S^2\ for\ i = j \end{cases},\ i, j = 1,2, \dots, N, \tag{4}$$

where: β – vector of model parameters, $E(\beta)$ – expected value of parameter vector β, $E(\beta, \beta)$ – expected value of the dot product of parameter vectors β_i and β_j, σ_S^2 – common variance for all parameters.

In order to assess the validity of employing the Classical Ordinary Least Squares (OLS) method or the FE estimator, it was necessary to utilise the Wald test (Wooldridge, 2003). The Wald test serves as a tool to examine the null hypothesis, which posits that all constants are statistically equivalent and independent of time and units. Conversely, the alternative hypothesis proposes variations in constants across units while assuming their constancy over time. The insignificance of the variables in the model indicates homogeneity among the elements. In such a context, it is recommended to employ estimation through the OLS method. However, in situations where the alternative hypothesis is accepted, it is suggested to apply the FE estimator.

The evaluation of the appropriateness of employing either the OLS estimation or the RE estimation can be accomplished through the implementation of the Breusch-Pagan test (Breusch & Pagan, 1980). This test facilitates the assessment by calculating the variance of the random component, considering two distinct hypotheses: the null hypothesis and the alternative hypothesis. The null hypothesis posits that the variance is equivalent to zero, which implies the suitability of using the OLS model. Conversely, the alternative hypothesis suggests that the variance of the random component deviates from zero, indicating the applicability of employing the RE estimator.

To choose between the RE estimator and the FE estimator, it is recommended to employ the Hausman test (Hausman, 1978), which examines the unbiasedness of the mentioned estimators based on two hypotheses. The first hypothesis assumes the independence of individual effects from the explanatory variables, while the second hypothesis postulates the bias of the RE estimator with the absence of such bias in the FE estimation. Additionally, model misspecification can also contribute to the occurrence of errors. The Hausman test allows researchers to statistically evaluate the validity of these estimators

and make an informed choice based on their properties, and provides a framework to compare the performance of the RE and FE estimators and determine their appropriateness in specific research contexts. By testing the null hypothesis (H_0) that the RE and FE estimators are unbiased against the alternative hypothesis (H_1) that the RE estimator is biased while the FE estimator is unbiased, researchers can assess the presence of bias in the estimations. In the analysis to explore the drivers of fertility rates, the authors used both FE and RE models to investigate fertility patterns in Poland between 2004 and 2020. The fertility coefficient, which represents the number of children an average woman would have over her reproductive time (aged 15-49) based on observed fertility rates at different stages of this period, is the dependent variable in this study. The FE model matches well the theoretical expectation of within-unit (yearly) homogeneity in the setting of Poland, where socio--economic policies and cultural norms have exhibited relative stability and where changes over time are more gradual than rapid. This model efficiently isolates the impact of certain factors on fertility rates, such as unemployment rates, average wages, marriage rates, demographic load, and female labour force participation, while correcting for any unobserved, year-specific effects. The RE model, on the other hand, is less suitable for this research due to its assumption of cross-year unpredictability. The RE model's assumption of random year-to-year volatility may not hold true in the context of a nation with generally stable socioeconomic policies and cultural attitudes about reproduction over the research period. As a result, while RE can offer insights, its applicability and generalisability in this context are restricted when compared to the FE model.

Regression models are statistical tools extensively employed for analysing the relation between a dependent variable and one or more independent variables (Montgomery et al., 2021). The regression coefficients within such models elucidate the magnitude and direction of the influence exerted by the explanatory variables upon the dependent variable, thus enabling the examination of causal relationships and the prediction of future values of the dependent variable.

Among the fundamental types of regression models, linear regression stands out as the most prevalent, assuming a linear relationship between the dependent variable and the independent variables (Kutner et al., 2005). In the case of multiple linear regression, as applied in this study where more than one independent variable is involved, the regression model takes the following form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon, \tag{5}$$

where: $X_1, X_2, \ldots, X_k$ – the values of the independent variables for the i-th observation, $\beta_1, \beta_2, \ldots, \beta_k$ – the regression coefficients pertaining to the respective independent variables, β_0 – the constant, reflecting the theoretical value of the dependent variable when the independent variables assume a value of zero, ε – the random error term.

By virtue of the regression model, researchers gain the ability to estimate the impact of the independent variables on the dependent variable and draw inferences regarding the nature of their relations (Hair et al., 2019). Through an analysis of the regression coefficients, one can discern the significance and direction of these relations while simultaneously assessing the overall goodness-of-fit of the model.

The OLS method is widely recognised as one of the most popular and extensively employed techniques for parameter estimation in econometrics (Wooldridge, 2019). Its primary objective is to minimise the sum of squared differences between the observed values of the dependent variables and their corresponding model-predicted values. In the context of panel data models, OLS is used to estimate the parameters of panel equations, which encompass both fixed effects and individual effects. In panel data models, the OLS approach considers both cross-sectional and individual-level variability. Panel equations collect data for the same observational units across multiple time periods, creating data panels. The OLS method seeks to minimise the sum of squared residuals, representing the discrepancy between the observed values of the dependent variables and their model-predicted values. The application of OLS estimation in panel data models allows for the examination of relations between

variables while accounting for individual-specific characteristics and time-invariant factors. By employing OLS, researchers can obtain coefficient estimates that capture the average effects of the independent variables on the dependent variable across the entire panel dataset.

4. Data Selection and Description

In the conducted analysis, the dependent variable is the coefficient indicating the number of children that an average woman would give birth to during the entire reproductive period, i.e. 15-49 years, assuming she gives birth at the frequency observed in partial phases of this period. This is based on the assumption that specific fertility rates from a given period are constant. This variable, also known as the variability coefficient, is referred to as 'fertility'. The data for the years 2004-2020, links each observation to a single year. This choice was based on the availability and consistency of the data from the Local Data Bank of the Central Statistical Office. The independent variables affecting the explained variable and used in the analysis, are:

- Unemployed: the unemployment rate, namely the ratio of the number of registered unemployed individuals to the total active civilian population (expressed in %).
- Earnings: the average monthly gross earnings in Polish zlotys.
- Marriages: the number of marriages contracted within a year.
- Demographic burden: the demographic burden index, calculated as the number of post-reproductive-age individuals per 100 individuals in the reproductive age (expressed in number of persons).
- Female activity: the female labour force participation rate, calculated as the ratio of economically active women of the reproductive age to the total number of women of the reproductive age (expressed in %).

The theoretical rationale of these determinants was based on a variety of theoretical frameworks. Microeconomic theories show that individual economic conditions have a substantial impact on fertility decisions (Becker, 1960). The unemployment rate and average wages are thought to be indices for economic stability, which influences reproductive decisions. The Second Demographic Transition theory, which proposes a move toward more individualistic behaviour in family formation and childbirth (van de Kaa, 1987), was used to assess the impact of marriage rates on fertility. Marriage rates are dropping, which could impact on fertility trends, since empirical research reveals that marriage is still a substantial condition for motherhood in many societies (Lesthaeghe, 2010). Furthermore, the positive relation revealed in this study between female labour force participation and reproduction levels merits debate, especially given the extensive literature frequently demonstrating a negative link (Brewster and Rindfuss, 2000; Goldin, 1995). This association may indicate shifting socio-economic dynamics in which higher female labour-force involvement does not necessarily prevent having children, possibly as a result of improved work-life balance legislation and cultural shift in gender roles.

Regarding the incorporation of time delays, particularly in respect to covariates such as unemployment rates, the model did not initially include time-lagged variables. Poland experienced varying levels of unemployment between 2004 and 2020, with higher rates recorded in the early 2000s, which then steadily fell, notably after 2008, indicating the country's economic stabilisation and growth. Short-term changes, affected by external economic conditions and internal policy, were noted. Average income in Poland increased generally throughout this time, indicating economic expansion and rising living standards. This trend is relevant because it pertains to household economic stability, which is a critical determinant in fertility decisions. Marriage rates and demographic loads varied as well, with marriage rates slightly falling and demographic burdens increasing, reflecting stronger demographic trends in the population.

Given Poland's relatively steady socio-economic situation during the studied period, the FE model is conceptually more adequate. When unobserved heterogeneity is stable across time and associated with the independent variables, the FE model reflects it. This assumption is consistent with the expected homogeneity of each year in Poland over the analysed period. As a result, the FE model aids in separating the influence of factors that vary over time while discounting those that remain constant and may induce bias. However, the RE model posits that differences across entities (in this example, years) are random and unrelated to the independent variables. Given Poland's socio-economic stability throughout this era, this assumption may not hold as firmly as it does for the FE model, but resulting, from the investigation, the model is more theoretically warranted.

5. Empirical Results and Discussion

The following analyses were conducted using the econometric Gretl software package. In addition to the dependent variable, which is the fertility coefficient, and the five independent variables, the model also includes dummy variables corresponding to sixteen voivodeships. Based on data from the Central Statistical Office, a panel model was estimated using the Classical Least Squares method. The model is presented in Table 1 with significance level: ***p < 0.001, **p < 0.01, *p < 0.05.

Table 1. Estimation using OLS, dependent variable (Y): fertility

Variable	Coefficient	Standard error	t-Student	p-value
Const	0.764342	0.164852	4.64	5.70e-06***
Unemployed	–0.00594871	0.00228692	–2.60	0.0098***
Earnings	4.87328e-05	1.36388e-05	3.57	0.0004***
Marriages	1.73307e-05	3.28876e-06	5.27	2.94e-07***
Demographic burden	–0.00533864	0.00318794	–1.67	0.0953*
Female economic activity	0.00676835	0.00243422	2.78	0.0058***
dolnoslaskie	–0.194529	0.0265152	–7.34	3.03e-12***
kujawsko_pomor	0.0103411	0.0199243	0.52	0.6042
lubelskie	–0.0428506	0.0245483	–1.75	0.0421*
lubuskie	0.0864274	0.0261831	3.30	0.0011***
lodzkie	–0.0934858	0.0298733	–3.13	0.0020***
małopolskie	–0.146710	0.0318768	–4.60	6.64e-06***
mazowieckie	–0.341078	0.0652079	–5.23	3.56e-07***
opolskie	–0.0903850	0.0247789	–3.65	0.0003***
podkarpackie	–0.0544269	0.0210271	–2.59	0.0100**
podlaskie	0.00791220	0.0259672	0.31	0.7608
pomorskie	0.0594886	0.0214481	2.77	0.0060***
slaskie	–0.327364	0.0506927	–6.46	5.46e-10***
swietokrzyskie	–0.0113738	0.0223809	–0.51	0.6118
warmińsko_maz	0.111028	0.0187175	5.93	9.89e-09***
wielkopolskie	–0.102617	–0.0316222	–3.25	0.0013***

Mean of the dependent variable	1.32	Standard deviation of the dependent variable	0.10
Sum of squares of residuals	0.69	Standard error of residuals	0.05
Determination coefficient R-squared	0.77	Adjusted R-squared	0.75
F(20,251)	41.21	p-value for the F-test	1.42e-67
Log-likelihood	425.77	Akaike information criterion	–809.53
Bayesian Schwarz criterion	–733.81	Hannan-Quinn criterion	–779.13

Source: own work.

In the next stage, analyses were performed using the FE estimator, and the results are illustrated in Table 2.

Table 2. Estimation using FE, dependent variable (Y): fertility

Variable	Coefficient	Standard error	t-Student	p-value
Const	0.693741	0.175165	3.961	9.75e-05***
Unemployed	–0.00594871	0.00228692	–2.601	0.0098***
Earnings	4.87328e-05	1.36388e-05	3.573	0.0004***
Marriages	1.73307e-05	3.28876e-06	5.270	2.94e-07***
Demographic burden	–0.00533864	0.00318794	–1.675	0.0953*
Female economic activity	0.00676835	0.00243422	2.781	0.0058***

Mean of the dependent variable	1.316026	Standard deviation of the dependent variable	0.104877
Sum of squares of residuals	0.695788	Standard error of residuals	0.052650
Determination coefficient R-squared	0.766573	Adjusted R-squared	0.514115
F(20.251)	41.21409	p-value for the F-test	1.42e-67
Log-likelihood	425.7663	Akaike information criterion	–809.5327
Bayesian Schwarz criterion	–733.8108	Hannan-Quinn criterion	–779.1330

Source: own work.

Table 3. Tests for the FE method

Joint test on named regressors:
Text statistics: F(5.251) = 53.1166 With value p = P(F(5,251) > 53.1166) = 1.82898e-37
Test on the diversity of a free word in groups:
H_0: groups with the common free word Statystyka testu: F(15.251) = 25.5139 z wartością p = P(F(15,251) > 25.5139) = 3.67219e-42

Source: own work.

In order to identify the presence of significant individual effects in the model and select the most appropriate estimator, diagnostic tests for panel data models should be applied, presented in Table 3. The test for between-group differences for constants, also known as the Wald test, allows for a decision regarding the suitability of using the FE estimator. The test result suggests rejecting the null hypothesis in favour of the alternative hypothesis, which recommends using the FE estimator instead of the OLS method. In the next stage, research was conducted using the RE estimator. The results of these investigations are shown in Table 4.

Table 5 presents the results of the Breusch-Pagan test, indicating the rejection of the null hypothesis in favor of the alternative hypothesis. This suggests the validity of employing the RE estimator. Analysing the results of the Hausman test, it was found that the null hypothesis should be rejected in favour of the alternative hypothesis. This is equivalent to stating the bias of the RE estimator, while the FE estimator remains unbiased.

Table 4. Estimation using RE, dependent variable (Y): fertility

Variable	Coefficient	Standard error	t-Student	p-value
Const	1.18716	0.140225	8.466	2.54e-17***
Unemployed	–0.0113509	0.00193686	–5.860	4.62e-09***
Earnings	4.24377e-05	1.32241e-05	3.209	0.0013***
Marriages	5.31741e-06	1.99542e-06	2.665	0.0077***
Demographic burden	–0.0111286	0.00298015	–3.734	0.0002***
Female economic activity	0.00552444	0.00240701	2.295	0.0217**
Mean of the dependent variable	1.316026	Standard deviation of the dependent variable		0.104877
Sum of squares of residuals	2.138535	Standard error of residuals		0.089496
Log-likelihood	273.0613	Akaike information criterion		-534.1226
Bayesian Schwarz criterion	–512.4878	Hannan-Quinn criterion		-525.4370

Source: own work.

Table 5. Tests for the RE method

'Between' variance = 0.00298223 'Within' variance = 0.00277206 Theta using quasi-demeaning = 0.772309
Joint test on named regressors:
Asymptotic test statistic: Chi-square(5) = 232.703 with a p-value = 2.081704e-48
Breusch-Pagan test:
H_0: Error variance within units = 0 Asymptotic test statistic: Chi-square(1) = 542.819 with a p-value = 4.59418e-120
Hausman test:
H_0: GLS estimator is consistent. Asymptotic test statistic: Chi-square(5) = 31.25 with a p-value = 8.36047e-06

Source: own work.

The conducted research demonstrates that the estimators' evaluations were similar in terms of value and sign. This suggests that the selection of variables and the model structure were justified with respect to the phenomenon and the collected data.

Table 6. Assessment of structural parameters based on panel models

Variable	The estimated value of the variable		
	OLS Model	FE Model	RE Model
Const	0.764342	0.693741	1.18716
Unemployed	–0.00594871	–0.00594871	–0.0113509
Earnings	4.87328e-05	4.87328e-05	4.24377e-05
Marriages	1.73307e-05	1.73307e-05	5.31741e-06
Demographic burden	–0.00533864	–0.00533864	–0.0111286
Female economic activity	0.00676835	0.00676835	0.00552444

Source: own work.

According to the alternative hypothesis in the Hausman test, it was assumed that the estimator of random individual effects is biased, while the FE estimator is unbiased, leading to the use of the FE estimator. Therefore, out of the three models used: OLS, RE estimation, and individual effects estimation, an interpretation can only be made from one of them.

Increasing the unemployment rate by 10% leads to a 0.059 unit decrease in the fertility coefficient, assuming constant average wage, number of marriages, demographic burden ratio, and female labour force participation. Conversely, a 1,000 PLN increase in the average monthly gross wage results in a 0.049 unit increase in the fertility coefficient, holding constant the unemployment rate, number of marriages, demographic burden ratio, and female labour force participation. Moreover, a rise of 10,000 marriages per year corresponds to a 0.173 unit increase in the fertility coefficient, assuming no variation in the unemployment rate, average monthly wage, demographic burden ratio, and female labour force participation. Additionally, a 10% increase in the ratio of post-productive age individuals to 100 productive age individuals leads to a 0.054 unit decrease in the fertility coefficient, assuming no changes in the unemployment rate, average wage, number of marriages, and female labour force participation. Finally, a 10% increase in female labour force participation results in a 0.068 unit increase in the fertility coefficient, assuming no changes in the unemployment rate, average salary, number of marriages per year, and demographic burden ratio.

The study showed a strong correlation between fertility and stability in three aspects: financial, occupational, and marital. Increasing unemployment and a high demographic burden have a negative impact on the fertility coefficient. This suggests that financial and occupational stability is crucial in the decision to start a family, whereas higher average wages, increased marriage rates, and female labour force participation contribute to a positive trend in fertility. In this context, marital stability, reflected in the number of marriages, as well as financial and occupational stability resulting from female labour force participation, are stimulating factors for fertility growth. Public policy strategies emphasising these determinants can contribute to increased fertility, which is crucial for a stable demographic structure.

In order to analyse the fertility coefficient over the period of 2004-2020, a time series analysis was conducted as a comparison of this indicator in extreme time observations, divided by voivodeships (see Figure 2).

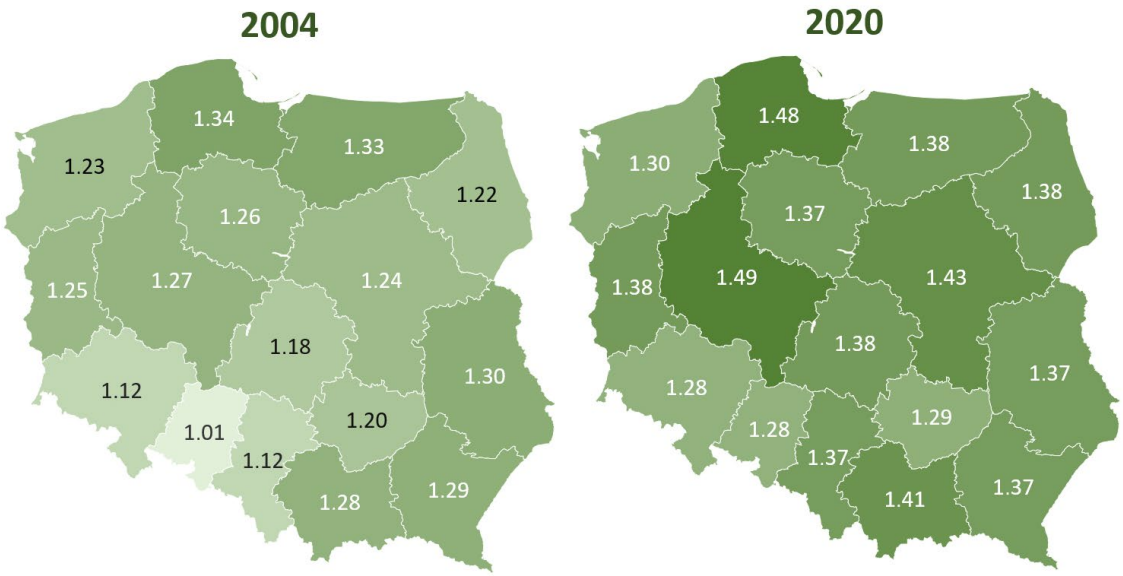

Fig. 2. Fertility rate in Poland for the years 2004 and 2020 by voivodeship

Source: own work.

The demographic analysis for Poland for the period from 2004 to 2020, reveals heterogeneity in fertility rates at the level of voivodeships, suggesting the influence of local socio-economic factors. In 2004, the lowest fertility rates were observed in Opolskie and Sląskie voivodeships, while the highest rates were found in Pomorskie and Wielkopolskie voivodeships. By 2020, there was noticeable growth in the average fertility rate for most voivodeships, with the largest increases observed in the Pomorskie, Wielkopolskie, and Mazowieckie voivodeships. Some voivodeships, such as Dolnośląskie, Opolskie, Podkarpackie, Śląskie, Świętokrzyskie, and Zachodniopomorskie, continued to show relatively low fertility rates, suggesting the potential for further growth. Subtle variations in fertility rates among voivodeships may stem from differences in the labour market and earning opportunities in different regions of Poland. Given these findings, it is more appropriate to concentrate future study on the geographical element of fertility changes in Poland. A panel study using region-year records might give more information on how local variables impact fertility rates. Such an approach would enable a more extensive investigation of the factors underlying observed regional disparities in fertility rates, as well as the creation of more focused demographic strategies. The differences in fertility rates among the regions highlight the significance of adjusting demographic policy to unique regional circumstances. Policies that work in one region may not work in another, due to the various socioeconomic landscapes that exist across Poland's voivodeships. This comprehensive knowledge is critical for devising interventions that address the specific difficulties and possibilities in each region, resulting in a more balanced and successful approach to controlling national demographic trends.

6. Conclusions

The demographic analysis for the period from 2004 to 2020 shows little variance in fertility rates throughout Poland's voivodeships. The study presents direct quantitative evidence linking numerous factors to fertility rates in Poland in the empirical analysis using the Classical Least Squares, Fixed Effects, and Random Effects models. The findings paint a complex picture of how economic, social, and geographical variables combine to impact on fertility decisions. There is a 0.059 unit decline in fertility for every ten percentage point rise in unemployment. This significant negative impact demonstrates how economic stress and employment volatility might inhibit family growth, whilst a PLN 1,000 rise in average monthly gross salaries, on the other hand, is connected with a 0.049 unit increase in the fertility rate. This positive link highlights the impact of economic well-being in increasing fertility rates. The study discovered a link between marriage rates and fertility. An increase of 10,000 marriages each year is related to a 0.173 unit rise in fertility rate, supporting the conventional relation between marriage and childbirth. The study defied conventional wisdom by discovering a positive relation between female labour force involvement and fertility rates. A 0.068 unit rise in the fertility coefficient is associated with a 10% increase in female labour force participation, indicating a potential change toward more family-friendly work conditions and altering cultural norms regarding women's responsibilities. A 10% rise in the demographic load ratio results in a 0.054 unit drop in fertility. This research highlights the strain that an ageing population may have on the reproductive decisions of the next generations, and also reveals considerable geographical variations in fertility rates among Poland's voivodeships. These differences demonstrate that local socio-economic factors have an impact on fertility patterns, implying that a one-size-fits-all approach to demographic management may be ineffective.

One of the primary findings of the study is the need for a public policy that encourages reproduction and provides enough assistance for families. It is vital to establish situations in which young couples believe that having children would not have a detrimental impact on their quality of life or professional aspirations. Demographic factors must also be considered while developing social and economic policies. The analysis of fertility in Poland is a comprehensive research area that considers a variety of elements that influence this demographic component. This is especially important given the issues

that an ageing society faces (Pakulski, 2016). It is critical to perceive the influence of socio-economic circumstances on the decision to have children as only through such evaluations it will be possible to develop acceptable answers and policies which contribute to improving fertility in Poland.

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Wyzwania demograficzne w Polsce: analiza niskiej dzietności

Streszczenie

Tło badań: Zjawisko niskiej dzietności w Polsce stanowi kluczowy obiekt analiz demograficznych. W ostatnich latach obserwuje się nie tylko zmiany w modelach prokreacyjnych i rodzinnych, ale także w strukturze wiekowej społeczeństwa. Jest to szczególnie istotne w kontekście starzenia się populacji, które staje się coraz bardziej widoczne. Starzejące się społeczeństwo niesie za sobą liczne wyzwania, takie jak wzrost obciążenia systemów opieki zdrowotnej, zmniejszenie aktywnej siły roboczej i konieczność zabezpieczenia odpowiednich środków na emerytury. Mimo że wiele osób pragnie mieć potomstwo, powstrzymują się od podjęcia takiej decyzji, a przyczyny tego wyboru są zróżnicowane. W związku z tym istotne jest przeprowadzenie analizy czynników determinujących dzietność w Polsce, z uwzględnieniem aspektów zarówno ekonomicznych, jak i społecznych. Konieczne jest zrozumienie, w jaki sposób sytuacja ekonomiczna, warunki na rynku pracy oraz zmiany w strukturze społecznej wpływają na proces podejmowania decyzji dotyczących posiadania dzieci.

Cel artykułu: Artykuł ma na celu analizę dzietności w Polsce w okresie 2004-2020. Wykonane badania umożliwią identyfikację czynników wpływających na obserwowany stan niskiej zastępowalności pokoleń oraz określenie ich intensywności.

Metodologia/Metody/Źródła danych: Dane wykorzystane w artykule pochodzą z Głównego Urzędu Statystycznego i obejmują lata 2004-2020. Praca opiera się na literaturze z zakresu demografii i ekonometrii. W analizie dzietności w Polsce zastosowano trzy metody statystyczne: model Klasycznej Metody Najmniejszych Kwadratów (KMNK), estymator o efektach ustalonych (FE) oraz estymator o efektach losowych (RE). Następnie przeprowadzono analizę dzietności w przekroju regionalnym, dzieląc Polskę na 16 jednostek administracyjnych (województw). Do analizy wykorzystano model panelowy, a wyniki poddano testom Walda, Breuscha-Pagana i Hausmana w celu porównania rezultatów uzyskanych z różnych modeli.

Wyniki/Wnioski: Wyniki analizy wskazują, że sytuacja ekonomiczna i rynek pracy mają znaczący wpływ na decyzję o posiadaniu dzieci w Polsce. Trend niskiej dzietności, chociaż obserwuje się pewien jej wzrost, wciąż jest charakterystyczny dla kraju w porównaniu z innymi państwami UE. Analiza czynników determinujących dzietność jest istotna dla zrozumienia decyzji młodego pokolenia Polaków w kwestii posiadania potomstwa.

Słowa kluczowe: dzietność, starzenie się społeczeństwa, analizy demograficzne