From economic turbulence to demographic change: Tracing the pathways of the second demographic transition in post-socialist contexts

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ABSTRACT

Building on the rich tapestry of demographic and economic research, this paper extends the analysis of the Second Demographic Transition (SDT) within the milieu of Czechia, Slovakia, Poland, Romania, and Austria, shedding light on the nuanced interplay between economic variables and demographic indices such as the Total Fertility Rate and the Sobotka's Second Demographic Transition Behavioral Index (SDT1). Drawing from an extensive dataset spanning over two decades, the study applies Pearson's correlation analysis, Holt's Exponential Smoothing, and stepwise regression to unravel the complexities of demographic behaviors in the face of economic prosperity and inequality, as measured by GDP, Gini coefficient, and the Human Development Index. The findings reaffirm the pivotal role of economic factors in shaping demographic trends and highlight the divergent paths Czechia, Slovakia, Poland, and Romania have embarked upon compared to Austria, a representation of Western Europe's demographic evolution. This comparative analysis underscores the significance of wealth distribution in influencing demographic outcomes, offering a comprehensive understanding of the second demographic progression in the context of economic transitions. The research contributes to the broader discourse on demographic changes, providing insightful implications for policy and future studies in the dynamic landscape of Central and Eastern Europe and beyond.

KEYWORDS

second demographic transition; economic transition; post-socialist; demography; total fertility rate

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1. Introduction

The Second Demographic Transition (SDT) is characterized in a demographic context by evolving familial configurations, delayed initial marriages and first childbirths, sub-replacement fertility rates, increased extramarital births, cohabitation, and escalated divorce rates. Since Lesthage and van de Kaa's seminal introduction of the SDT concept in 1987, a substantial body of research has emerged, concentrating on the extent of SDT adoption across various nations (Zaidi and Morgan 2017). Initially conceptualized within a Western context, excluding the factors associated with mortality, scholars examining post-socialist countries (PSCs) have raised critical inquiries regarding the applicability of SDT frameworks to these regions, which displayed divergent developmental trajectories. It is important to note that the Second Demographic Transition theory is not universally accepted, as initially mentioned by Cliquet (1991), who believed value changes are essential, but economic factors should be addressed. Coleman posited that the theory was part of a more extensive explanation but not the transition on its own (2004).

This divergence between PSCs and Western European countries' transitions prompted significant scholarly investigation. A central line of inquiry pertained to how populations responded to sociocultural and economic transformations in the context of SDT-related phenomena, such as shifts in familial structures and fertility patterns. In the Western European context, the advent of the SDT coincided with economic affluence, a change in family values, and increased female participation in the workforce and higher education. In contrast, the post-socialist transition was marked not by economic prosperity but by economic upheaval. Post-1990, populations like those of Czechia, Poland, Romania, and Slovakia experienced reduced employment rates and increased unemployment and uncertainty, which had not been experienced previously – socialist countries previously had a near-zero unemployment rate. Notably, female unemployment rates in Romania and Czechia were lower than in Austria, a regionally comparative economy with a differing economic system. This observation led to the hypothesis that there are dual economic pathways to the SDT: one through economic prosperity and the other via economic crisis, yielding comparable demographic outcomes and familial behavior.

Sobotka (2008) developed two indices to gauge the progression of the SDT: the behavioral SDT index (SDT1) and the values-based SDT index (SDT2). SDT1 was introduced to define the degree to which select countries comparatively changed based on teen fertility rate, age of women at first marriage, the mean age of the woman at primo childbirth, the percentage of extramarital births, and the proportion of cohabitation. The SDT1 index revealed pronounced distinctions between Western and Northern European countries and PSCs, exhibiting significantly lower scores (Sobotka 2008). This study seeks to examine temporal shifts in the SDT1 index and to ascertain the economic and socioeconomic factors influencing these variations, focusing on the Total Fertility Rate (TFR) in Czechia, Austria, Poland, Romania, and Slovakia.

The research methodology encompasses three primary predictive techniques to examine the dependent variables (TFR and SDT1), aiming to identify the most accurate model and explore potential inter-variable relationships. Initially, Pearson's correlation coefficient will detect possible associations among the variables – TDR, TFR, and SDT1 Index, GDP per capita PPP (GDP), Gini coefficient of income inequality (GINI), and Human Development Index (HDI). These insights will provide a preliminary, non-causal understanding of the possible association between variables. Subsequently, two time-series methodologies will be applied to evaluate the STD1 and TFR variables' predictability and assess the suitability of regression models: Holt's Exponential Smoothing with Trend Adjustment and Simple Linear Regression. The accuracy will be measured by mean absolute deviation (MAD). Finally, the stepwise regression model will determine the most predictive independent variables for SDT1 and TFR.

Prior studies have demonstrated a correlation between TFR and SDT1, suggesting a parallel fluctuation between these measures. Additionally, correlations have been established between TFR and macroeconomic indicators such as GDP, GINI, and HDI. Given the World Bank's classification of PSCs as lower-middle and upper-middle income nations and their relatively lower SDT1 scores compared to Western counterparts, this study will explore the influence of GDP and GINI on SDT progression in post-socialist European countries and Austria as a control population (Lesthaeghe 2020), thereby shedding light on potential drivers of demographic transitions in this region. These populations were chosen particularly due to their closeness in fertility and familial structure (Rychtarikova and Monnier 1992). Austria was chosen as a control population in the study due to the geographical and historical similarities, but differing political and economic history, in combination with the East-West division despite geographical location.

This research provides a nuanced understanding of the Second Demographic Transition (SDT) within the post-socialist countries (PSCs) context, focusing on the interplay between socioeconomic factors and demographic changes in Czechia, Poland, Romania, and Slovakia. The study's multifaceted approach, encompassing the behavioral-based index, aims to elucidate the temporal dynamics and predictive factors of the SDT1 index and Total Fertility Rate (TFR). Incorporating various methodological tools, including

Pearson's correlation coefficient, time-series analyses, and multiple regression, will offer a comprehensive understanding of the relationships and potential causative factors influencing these demographic phenomena. The study's findings are anticipated to contribute to the broader discourse on demographic transitions, particularly in the context of economic and social transformations experienced by post-socialist populations.

2. Literature review

The Second Demographic Transition (SDT) phenomenon is predominantly characterized by shifts in societal attitudes and practices related to marriage, cohabitation, childbearing, and divorce. This shift was especially pronounced in Western European populations, where an increasing social acceptance of premarital cohabitation emerged. Advances in contraceptive technologies facilitated more effective family planning, leading to delayed childbirth and a consequent reduction in period total fertility rates. While Western Europe began witnessing these demographic shifts as early as the 1960s, as delineated by van de Kaa (1987), recent scholarship, such as that by Zaidi and Morgan (2017), has pointed to the ethnocentric limitations of this theory, emphasizing its grounding in Western and postmodern values. In this regard, postmodernism is used in the context expressed by van de Kaa (2002), where the population has exceptional economic security, high standards of living, and access to fair and reliable democratic processes.

Contrasting this Western experience, post-socialist countries (PSCs) underwent a more delayed demographic evolution. Rychtarikova (1999) proposed that the post-1990 demographic shift in PSCs was more reflective of crisis behavior than a response to the economic affluence and postmodernist influences experienced in Western Europe. Sobotka (2008) furthered this position by suggesting that the SDT can follow two distinct paths: one emerging from economic prosperity and the other from economic adversity. However, this theory and the associated data, spanning 1990 to 2004, have yet to be revisited, despite mentions more recently by Lesthaeghe and Permanyer (2014) and Lesthaeghe (2020). Sobotka (2008) noted that the conventional development path in the SDT aligns with economic well-being and higher education. In contrast, the alternative path, consistent with Rychtarikova's (1999) crisis behavior concept, might be more applicable to PSCs. The present research seeks to determine whether PSCs are still following the same trajectory as previously or if their paths have converged with those on the conventional path.

Lesthaeghe (2020) observed varying phases and extents of cohabitation across European countries. For instance, Austria and other German-speaking nations experienced an early surge in cohabitation between 1970 and 1979. In contrast, Romania and Poland experienced such trends in the 1990s, and even then, the extent was more muted compared to Western Europe. Lesthaeghe's (2020) analysis, utilizing data from the Generations and Gender Survey (GGS), also highlighted the interplay between educational attainment and cohabitation patterns. In Poland, for example, the period from 1990 to 1999 saw no significant correlation between education levels and cohabitation, but this changed in the subsequent years, particularly among higher-educated individuals. Romania displayed similar patterns, with notable distinctions in cohabitation based on educational attainment emerging in later years. Cohabitation differs from region to region in Czechia, where half of cohabitation, or "de facto marriage" as it is sometimes referred to, is the population aged 25–39 (Cesky Statisticky Urad 2014).

The economic struggles of Romania, as discussed by Ban-Ner and Montias (1991) and Ban (2012), centered around debt, capital-intensive industrial strategies, and the faltering socialist state, leading to profound socio-demographic impacts, including a sharp decline in fertility post-decentralization. As detailed by Ouanes and Madhav Thakur (1997) and Kolodko (2009), Poland's situation mirrored Romania's, with the economic crisis reaching its lowest points in 1993. The economic instability, exacerbated by debt servicing challenges and currency issues, severely impacted Poland's economic stability. Czechia, in contrast, experienced a more democratic transition away from socialism, driven by personal choice, as described by Lijphart (1992). This peaceful transition in Czechoslovakia provided the macroeconomic elements of success, and when Slovakia and Czechia split, this macroeconomic foundation was inherited by Slovakia. Unfortunately, however, when Slovakia attempted to float its currency, the economy took a heavy hit and caused a stagnation in economic growth (Koyame-Marsh 2011).

2.1 Fertility transitions

Fertility rates are a pivotal marker in the study of demographic transitions. As noted by Sobotka (2008), the transition period from socialism in European countries was characterized by a palpable sense of crisis, a sentiment that resonated in Czechia as much as it did in post-Ceaușescu Romania (Ben-Ner and Montias 1991; Kocourková et al. 2022). The research by Kocourková, Slabá, and Šťastná (2022) delves into the socioeconomic impacts on fertility trends, revealing a notable decline in fertility rates starting from 1990, which persisted below pre-democratization levels. This tells a more critical fertility story than simply fewer women having children. Bongaarts and Feeney (1998) made a case that period fertility rates did not accurately describe the ongoing fertility trends in a population, and life course is essential to consider – meaning that postponement was more common during economic crises. This trend was mirrored during the 2008 financial crisis, further underscoring the influence of economic stability on timing associated with Total Fertility Rates (TFR), thus supporting the crisis response theory posited by Rychtarikova (1999) and Sobotka (2008). Kocourková, Slabá, and Šťastná's (2022) cohort-based approach to analyzing fertility shifts addresses previous criticisms regarding the reliance on period fertility as a metric, as pointed out by Lesthaeghe and Permanyer (2014).

In Czechia, similar to their Western European counterparts, women experienced increased opportunities for travel, university education, and self-actualization. Parallel trends were observed in Romania, where Ianoș and Heller (2004) noted that shifting to a market economy led to significant demographic changes through mass temporary and permanent emigration. However, this shift did not equate to childlessness; instead, a postponement in fertility was observed, as highlighted in Sobotka's (2015) Czechia cohort analysis. The cross-sectional perspective in Fig. 1 observes the upward shift in the mean age of mothers at childbirth. In Austria, since 2011, the birth rates among women under 20 have surpassed those over 40 (Sobotka 2015; Beaujouan 2018). Moreover, Vienna, which traditionally exhibited lower fertility rates relative to the rest of the country, has seen its rates converge with the national average (Sobotka 2015), meaning that the country's rural and less dense regions are experiencing low total fertility rates similar to those in the capital city.

Poland, too, witnessed a decrease in total fertility rates following the shift from socialism (Kotowska et al. 2008). In response, Poland adopted pro-natalist policies, including increasingly restrictive abortion laws. However, these measures have not significantly influenced fertility rates, likely due to the prevalence of effective contraception (Cook et al. 2023). Kotowska et al. (2008) identified several socioeconomic factors impacting fertility, particularly material and economic disparities and limitations in social welfare for families desiring children. Poland's rapid transition mirrors that of other PSCs, yet it stands out for its continued decline in TFR since 1990, unlike Czechia, Romania, and the Slovak Republic, as observed in Fig. 2 – attributed to better contraceptives and personal choice (Cook et al. 2023).

This data illustrates the mean age of mothers at all live births in each period. As can be observed in this time series graph, there has been a consistent increase in age across all countries. Slovakia and Czechia are unique population groups that appear to have a stagnated pattern of transition.

Fig. 2 illustrates the change in period total fertility rates across Czechia, Austria, Poland, Romania, and Slovakia. Austria, as the most post-modernist countries in the study, had the lowest change in fertility behaviour; whereas, Poland had the most significant change. Czechia, Romania, and Slovakia have all experienced increased total fertility rates, indicating that it may be a case of postponement of childbirth rather than decreased desire for children.

The Total Fertility Rate (TFR) is a pivotal indicator within the framework of the Second Demographic Transition (SDT), underscoring the significance of personal choice and fertility dynamics in modern demographic studies (Lesthaeghe 2020). Sobotka (2008) proposed that economies may undertake one of two principal trajectories toward the SDT, highlighting the intricate challenges that post-socialist economies encounter when transitioning to market economies. This narrative is consistently reflected across the landscapes of Czechia (Kocourková et al. 2022; Sobotka 2015), Poland (Kotowska et al. 2008; Cook et al. 2023), Romania (Ban 2012; Ianoș and Heller 2004), and Slovakia (Sobotka 2008; Rychtarikova 1999), where similar fertility trends have been documented despite varying degrees of transition levels and economic well-being.

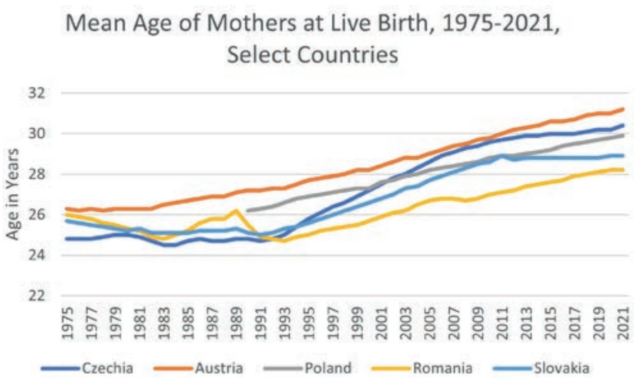

Fig. 1 Mean Age of Mothers at Live Childbirth, 1975–2021.

Data Source: Eurostat (2023). Mean age of Mothers at first birth data was taken from Eurostat – Poland's data was limited to 1991 onward.

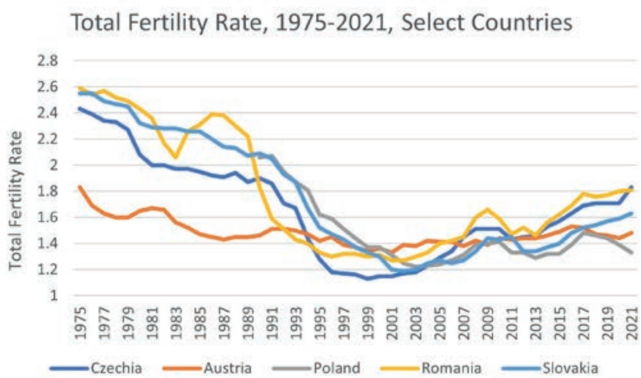

Fig. 2 Total Fertility Rates, 1975–2021, Select Countries.

Data Source: Eurostat (2023).

2.2 Nuptiality and divorce trends and transitions

A primary factor associated with the second demographic transition is the structural changes in unions and family structure in postmodernist countries. Trost (1978) examined the emergence of cohabitation in Nordic countries; between 1950 and 1964, 58–68% of Icelandic couples cohabitated in “marriage-like conditions”. The “lifestyle” was suggested to be one for the adventurous at the time, with some characterizing women who entered cohabitation as lacking interests and values typically associated with marriage (Bernard 1982, p. 159; Blanc 1984). In Czechia, between 1985 and 1990, it is estimated that 31–37% of couples cohabitated before their first marriage (Možný and Rabušic 1992); typically, with plans to marry. This concept differs from the shift from the *golden age of marriage to the dawn of cohabitation*, as it implies a remaining relative importance of marriage (Sobotka et al. 2003). The European Values Survey (EVS) recorded that more respondents agreed that *marriage is outdated* in Czechia and Slovakia. Fig. 3 illustrates the percentage of extramarital births in select countries. Rabušic and Manea (2019) discuss the changing perception of single motherhood and cohabitation in 1991 and 2017 in both Czechia and Slovakia.

In Slovakia, like Czechia, there has been a rise in cohabitation and non-traditional relationship forms, leading to a higher rate of extramarital childbirth compared to Romania and Poland (Potančoková et al. 2008). Czechia has the highest rate of extramarital births among the countries studied, followed closely by Austria and Slovakia. Conversely, Poland and Romania are among the European countries with the lowest rates of extramarital births (Rotariu 2010). In Poland and Romania, as of 2021, the mean ages for married and unmarried mothers at first live birth are 28.8 and 25.9, and 28.2 and 24.5, respectively. In Austria and Czechia, these ages are higher, with Austria having mean ages of 30.6 for married and 28.7 for unmarried mothers, and Czechia demonstrating similar patterns.

Fig. 3 indicates that growing share of extramarital births in each of the select countries. Poland and Romania continue to have a growing Percentage;

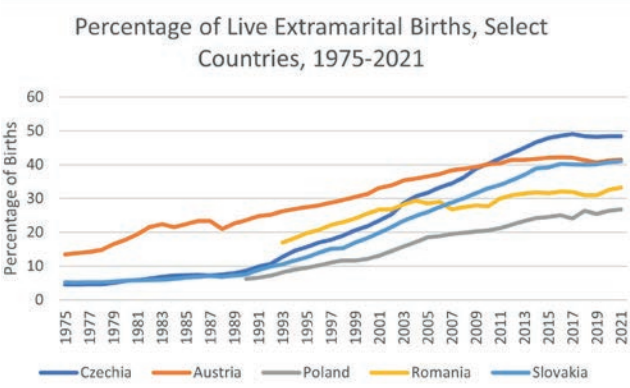

Fig. 3 Percentage of Total Extramarital Live Births in Select Countries, 1975–2021.

Data Source: Eurostat (2024).

Czechia and Slovakia appear to be stagnated. Austria appears to be on the decline. What is most notable about this data is the percentage of extramarital childbirths in Czechia compared to Austria, which was overtaken after 2010.

In contrast to Czechia, Romania exhibits a markedly lower prevalence of cohabitation among couples. As of 2002, merely 6.5% of Romanian couples cohabited, a stark difference from other European countries (Wiik et al. 2012). The country experienced a decline in Crude Marriage Rates (CMR) from 1970 to 1989, which conversely saw an increase in female

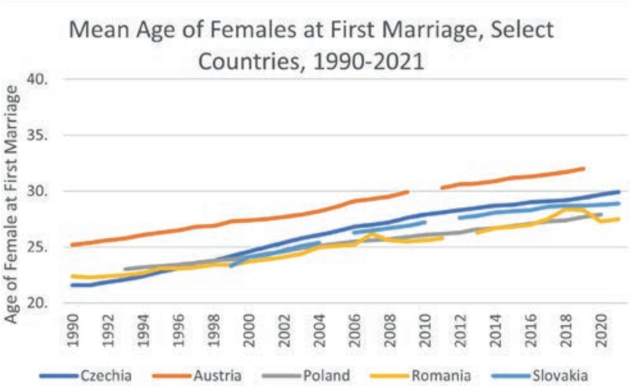

Fig. 4 Mean Age of Females at First Marriage, Select Countries, 1990–2021.

Data Source: Eurostat (2023).

Tab. 1 Percent of Consensual Unions by Country 2011 Census.

Country	Total Unions	Total Consensual Unions	Percent of Unions as Consensual Unions [%]
Austria	1,614,273	321,689	16.6
Czechia	1,856,715	237,933	11.4
Poland	8,206,239	313,114	3.7
Romania	4,666,020	340,019	6.8
Slovakia	761,811	70,337	8.5
Total	17,105,058	1,283,092	7.0

Data Source: Eurostat (2024).

educational attainment and employment in every post-socialist country except Romania (Cornia and Panicci 1996).

This figure describes the increased mean age of primo-nuptiality in Czechia, Austria, Romania, Poland, and Slovakia. In each of these countries, there is a clear positive trend. There was a sudden increase in age for Romania, which quickly readjusted during the COVID-19 pandemic years. Austria maintains the oldest mean age of primo-nuptiality, > 32 years old. Romania, with the lowest, has a mean age of < 27.6.

Despite this decline in marriage rates in Poland and an upward shift in the average age of first marriage – from 22.5 years in 1993 to 27.9 years in 2020 – Poland still maintains the second-youngest average age at primo-marriage among the studied countries, as depicted in Fig. 4. Notably, all countries in this study have seen an increase in the mean age of first marriage for females. In a unique deviation, Romania experienced a brief anomalous period between 2017 and 2019, where the average age of first marriage peaked before reverting to levels close to those observed before 2017, followed by a more predictable and consistent pattern.

Oláh and Frątczak (2003) observed that in Poland and Romania, the increased opportunities for women in employment and education did not significantly alter with the crude marriage rate, a contrast to the trends seen in Western nations and even in Czechia and Slovakia. Traditional gender roles, particularly regarding household responsibilities, have remained essentially unchanged in Poland, potentially influencing marital and childbirth dynamics.

2.3 Human Development Index, GDP, Gini, and Second Demographic Transition

The choice of Gross Domestic Product (GDP) over Gross National Income (GNI) as the primary economic indicator in this study is underpinned by several key considerations. Firstly, GDP offers a more concentrated measure of economic activity at the national level, which is particularly pertinent for this analysis as it excludes the potentially distorting effects of remittances. This focus ensures a more precise depiction of actual economic activities within the studied countries. Moreover, GDP's prevalent use among policymakers underscores its vital role in elucidating the relationship between economic output and various socioeconomic and socio-demographic variables. This widespread adoption enhances the validity and comparability of our findings, aligning them with established policy frameworks. GDP's significance is further highlighted by van de Kaa (2002), who identified it as a structural component and an explanatory factor in the Second Demographic Transition (SDT). Bloom et al. (2001) also suggested that GDP is influenced by the Total Fertility Rate (TFR), positioning it as a dependent variable in their analysis. Finally, it discusses the key policy variables that, combined with reduced fertility and increases in the working-age population, have contributed to economic growth in some areas of the developing world.

As a measure of income equality, the Gini coefficient ranges from 0 (perfect equality) to 1 (perfect inequality). Mierau and Turnovsky (2014) discovered a correlation between rising TFR and increased income inequality. Although it was proposed that wealth distribution becomes more unequal with increasing life expectancy, Kopczuk and Saez (2004) demonstrated that wealth has been concentrated in the top decile for over five decades, proposing that wealth inequality may be more static than dynamic in relation to demographic changes. This suggests wealth inequality could be independent, not necessarily dependent on demographic transitions.

Lesthaeghe and Permanyer (2014) provided insights into the impact of the Human Development Index (HDI) on TFR across various European regions. They identified two primary clusters: Cluster A, comprising mainly Nordic and Anglo populations, and Cluster B, including 25 countries such as Czechia, Slovakia, Romania, Poland, and Austria, characterized by low to moderate TFR. Notably, the relationship between TFR and HDI in both clusters was weak, indicating that these variables might not sufficiently explain the variance in TFR.

This study treats GDP, HDI, and the GINI as independent variables. While GDP has been previously identified as independent in relation to the SDT (Sobotka 2008), its influence on SDT1 is mediated by social norms. The GINI relationship with TFR suggests a link between increasing inequality and rising fertility rates (Mierau and Turnovsky 2014). These indicators provide a robust foundation for examining economic and socioeconomic predictors in relation to crucial demographic measures like TFR and the SDT1 Behavioural Index. By evaluating the SDT Index against GDP, this paper aims to ascertain whether there is a consistent trajectory in line with Sobotka's (2008) propositions.

3. Methodology

This paper aims to identify whether these countries remain on the same "path" in demographic transition or if the paths have changed in any way. The initial SDT indices (SDT1 and SDT2) were developed using data from 1990 and 2004. These data were from a period before the accession of Romania to the EU and the year Czechia entered the European Union (2004). The SDT1 index is calculated by observing the Mean Age of Mothers at First Birth (MAFB), the Sum of Age-Specific Fertility Rates Below age 20 per 1,000 (TEENFERT), the Percentage of Non-Marital Live Births (NONMAR),

Tab. 2 SDT1 Behavioural Index Indicators.

Factor	Factor Abbreviation	SDT score = 0	SDT Score = 5	SDT Score = 10
Mean Age of Mother at First Birth	MAFB	< 24	27	> 30
Age Specific Fertility Rate Below Age 20 (per 1,000)	TEENFERT	> 180	90	0
Percentage of Non-Marital Live Births	NONMAR	0	30	> 60
Total First Marriage Rate	TFMR	> 0.80	0.60	< 0.40
Mean Age at First Marriage	MAFM	< 23	27	> 31
Total Divorce Rate	TDR	< 0.15	0.35	> 0.55

Source: Sobotka (2008).

Total First Marriage Rates (TFMR), Mean Age at First Marriage (MAFM), and Total Divorce Rate (TDR). The model thresholds were set out by Sobotka (2008) and illustrated in Tab. 2.

The rates are each scored based on the scoring criteria, aggregated, and averaged, leading to the SDT1 index score, where 0 is not considered to be transitioning, and 10 is regarded as an advanced second demographic transition. Sobotka added 0.5 to each of the indexed scores for countries where unmarried cohabitation counts for more than 10 percent of the total unions in the country. For this research, the most recent data available at the time of this research is from the 2011 census, as the data from the 2021 census is not yet robust enough within the same context. The breakout and percent of each of the countries' unions is illustrated in Tab. 1.

Based on the 2011 census, Austria and Czechia are the only countries that receive the 0.5 increase. These indices are a basis for each country's perceived transition level based on the leading indicators associated with the second demographic transition. This research, along with revisiting the SDT1 indices for 2004-2021, will entail econometric methods of analysis, including Holt's Exponential Smoothing model and simple linear regression, used to depict changes in both level and trend elements of TFR and STD1 index indicators. Stepwise regression will be implemented to define the predictability of the data. For a baseline data analysis, Pearson's r correlative testing will identify preliminary associations between demographic variables and economic data, including GDP, GINI, and HDI. This framework will provide insight into several key concepts.

This study will re-examine the transition level experienced by former socialist countries while also examining the factor associations to Sobotka's SDT1 Index. These data will also provide insight into these select countries' trends in associative and time-series approaches. These combined approaches will provide evidence of whether these data are predictable and associated with one another. In the following section, the sources and calculation methods for data will be expanded upon. Appendix 1 describes the data types, sources, and the mode of calculation for the indicators used in the study.

3.1 Exploring relationships using Pearson's r

Pearson's r will be initially used to develop a baseline understanding of the relationships between the variables. This basis will provide insight into the level of potential relationships between each variable and use these data to determine the most critical variables to test in a regression test. The results for the Pearson correlations will also provide insight into the potential way select values interact while also understanding how multiple dependent variables may fluctuate similarly.

3.2 Time series analyses

This analysis will examine the variables' predictability of TFR and STD1 and which of the two models is best for predicting the variables. The two methods will be time series simple linear regression and Holt's Exponential Smoothing with trend. Holt's does not include a seasonality component, which allows the model to predict without the assumption of cyclicality. Regression is a commonly accepted approach, so the equations have yet to be included in this research; however, Holt's equations are included in the following section.

3.3 Holt's Exponential Smoothing

Holt's Exponential Smoothing (Holt's) is a linear model that addresses data that increases in a trended pattern. The method of analysis has been used in the past due to its relative ease, cross-disciplinary usage, and the general accuracy of the model (Maia and de Carvalho 2011). The results will be compared against the results of the simple linear regression analyses using Mean Absolute Deviation (MAD). Holt's is expressed in two functions: a level component (L) – the baseline values of the series in a simple forecast, and the trend component (T) – a representation of the increased trend in the model. To conduct this analysis, observed values (Y) from the previous period(s) have to be known. A smoothing constant for the L is used in the level equation(α), and a smoothing constant for the T variable is placed in the trending component equation (β). The predicted future value ($\hat{Y}$) is then calculated.

Equations (1), (2), and (3) illustrate the principle components.

Equation 1 Holt's Exponential Smoothing

$$L_t = \alpha Y_{t-1} + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (1)$$

$$T_t = \beta(L_t - L_{t-1})) + (1 - \beta)T_{t-1} \quad (2)$$

$$\hat{y}_t = L_t + T_t \quad (3)$$

This output will provide an understanding of the data's predictability based on the trends of the known data points. The model parameters (α and β) will be adjusted to best fit the data series.

For the first period, a naïve approach to forecasting will be used – the forecast (L) for 2007 will be the actual (A) value from 2006. In this example, the smoothing constant α = 0.2 and the trending constant β = 0.495. These constants are dynamic and adjusted to the best fit. The Czech data is: Y_{2006}^{TFR} = 1.34: T_{2006}^{TFR} = *0.066*, L_{2006}^{TFR} = 1.302. Equations (4), (5), and (6) illustrate the process.

$$L_{2007}^{TFR^{CZ}} = (0.2)(A_{2006}^{TFR}) + (1 - 0.2)(L_{2006}^{TFR} + T_{2006}^{TFR})$$

$$L_{2007}^{TFR^{CZ}} = 1.36 \quad (4)$$

$$T_{2007}^{TFR^{CZ}} = 0.495(L_{2007}^{TFR} - L_{2006}^{TFR}) + (1 - 0.495)T_{2006}^{TFR}$$

$$T_{2007}^{TFR^{CZ}} = 0.068 \quad (5)$$

$$\hat{Y}_{2007}^{TFR^{CZ}} = L_{2007}^{TFR} + T_{2007}^{TFR}$$

$$\hat{Y}_{2007}^{TFR^{CZ}} = 1.43 \quad (6)$$

Using Holt's Exponential Smoothing with a trend, the level plus trend for 2007 ($\hat{Y}_{2007}^{TFR^{CZ}}$ is 1.43; the actual for 2007 was 1.45; therefore, there is an absolute deviation of 0.02. This method of forecasting is used in each of the countries' dependent variables: TFR and the SDT1 behavioural index.

3.4 Comparing models using MAD

Holt's and Time Series Regression are employed to project the dependent variables in a time series. One is linear in nature and only has a smoothing predictor (regression); conversely, Holt's considers trends in data and can exaggerate changes over time. The two methods will be compared for accuracy against the known data points using mean absolute deviation, where the lowest deviation represents a more accurate forecast than with a higher number. Each country will be compared for each of the dependent variables.

$$MAD = \frac{1}{n}\sum_n |x_i - \hat{x}_i| \quad (7)$$

In this equation, the forecasted value (x_i) is subtracted from the observed value ($\hat{x}_i$) of the period (i). Then, all the absolute differences between the and the are divided by the n of periods. This represents the mean absolute deviation (MAD). This is one of the statistical methods used to compare forecasting methods to determine a more accurate method. If linear regression is the ideal mode, it contributes to a case to a stepwise regression model.

3.5 Stepwise regression

Stepwise regression progressively adds independent variables to a multivariate regression model while eliminating independent variables that have little or no impact on the dependent variables. Equations (8), (9), and (10) represent the multiple regression formula steps, with SDT1 or TFR as the dependent variable. This would be an example of the 5 steps of the function, provided that all x-variables impact the predictability of y-variables. The initial point in the model is the y-intercept.

Equation 3: Multiple Regression, Stepwise

$$\hat{Y} = \beta_0 + \beta_1 \times x_1 + \beta_2 \times x_2 + \cdots + \beta_5 \times x_5 \quad (8)$$

$$SDT1 = \beta_0 + \beta_1 \times GDP + \beta_2 \times GINI + \beta_3 \times HDI \; (9)$$

$$TFR = \beta_0 + \beta_1 \times GDP + \beta_2 \times GINI + \beta_3$$

$$\times SDT1 + \beta_4 \times HDI \; (10) \quad (10)$$

Each independent variable is tested and combined to find the best fit for the analysis. Cluster analysis for examined cases (countries) will be conducted based on explanatory variables of the best-fitting models, implementing Ward's clustering. This clustering will provide insight into the closeness in relationship between the five populations.

3.6 Data: Demographic indicators

The six indicators of the SDT1 index and the observed dependent and independent indicators were calculated using several data sets within the Eurostat database. Appendix 1 lists the indicators, data sets, descriptions, and calculation methods. Eurostat's indicators have been used when available, including mean age at first marriage (MAFM) and Total Divorce Rate (TDR). Several indicators were calculated for the SDT1 index, comprising Teen Fertility Rate (Fertility < 20 years) (TEENFERT), Total First Marriage Rate (TFMR), and Percent of Non-Marital Births (NONMAR).

3.7 Data: Economic and socioeconomic indicators

The data used in this study to accurately identify predictability relies on accurate and meaningful economic data. The variables used in this study are GDP, GINI, and the HDI. Each of these variables plays a role in understanding the structural differences in

Tab. 3 Historical World Bank Income Categories, Select Countries 2004–2020.

	World Bank Income Classification				
Country	**2004**	**2008**	**2012**	**2016**	**2020**
Austria	High	High	High	High	High
Czechia	Upper-Middle	High	High	High	High
Poland	Upper-Middle	Upper-Middle	High	High	High
Romania	Lower-Middle	Upper-Middle	Upper-Middle	Upper-Middle	Upper-Middle1
Slovakia	Upper-Middle	High	High	High	High

Romania was categorized as a high-income country in 2019 and 2021; 2020 was anomalous in this trend.
Data Source: World Bank Historical Income Levels.

economies. For instance, a country may have a strong GDP per Capita PPP (hereafter GDP) but weak purchasing power, thereby reducing the actual power of the currency in the market. Gini is an indicator of wealth distribution – providing insight into the income quantiles spread of wealth. The perfect distribution of wealth with GINI is 0, whereas the concentration of wealth to one person or entity is "perfect inequality".

Each independent variable will be progressively added to the models to identify the predictability of each variable. Interestingly, the HDI has yet to be used in studies within this context, though analyses have been conducted to observe the relationship between TFR, HDI, and GINI. GDP has been used in several studies, but these indicators have yet to be used in tandem with the SDT1 Behavioural Index. These indicators will build a case to identify the second demographic transition path based on the SDT1 index in relation to GINI, GDP, and HDI – all factors associated with the dual paths of SDT proposed by Sobotka.

To further understand the World Bank income classification, Tab. 3 illustrates the income classification of each studied country. In 2016, the World Bank classification based on GDP per capita shifted downwards, meaning the GDP thresholds were lowered because of the *World Bank Atlas Method* conducted in July of each year (Fantom and Serajuddin 2016). This may be due to the slowed growth compared to previous years relative to the rest of the world. By 2020, the income classifications appeared to return to previous levels, but this reduced threshold may be a reason for Romania's classification as "high income" in 2019 and not 2020.

these shifts are associated with TDR and TFMR. Total marriage rates and total divorce rates declined in all countries. In 2020, Romania had the most intensive spike, which resulted from TFMR and TDR, similarly experienced by Slovakia. Poland's spike in 2020 was primarily associated with TFMR, while all other index scores maintained the same pattern. Czechia's spike only slightly dropped, and it was similar due to the drop in TFMR (Fig. 5).

Slovakia's TEENFERT rate is the explanatory factor associated with the immediate drops in 2017 and 2019 when the teen fertility rate was more significant than 180 live births from females below 20 years per 1,000. Slovakia has traditionally had the highest TEENFERT levels in these five countries and became more emphasized in 2017 through 2021. These indices will be used to understand further the association between the economic variables and the demographic behavior expressed in these countries. Fig. 5 illustrates the transition in the SDT1 index between 2004 and 2021.

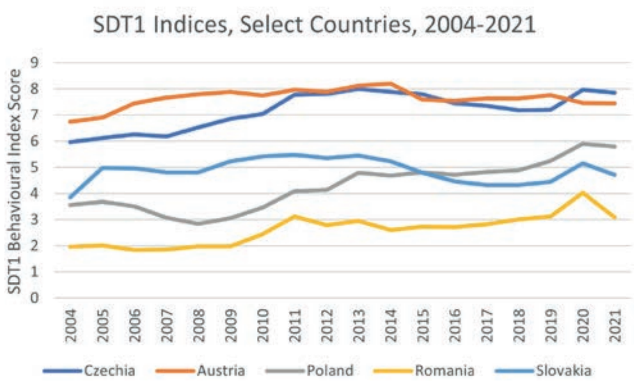

Fig. 5 SDT1 Indices, Select Countries 2004–2021.
Data source: Author's own calculations.

4. Results

The initial findings associated with calculating the SDT1 indices reflect that countries continued to transition, albeit some more than others. Czechia, Slovakia, and Romania follow similar patterns, albeit at varying levels. During the COVID-19 pandemic in 2021, all countries experienced a decline in the SDT1 index (Fig. 5). The most impactful indicators of

Using Sobotka's SDT1 "Behavioral Index" framework, each of the five countries' indices were calculated considering the six indicators. Observable is the instance in 2020 when Austria and Czechia switched roles as the leader. All countries appeared to have improved; however, it also appears that COVID-19 impacted the index.

4.1 Pearson's r correlation

Pearson's r was chosen as an initial method of testing, which is ideal for testing linear relationships with complete available data. The following section will describe and introduce the results of the correlative tests for the factors SDT1, HDI, GDP, GINI, TFR, and TDR. The purpose is to develop a basis for testing between variables in the subsequent regression stage of the study. In this phase, any correlation that results as a moderate or greater level (≥0.4 and ≤−0.4) will be subsequently selected for the regression analysis, either independently or as part of a multivariate model.

Sobotka's dual path theory posits that there are two streams that countries may take that impact the SDT1 index, representing the level of transition. As Western countries became more prosperous, the drive to SDT maturity became more pronounced; in contrast, Central and Eastern European countries tended to have an inverse relationship – lower GDPs and economic uncertainty created a sense of crisis, which has been proposed as one of the reasons for change. GDP, GINI, and HDI have been found to affect TFR and SDT1, amongst other variables, directly or indirectly. The null hypothesis is that SDT1 and TFR should have a strong negative correlation, where TFR should become lower as SDT1 increases (Sobotka 2008). Fig. 6 illustrates the relationship between the two variables across the five countries between 2004 and 2021.

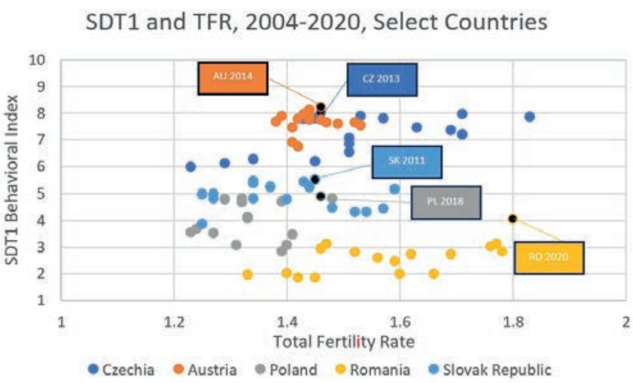

Fig. 6 SDT1 Index and Total Fertility Rate, Select Countries 2004–2020.

Data Source: TFR: Eurostat (2024); SDT1: Author's Own Calculations.

This scatter plot illustrates the correlation between the SDT1 Behavioral Index and the Total Fertility Rate of each of the five select countries. The boxes and arrows indicate the highest SDT1 indices. Notably, the highest SDT1 indices seem to all be when 1.46 > TFR > 1.45, while Romania is the outlier, with a TFR of 1.8 at the highest SDT1.

The most substantial relationship between the SDT1 index and TFR is moderate and found only in Romania and Czechia. The strongest non-negative correlation was observed in Czechia (0.601), while the lowest correlation was in the Slovak Republic (−0.114), and Austria demonstrated nearly no correlation (0.100). The two variables are unrelated despite the moderate correlations associated with SDT1 and TFR. Thus, the results did not support the hypothesis of a negative correlation between TFR and STD1. The mean r coefficient amongst the five countries was 0.304, with a MAD of 0.264. Despite a below-moderate correlation coefficient, Romania and Czechia should be further investigated using a more robust model, such as multivariate regression. Complete descriptive data results can be viewed in Tab. 4, and a complete audit of the Pearson r results is in Appendix 2.

Tab. 4 Descriptive Data, Pearson's r Coefficients 2004–2021, Select Countries.

	Min	Max	Mean	MAD	Range
SDT1-HDI	0.131	0.874	0.611	0.204	0.743
SDT1-GDP	0.036	0.856	0.566	0.252	0.820
SDT1-GINI	−0.621	0.687	−0.030	0.390	1.308
SDT1-TDR	−0.297	0.902	0.300	0.414	1.199
SDT1-TFR	−0.114	0.633	0.309	0.253	0.747
HDI-GDP	0.844	0.978	0.936	0.037	0.135
HDI-TDR	−0.849	0.639	−0.296	0.539	1.489
HDI-TFR	0.668	0.914	0.803	0.063	0.246
GDP-GINI	−0.867	0.338	−0.336	0.448	1.205
GDP-TDR	−0.879	0.588	−0.374	0.539	1.467
GDP-TFR	0.731	0.962	0.844	0.082	0.231
GINI-TDR	−0.348	0.754	0.168	0.347	1.103
GINI-TFR	−0.813	0.195	−0.398	0.411	1.008
TFR-TDR	−0.887	−0.044	−0.503	0.367	0.844

The most significant coefficients are between GDP and TFR, with a minimum and maximum value of 0.731 and 0.962, respectively, and a mean absolute deviation of only 0.082 – the second lowest MAD of the correlative study. There may be a connection between GDP and TFR; the result discovered here implies that all the countries' TFRs increased with GDP simultaneously. Compounding these results with the outputs between SDT1 and GDP, it becomes clearer how GDP may be associated with the demographic transition.

There appears to be a distinct relationship between the Human Development Index (HDI) and TFR, further validating the findings of Myrskylä, Kohler, and Billari (2009). With a min-max of 0.668 and 0.914 and a low MAD of 0.063, this output is the most significant of the correlative tests, as seen in Fig. 7. Because of the strength of the relationship, HDI will be used as an initial independent value in the stepwise framework. Similar steps will be taken with the TDR independent variable, as HDI has a strong relationship with GDP and SDT1, but GDP and SDT1 do not have as significant a relationship. In the search for predictor values, GDP will be used as a compounding variable.

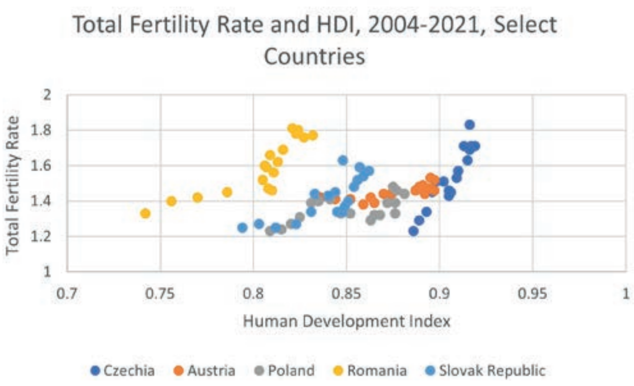

Fig. 7 Total Fertility Rate and HDI 2004–2021, Select Countries.
Data Source: TFR: Eurostat (2024); HDI: World Bank (2023).

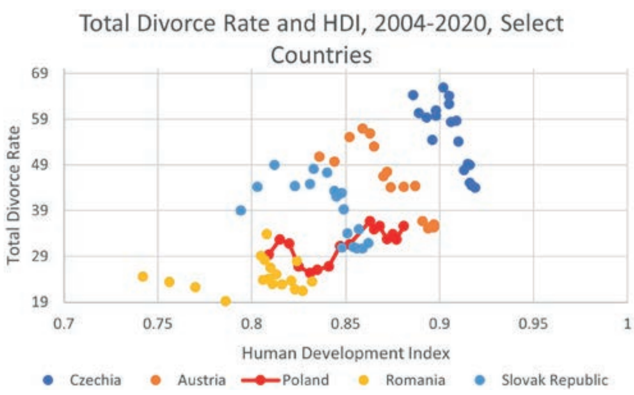

Fig. 8 Total Divorce Rate and HDI 2004–2020, Select Countries.
Data Source: TDR: Eurostat (2024); World Bank (2023).

The correlation between HDI and TFR is quite strong and has a linear path; that is, it follows a chronological pattern in the development of both indicators. As the Human Development Index increased, so did the TFR. Though the outliers of the patterns are not counter to the normal developments, the correlation between Austria and Poland is less pronounced. The patterns of the other three PSCs remain very closely aligned in pattern despite differences in levels of human development.

Considering the relationship between HDI-TFR and TFR-GDP, it is essential to note that GDP and HDI have strong relationships: 0.937 (Czechia), 0.963 (Austria), 0.978 (Poland), 0.844 (Romania), and 0.844 (Slovak Republic). According to Hamadeh, Rompaey, Metreau, Eapen's (2022) data, Romania was classified as a Lower Middle-Income country in 2004, and Poland, Slovakia, and Czechia were classified as middle-income countries. In only two years, from 2004 to 2006, Czechia progressed to a high-income country, and Romania was classified as an upper-middle-income country. A year later, the Slovak Republic caught up to Czechia; however, it was not until 2009 that Poland was classified as a high-income country. Romania finally caught up to the rest of Europe in 2019 and was classified as a high-income country; however, this may have partly been due to a lowered threshold from 2016 to 2019, causing a temporary relegation to upper-middle income in 2020. This contextualizes the value associated with GINI, GDP, and other indicators.

Fig. 8 demonstrates an inverse relationship between TDR and HDI in Czechia, Austria, and the Slovak Republic. Interestingly, Poland exhibited a moderate positive correlation, while Romania had minor results, illustrated in the figure as a line. In a previous study by Vlasov et al. (2023), the relationship between TDR and HDI was negligible – like the experience in Romania. When identifying the depth of these results, it becomes apparent that the total fertility and divorce rates have a relationship with HDI and, subsequently, a strong relationship with both GDP and SDT.

This figure illustrates the association between divortiality and the Human Development Index. The negative correlations between the variables in Czechia, Slovakia, and Austria can be observed, while there appears to be an inverse relationship between the variables in Poland and Romania. There does not appear to be a common threshold across the countries; however, there do appear to be similar trends. Simpson's Paradox appears in this example.

The initial findings from this step of the research uncovered several interesting insights. The results included the moderate relationship between SDT1 and TFR and the surprisingly strong relationship between GDP and HDI with TFR, and SDT1 (Appendix 2). Three countries had moderately strong negative correlations between GINI and TFR, and interestingly, the TFR and TDR in Czechia with the GINI demonstrated the same but inverse coefficient GINI/TDR = 0.754; GINI/TFR = −0.754). Fig. 9 demonstrates an interesting take on the Simpsons Paradox – in each of the five populations, there is an inverse relationship between TDR and GINI; however, when all data is combined, there is a positive correlation between TDR and GINI.

4.2 Holt's Exponential Smoothing and linear regression testing

Before progressing with associative testing techniques, Holt's Exponential Smoothing forecasting technique was run to determine the level of predictability of variables TFR and STD1 in a time series model. results are interesting, especially compared to a linear regression time-series model. Holt's indicated a higher MAD (Mean Absolute Deviation) than the single-factor time-series regression model (Tab. 7). This means that on their own, without any predictor values, variables of TFR and STD1 had a slightly lower level of predictability using the α and β (Holts) than the alternative method of linear regression time-series model (LR).

Tab. 6 Holt's Exponential Smoothing Constants, Variables.

	α	β
SDT1	0.05	0
TFR	0.2	0.495

Note: α = level component, β = trending component.

Tab. 7 illustrates the better prediction of the linear regression model against the exponential smoothing model, with the actual values of the TFR in Czechia as an example. The figure below illustrates that the MAD of the TFR forecast for Czechia is much lower, with regression (2.63), than Holt's (4.72).

The trending component of exponential smoothing exaggerated the peak and drops as observed in Fig. 9. Under every condition, simple linear regression is better than Holt's for these data. Holt's method tends to be over-aggressive because of the trending from the beta (β) constant. In this case, Holt's method is not ideal for forecasting Romania's TFR because of the sudden shifts in trend; however, it adequately forecasted the TFR for Austria. Under these circumstances, the forecasting for both Linear Regression and Holt's is nearly identical for Austria – meaning that either would be reasonably accurate. Neither of these methods perfectly predicts SDT1 or TFR; however, in general, linear regression was a better fit aggregated over the years. As observed in Fig. 10, the predictability for SDT1 remained quite similar using both models.

Fig. 9 illustrates the difference in the predictability of the two single-variable forecasting methods – Holt's Exponential Smoothing and Simple Linear Regression. These have both been used in Czechia and Austria using the TFR data. Due to Austria's relatively low variance compared to Czechia's, both methods work well; however, the greater variance in Czechia's data caused Holt's method to deviate more than Linear Regression.

In Fig. 10, SDT1 for Romania and Austria are predicted using Holt's Exponential Smoothing and Simple Linear Regression. Austria's observed data tends to have a low variance, which makes the predictability with both methods quite accurate. Romanian's data had slightly less aggregate variance and, therefore, less deviation than Austrian data. Under both circumstances, simple linear regression is a better predictor model, though Holt's adequately predicts SDT1 for Austria and Romania.

Despite being generally poor fit for predicting the TFR, Holt's forecasts the changes in the SDT1 Behavioural Index reasonably well. This may be due to the closeness to trend projection for the changes in Austrian levels from 2005–2015, where linear regression had continued to over-predict, Holt's tended to maintain a closer relationship with the observed data. This is not unlike the data found when predicting Romania's SDT1 index. These findings may be due to the relatively level behavioral index – Holt's β was 0, meaning that the leveling function was the only predictor. The linear regression and Holt's models are good fits for predicting the SDT1 index, although the linear regression model remains slightly better.

These two models are accurate by individual measures; however, the linear regression model tends

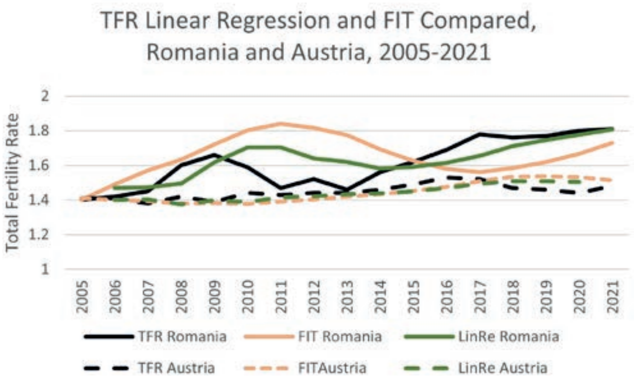

Fig. 9 Linear Regression and Holt's Exponential Smoothing Compared, TFR, Romania and Austria.

Data Source: Author's Own Calculations.

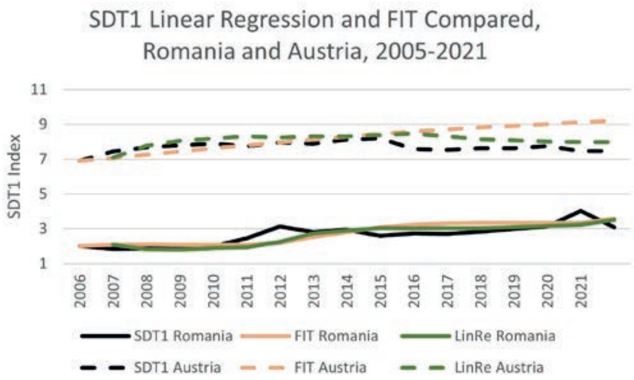

Fig. 10 Linear Regression and Holt's Exponential Smoothing Compared, SDT1, Romania and Austria.

Data Source: Author's Own Calculations, Excel.

Tab. 7 MAD, Linear Regression and Exponential Smoothing with Trend.

	CZ		AU		PL		RO		SK	
	Holts	LR	Holts	LR	Holts	LR	Holts	LR	Holts	LR
SDT1	0.31	**0.31**	0.35	**0.18**	0.29	**0.27**	0.26	**0.21**	0.71	**0.32**
TFR	4.72	**2.63**	2.52	**2.41**	4.28	**1.95**	3.19	**1.85**	5.22	**2.57**

Data Sources: Author's Own Calculations, Excel.

to predict SDT1 and TFR better. There appears to be a pattern of predictability; however, as dependent variables on their own, there is an opportunity to explore the predictability of these patterns by observing independent variables' changes and their associations to the dependent variables. By implementing an associative technique using the stepwise regression model, it is anticipated that there will be more accurate predictors of change.

4.3 Stepwise regression

Stepwise regression assessed the predictive capacity of independent variables such as GDP, GINI, and HDI on SDT1, and GDP, GINI, HDI, and SDT1 on TFR. Utilizing a 95% probability-in-confidence level, the model was adjusted to remove variables with a Probability of f (removal level) set at > 0.1, indicating variables were excluded if they fell below 90% probability. The analysis revealed significant, albeit varying, strengths among the independent variables across different countries, demonstrating an overall significant connection and establishing these models as robust predictors for TFR and SDT1. The predictive capacity for SDT1 was weaker than TFR, presenting a range from moderate to strong associations based on a combination of the adjusted R^2, Standard Beta Coefficient, and significance level. The standard beta coefficient was chosen as a metric due to the standardized output in relation to the varying size of the data for each of the variable outputs.

4.3.1 Stepwise linear regression, Y = TFR

The comparative analysis of predictive models for TFR outcomes across the study populations revealed distinct variations, highlighting the nuanced relationship between demographic trends and economic indicators (Tab. 8). GDP was identified as a vital predictor across the dataset, with the notable exception of Poland, indicating divergent socioeconomic or policy influences on fertility within this context. In Czechia, the SDT1 index had a negligible influence on TFR predictability. Its statistical insignificance ($p < 0.05$) and exclusion from the model suggest a limited or non-existent connection in this specific analysis. Similarly, the SDT1 index did not emerge as a significant factor in model predictability in Poland, contrasting with its discernible impact on the models for Austria and Romania. As encapsulated by GINI, wealth distribution dynamics demonstrated a varying degree of predictive strength in Poland and notably enhanced the model's predictive accuracy for Czechia. This underscores the importance of considering economic disparities alongside GDP in understanding the socioeconomic determinants of fertility rates, emphasizing the complex interdependencies between economic conditions and demographic behaviors.

Stepwise regression analysis, a methodical approach designed to identify the most statistically significant independent variables affecting dependent variables, often identifies variables with p-values as low as 0.000. This outcome indicates a significant relationship, underscoring the method's utility in discerning key predictors from potential variables. However, it is essential to acknowledge the limitations inherent to stepwise regression, including potential overfitting, biased estimates, and the model's sensitivity to the order of variable inclusion. These factors can affect the reliability and interpretability of the results, particularly in datasets prone to multicollinearity or when many variables are considered.

In the analysis of Austria's fertility trends, the HDI demonstrated a relationship of moderate strength, suggesting that HDI alone did not emerge as a dominant predictive factor. This observation points to the nuanced role of HDI in modeling fertility rates, highlighting the complexity of socioeconomic influences on demographic patterns. While HDI is a composite measure encompassing life expectancy, education, and income, pivotal in understanding socioeconomic development and its demographic implications, its predictive capacity may depend on interaction with other socioeconomic and cultural variables. This nuanced interpretation suggests that, particularly in economically advanced contexts like Austria, the relationship between HDI and fertility trends

Tab. 8 Select Stepwise Regression Outputs, TFR.

Country	Model	Adjusted R2	Stand. Coef. Beta	Significance	F
Czechia	(1) GDP	.920	0.962	0.000	184.537
	(2) GINI	.940	−0.260	0.027	126.598
Austria	(1) HDI	.570	0.773	0.000	22.216
	(2) SDT1	.685	−0.411	0.000	18.389
	(3) GDP	.756	−0.948	0.000	17.504
Poland	(1) GINI	.618	−0.801	0.000	26.333
Romania	(1) GDP	.812	0.908	0.000	70.046
	(2) SDT1	.851	−0.385	0.000	46.725
Slovakia	(1) GDP	.739	0.869	0.000	43.363

Source: Author's Own Calculations, SPSS.

necessitates a comprehensive analytical approach, considering a broader array of factors beyond HDI to accurately capture the dynamics at play.

Within the context of the four PSCs examined, a consistent linkage was observed between GDP growth and variations in TFR. This relationship not only underscores the impact of economic expansion on demographic patterns but also highlights the critical role of wealth distribution within these countries, as evidenced by the GINI coefficient. Such findings clarify the intricate dynamics between economic development, income inequality, and fertility trends, suggesting that economic prosperity and its equitable distribution across the population are pivotal determinants of fertility rates in these settings. This analysis highlights the complex matrix of economic and socio-demographic factors that orchestrate fertility behaviors, signifying a comprehensive framework for understanding how economic policies and societal wealth distribution mechanisms influence demographic outcomes.

Fig. 11's dendrogram illustrates the likeness of three countries, Poland, Slovakia, and Czechia, using Ward's Clustering. SK and RO are the most similar and PL and CZ are the second most closely related. The closeness of PL and CZ may be related to the inclusion of GINI – the only two populations in this study with this variable included.

Delving deeper into the comparative analysis of nations based on the dataset, employing Ward's hierarchical clustering utilizing two distinct groupings by the second distancing level. The elements and codes can be found in Appendix 3. This method reveals a pronounced affinity between Romania and Slovakia and a notable closeness between Poland and Czechia, suggesting a significant degree of similarity in their demographic and economic profiles. Austria becomes associated with this cluster at a secondary level, marked by a semipartial R2 of 0.2240 (R2 = 0.437) when juxtaposed with Poland and Czechia (R2 = 0.661), and itself, highlighting the relative divergence in their characteristics. Furthermore, Austria's positioning is markedly distant from the Slovakia-Romania nexus, with a semipartial R2 of 0.1267, suggesting a dissimilarity that could be attributed primarily to the differential roles of the HDI in Austria and the SDT1 index in both Romania and Austria. This variance underscores the nuanced underpinnings of demographic and economic indicators in shaping the relational dynamics between these nations, suggesting that HDI and SDT1 are pivotal factors in understanding the broader socioeconomic landscape across these countries.

A key finding from this data is the relationship of economic factors on the transitions in fertility in the top three countries and the SDT1 index and HDI in the bottom two. These results indicate that the SDT1 behavioural index can be used as a predicting indicator for Romania and Slovakia but does not help predict Czechia, Austria, and Poland; instead, economic well-being is a stronger predictor. What is most exciting about this clustering is the indication that economic prosperity and distribution of wealth are vital explanatory variables that had previously been negatively related. The implications of these results will be further expanded upon in Discussions.

4.3.2 Stepwise linear regression, Y = SDT1

Predicting the SDT1 behavior index trend was not as prominent as with TFR; however, key takeaways exist. Firstly, Slovakia had the least significant model (Tab. 9). No independent variables fit the model with a probability-in (PIN) level of < 0.05; therefore, it was necessary to increase the PIN to < 0.1 – meaning that there was a lower probability that the variables impacted the dependent variables. This data was related to the significance of GINI in all models except for Romania. The limited use of HDI in the stepwise approach for AU, PL, and RO was surprising, as in previous literature, it was found that HDI had an impact on demographic change. GINI predicts SDT1, but HDI – including life expectancy, GNI, and educational attainment – only impacted to a shallow degree

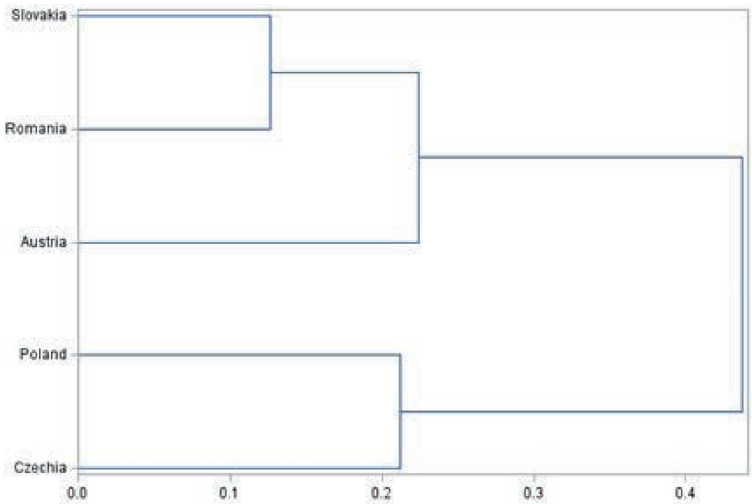

Fig. 11 Dendrogram, Adjusted R2, Ward's Clustering, TFR
Source: Author's Own Analysis, SAS.

Tab. 9 Select Stepwise Regression Outputs, SDT1.

Country	Model	Adjusted R2	Stand. Coef. Beta	Significance	F
Czechia	(1) HDI	0.582	0.763	0.000	20.923
	(2) GINI	0.797	0.936	0.000	27.462
Austria	(1) GINI	0.444	0.692	0.002	13.801
Poland	(1) GDP	0.806	0.905	0.000	67.505
	(2) GINI	0.876	0.422	0.000	57.641
Romania	(1) GDP	0.668	0.830	0.000	33.199
Slovakia*	(1) GINI**	0.229	0.204	0.061	4.164
	(2) HDI**	0.436	0.206	0.024	5.019

* No variables met the threshold of significance < 0.05
** Probability-in threshold was altered to < 0.1
Source: Author's Own Calculations, SPSS.

Model 1 in Czechia (R2 = 0.582) and Model 2 in Slovakia (R2 = 0.436).

Czechia and Poland have negative correlations between SDT1 and GINI (–0.413 and –0.621, respectively; (Appendix 2) – meaning that as wealth distribution becomes more equal, SDT1 behaviors continue progressing with the expectations of the Second Demographic Transition. This contrasts with Austria, where there is a surprising positive correlation between GINI and SDT1 – the more unequally wealth is distributed, the higher the SDT1 rates rise. It is at a moderate Pearson r coefficient (0.687;), and GINI explains about 47.9% of the variances in SDT1. This is a primary indicator of the two paths of the SDT; however, wealth distribution appears to be a differentiating factor rather than economic prosperity.

Unexpectedly, HDI was not a significant predictor of SDT1 change in Romania or Poland despite generally strong Pearson r correlations (0.706 and 0.874, respectively). When isolating the variables HDI and SDT1 and running regression analyses, there is evidence to explore the impact of the SDT1 index on the HDI, as the R2 of those isolated variables in linear regression is 0.764, and a significance level of < 0.001 and an F score of 45.31. This indicates that SDT1 is an independent rather than a dependent variable, as initially posited.

The dendrogram of Ward's hierarchal clustering below, Fig. 12, illustrates that Slovakia and Czechia have the highest level of closeness in terms of clustering, with Romania and Austria matching about five points later. CZ and SK are similar in that they are both dissimilar to the rest. The R2 for Slovakia-Czechia is 0.891 – close in similarity and important in the model; however, it only explains 10.9% of the model variance (semipartial R2 = 0.1087). In the Second level, where the nexus of Romania and Austria (R2 = 0.719, Semipartial R2 = 0.1720) meet Poland (Cluster 4), the R2 is 0.472. This may have more to do with the inclusion of GINI into the models for each country than any other variable.

This dendrogram illustrates the likeness and predictability of Czechia, Austria, Poland, Romania, and Slovakia by variables and significance. This graph shows the likeness of Austria and Romania, and Slovakia and Czechia. Poland had similar probability-in variables; however, it also exhibited the highest adjusted R2 of all populations examined.

This research examined the intricate dynamics between demographic shifts, epitomized by the SDT1

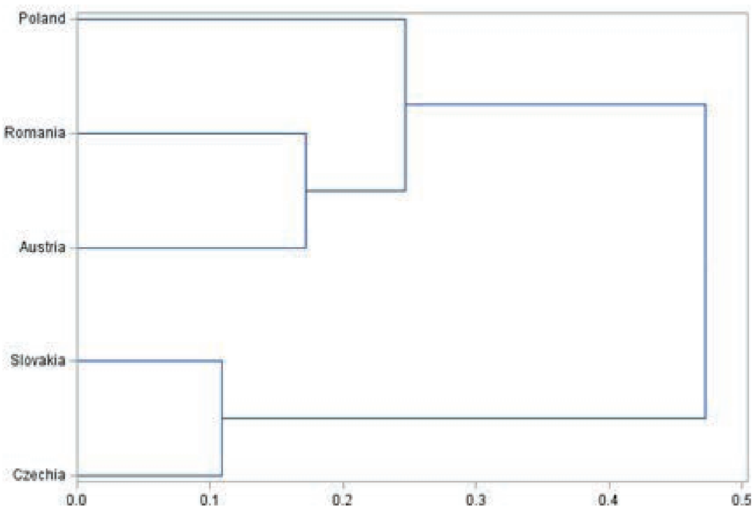

Fig. 12 Dendrogram, Adjusted R2, Ward's Clustering, SDT1.
Source: Author's Own Analysis, SAS.

indices, and economic indicators amidst the backdrop of the COVID-19 pandemic. The study has explained some complex interrelations that impact these phenomena by employing various analytical models, including Pearson's r correlation coefficients, Holt's Exponential Smoothing, linear time regression, and stepwise multiple regression analyses. The analysis results have unveiled a significant, though diverse, influence of economic metrics such as GDP, GINI, and HDI on demographic patterns, particularly regarding total fertility rates (TFR) and the SDT1 index, which includes several demographic indicators. These findings demonstrate a moderate to strong linkage between these economic measures and demographic outcomes, highlighting the critical influence of economic growth, income distribution, and human developmental achievements upon population and demographic transitions. Intriguingly, Czechia, Slovakia, and Romania exhibited congruent trends in demographic shifts, albeit with varying intensities, underscored by the direct impact of economic variables on these transitions.

Furthermore, the study has uncovered an unexpected resilience and predictive capacity of demographic trends in response to economic alterations, as evidenced by the accuracy of Holt's Exponential Smoothing compared with linear regression models. This indicates that demographic variables react predictably to economic fluctuations and follow patterns that can be forecasted with considerable precision. The research also pinpointed certain limitations, such as the minimal influence of the SDT1 behavioural index in forecasting fertility under these population contexts. This highlights the multifaceted nature of demographic changes, which elude variance explanation by economic indices alone. The correlation strength and significance disparity across various nations accentuate the role of unique national attributes, including cultural norms, societal structures, and policy frameworks, in shaping demographic conduct.

Through stepwise regression analysis, the investigation further refined population change conception, earmarking GDP and GINI as recurrent predictors across numerous models and explaining the intricate role of the SDT1 index in forecasting demographic shifts. This substantiates the notion that the demographic transformations observed in the countries under review are profoundly entangled with economic status, wealth allocation, and levels of development. An intriguing result of these analyses is the impact of GDP and GINI and the remaining differences in SDT1's influence on TFR. Of the study, the highest and lowest GDP nations (Austria and Romania, respectively) produced results in the stepwise regression model where SDT1 was a predictor of TFR. Both of these countries, Austria and Romania, also have the highest GINI coefficient, indicating the most significant wealth inequality.

5. Discussion and implications

This research explored the complex interplay between the Second Demographic Transition Index (SDT1) and an array of economic variables, shedding light on the intricacies of demographic evolution in the modern landscape. Our analysis has uncovered a nuanced, though deep, connection between the SDT1 index – a barometer for behavioral shifts in demographic indicators, including the age of marriage, cohabitation, childbearing, and teen fertility. These connections bring to the forefront the significant influence of economic conditions, as captured through the Gross Domestic Product per capita PPP (GDP) and the Gini coefficient, on the patterns of demographic behavior that span diverse socioeconomic backdrops.

Delving deeper, the study supports how the SDT1 index acts as a pivotal lens through which the evolution of societal behaviors can be assessed, reflecting broader changes in behavior toward family life and reproductive decisions. The intricate relationship between this index and demographic outcomes highlights the sensitivity of fertility and marital stability to the undercurrents of economic prosperity and income distribution. It is evident that economic variables such as GDP and the Gini coefficient are not mere background factors but are intimately linked with the foundation of demographic changes, influencing decisions at the most personal and societal levels.

The economic landscape, characterized by the GDP, provides a backdrop against which the drama of demographic transitions unfolds, suggesting that an economy's vibrancy can significantly sway demographic trends. Concurrently, as a measure of income inequality, the Gini coefficient offers insights into the disparities within this economic backdrop, further influencing demographic behaviors. This duality of economic prosperity and distribution paints a complex picture of how economic realities shape demographic shifts, from fertility patterns to marital formations and dissolutions.

The findings from this study extend beyond mere statistical correlations, weaving a narrative that captures the dynamic interplay between economic conditions and demographic transitions. They underscore the critical need for a holistic understanding of demographic changes, encompassing the economic drivers and the societal responses to these changes. This investigation, therefore, contributes to the academic discourse on the socioeconomic underpinnings of demographic rates and highlights the importance of integrating economic insights with demographic research to fully grasp the multifaceted nature of societal evolution in the contemporary era.

5.1 The dual paths re-examined

Sobotka (2008) posited that the second demographic transition is driven not by a single common reason but by a conventional path, which signified economic prosperity and a post-socialist path through economic crisis. This research initially recreated the SDT1 index to identify the changes observed from year to year since 2004. In this timeframe, it is clear that every country is trending toward more intense behaviors associated with the second demographic transition. The most notable jumps in SDT1 were in Poland (2.35), Romania (2.07), and Czechia (1.99), while Austria appeared to remain nearly stagnant. Initially, Austria was one of the countries on the primary path of transition, while post-socialist countries experienced the alternative pathway. This data leads to signs that these two paths are converging. This is most evident in Czechia and Poland, where economic prosperity and behavioral transitions have occurred.

Though this paper focuses on four select PSCs and Austria, which provides some insight into variable transitions, there is an opportunity to expand this research to cover more geographies, populations, and gender-specific dynamics, including using the gender equality index and the Global Gender Gap Report. The phenomena associated with changing economic and political structures and subsequent effects related to population and fertility change maintain significant value in policy and research. This critical longitudinal study should be tracked over several decades, as these patterns may influence policies as much as policies seem to influence the paths.

6. Conclusion

Population dynamics are ever-changing, and the phenomena that influence these distinctive changes are broad. The PSCs examined in this paper have shown signs of considerable movement towards the second demographic transition with respect to traditionally postmodernist countries. In terms of influence upon the second demographic transition, levels of income inequality tend to be the most significant predictor of change. Of the PSCs, only Romania showed evidence of SDT behavior's impact on fertility changes. This indicates that behavioral changes associated with the second demographic transition are more likely impacted by GINI and GDP than human development. This is also true for changes in fertility patterns, which are most predictable based on GDP and GINI.

Regarding factors predicting TFR, Poland and Slovakia are most alike, whereas Austria is the least similar to any other country. This is in contrast to the predictability of SDT1, where Slovakia is the least like the rest of the countries. Several factors may cause this to be the case, but the explanatory factors that are most insightful with respect to the overall changes in GDP, where in 2019, Slovakia became the weakest economy of the population groups and had the lowest GINI coefficient, meaning the most significant income equality. The most significant shifts were with Czechia, which recorded the highest SDT1 index of the 5 populations. Besides the highest total fertility rate, Czechia is uniquely positioned among PSCs and all the countries in the study. Czechia has transitioned exceptionally well since 1989 compared to other PSCs and is on par with the rest of the post-modernist European countries.

Overall, the SDT1 behavioural index provides some insight into the changing fertility rate phenomena across Europe; however, the index appears to be a dependent variable and holds very limited predictability for fertility. Conversely, fertility rates appear to have no meaningful impact on the SDT1 behavioural index. Future research should include a more robust set of countries and perhaps a regional SDT1 behavioral index for several countries to determine the most and least transitioned regions within each country. This may provide insight into how different population densities contextualize the root issue. It is imperative to recognize that the SDT1 is a valuable index that may act as a barometer for changing conditions but is not necessarily a predictor of fertility changes.

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Appendix 1 Data, Sources, and Methodology.

Name	Code	Dataset	Description of Dataset	Calculation Method
Median Age at First Childbirth	MAFB	Eurostat, Fertility Indicators (demo_find)	Dataset has several indicators, one of which is MAFB	No calculation Required
Age Specific Rate Below Age 20/1000	TEENFERT	Eurostat, Live Births by Mothers Age (demo_fordagec) Eurostat, Population on 1 January by age and sex (demo_pjan)	Total live births by age – < 14 to > 20. B_{x_t} Total Population by Age and Sex P_{x_t}	Live births in a year divided by the average of the next year's 1 January population, summed to represent the total fertility for under-20 years old. $\sum_{t}^{r,<20} \frac{B_{x_t}}{(P_{x_t}+P_{x_{t+1}})/2}$
Total First Marriage Rate (n_{x^r})	TFMR	Eurostat, Population on 1 January by Age, Sex, and Legal Marital Status (demo_pjanmarsta) Eurostat, First-Time Marrying Persons by Age and Sex (demo_nsinagec)	Total population on the first day of the year by age and sex. Marital Status did not impact this calculation. P_{x_t} Primo-Nuptiality by age and sex, up to 59 years $PN^1_{x_t}$	Primo-Nuptiality rates per age is the number of first marriages. This is calculated by summing each of the age-specific primo-nuptiality rates, as illustrated: $\sum_{t}^{r} \frac{PN^1_{x_t}}{(P_{x_t}+P_{x_{t+1}})/2}$
Percent of Non-Marital live Births	NONMAR	Eurostat, Live Births by Mothers Age and Legal Marital Status (demo_fagec)	Two points of data were derived from this data set. First were non-marital live births: $B^{nm}_{x_t}$ The second was the total live births: $B^{P}_{x_t}$	The Percentage of non-marital live births has been calculated as: $\frac{B^{nm}_{x_t}}{B^{P}_{x_t}}$ The output represents the percentage of extra-marital live births each year.
Mean Age at First Marriage	MAFM	Eurostat, Marriage Indicators (demo_nind)	Data includes 8 indicators. The indicator used for this study was "Mean Age at First Marriage – Females"	No calculation Required
Total Divorce Rate	TDR	Eurostat, Divorce Indicators (demo_ndivind)	Data includes 3 indicators. The indicator used for this study was "Divorces per 100 marriages"	No calculation is required.
Total Fertility Rate	TFR	Eurostat, Live Births by Mothers Age (demo_fordagec) Eurostat, Population on 1 January by age and sex (demo_pjan)	Total live births by age group > 14 to < 20. B_{x_t} Total Population by Age and Sex P_{x_t}	$\sum_{t}^{r} \frac{B_{x_t}}{(P_{x_t}+P_{x_{t+1}})/2}$
GINI Index	GINI	World Bank GINI Coefficients (SI.POV.GINI)	GINI Index indicates the disparity in income from upper and lower earners based on income deciles.	No calculation – indexed on the World Bank
Gross Domestic Product per Capita, Purchasing Power Parity	GDP	World Bank Gross Domestic Product per Capita PPP (Current USD) (NY.GDP.PCAP.PP.CD)	World Bank Calculation of the gross domestic product per person at purchasing power parity and standard.	No calculation- indexed on World Bank
Human Development Index	HDI	UNDP Human Development Report HDI (HDR23-24_Stistical_Annex_HDI_Table)	United Nations HDI is calculated based on education, health, and GNI – updated annually	No calculation, Indexed by UNDP

Appendix 2 Pearson's r Coefficients, All Countries.

	Czechia	Austria	Poland	Romania	Slovakia
SDT1-HDI	0.763	0.579	0.874	0.706	0.131
SDT1-GDP	0.644	0.467	0.856	0.830	0.036
SDT1-GINI	−0.413	0.687	−0.621	0.159	0.037
SDT1-TDR	−0.297	−0.137	0.902	0.437	0.597
SDT1-TFR	0.601	0.100	0.323	0.633	−0.114
HDI-GDP	0.937	0.963	0.978	0.844	0.956
HDI-GINI	−0.828	0.419	−0.845	0.528	−0.328
HDI-TDR	−0.775	−0.849	0.639	0.115	−0.612
HDI-TFR	0.914	0.792	0.668	0.850	0.792
GDP-GINI	−0.717	0.338	−0.867	0.110	−0.542
GDP-TDR	−0.873	−0.879	0.588	0.013	−0.718
GDP-TFR	0.962	0.753	0.731	0.908	0.869
GINI-TDR	0.754	−0.104	−0.348	0.089	0.449
GINI-TFR	−0.754	0.036	−0.813	0.195	−0.655
TFR-TDR	−0.834	−0.887	−0.044	−0.044	−0.704

Source: Author's Own Calculations, SPSS.

Appendix 3 Clustering Input, TFR.

	GDP	GINI	HDI	SDT1
Austria	0.756	0	0.570	0.685
Czechia	0.920	0.940	0	0
Poland	0	0.618	0	0
Romania	0.812	0	0	0.851
Slovakia	0.739	0	0	0

Appendix 4 Clustering Input, SDT1.

	GDP	GINI	HDI
Austria	0	0.797	0.582
Czechia	0	0.444	0
Poland	0.806	0.876	0
Romania	0.668	0	0
Slovakia	0	0.229	0.436

Appendix 5 Ward's Hierarchical Clustering Outputs, TFR.

Cluster History, TFR					
# Clusters	Clusters Joined		Freq	Semipartial R^2	R^2
4	Romania	Slovakia	2	0.1267	.873
3	Czechia	Poland	2	0.2123	.661
2	Austria	CL4	3	0.2240	.437
1	CL3	CL2	5	0.4370	.000

Appendix 6 Ward's Hierarchical Clustering Outputs, SDT1.

Cluster History, SDT1					
# Cluster	Clusters Joined		Freq	Semipartial R2	R2
4	Czechia	Slovakia	2	0.1086	.891
3	Austria	Romania	2	0.1720	.719
2	CL3	Poland	3	0.2472	.472
1	CL4	CL2	5	0.4722	.000