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SOCIOECONOMIC DRIVERS OF SUICIDE RATES ACROSS EUROPEAN COUNTRIES: A BAYESIAN MODEL AVERAGING

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ABSTRACT

This article aims to examine socioeconomic determinants of suicide rates across European countries. Using Bayesian Model Averaging and panel data specification with fixed effects on a sample of 25 European countries and two subsamples between 2001 and 2019, a data-driven model was estimated. Empirical findings for the whole sample suggested GDP per capita as a regressor with very strong posterior inclusion probabilities and negative effects of GDP per capita on suicide rates. Marriage rates appeared with positive inclusion probabilities and effects from marriage rates to suicide rates were negative. Share of population ages below fifteen years and divorce rates were identified as regressors with weak inclusion probabilities. The effects from a share of the population aged below fifteen years to suicide rates were negative while effects from divorce rates to suicide rates were positive. Empirical findings for a subsample of post-socialist countries revealed divorce rates as the most prominent regressor explaining suicide rates in post-socialist countries with very strong posterior inclusion probabilities. Female participation in the labour force and share of the urban population appeared as regressors with strong prior inclusion probabilities. The effects of female participation in the labour force on suicide rates were negative as well as the effects of urbanization on suicide rates. GDP per capita appeared as a regressor with positive inclusion probabilities and the effects of GDP per capita on suicide rates were negative. For a subsample of non-socialist countries, empirical findings suggested a share of the urban population and female participation in the labour force as regressors with very strong posterior inclusion probabilities. Unlike the estimates for the subsample of post-socialist countries, effects from participation in the labour force to suicide rates as well as from urbanization to higher suicide rates were positive.

KEY WORDS

suicide, socioeconomic factors, data-driven model, Bayesian model averaging

CLASSIFICATION

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INTRODUCTION

Attitudes towards suicide are complex and variable due to their dependence on very complicated social and cultural systems in which they exist [1, 2]. Suicide is a multifactorial and multi-layered phenomenon. Determinants of suicide seem to vary not only over time and across countries but also depend on model specification and estimation methods [3]. There is a need for a better understanding of suicide drivers. Hence, there is a space for further empirical as well as theoretical consideration of the topic. This article aims to contribute towards an understanding of suicide rates across European countries by providing empirical estimates of its determinants. Based on the previous literature findings, there are many potential socioeconomic determinants of suicide. Therefore, we are uncertain about which regressors to include in a model specification. While considering the uncertainty this article brings empirical estimates of suicide rates for a sample of 25 European countries and a subsample of 11 European post-transition countries between 2001 and 2019.

Besides the introductory part, the remainder of this article is organized as follows: Section 2 briefly summarizes existing literature related to the topic under consideration. Section 3 presents research methodology, while Section 4 empirical results and discussion. The final section provides an overview of the main findings of the research.

BRIEF LITERATURE REVIEW

Milner [4] based on panel data for 35 countries over the period 1980–2006 found female labour force participation, unemployment, and the proportion of persons over 65 years as the main drivers of the increase in suicide rates while reductions in suicide rates appeared was explained by increased health spending per capita. Cai et al. [5] considered GDP per capita, urbanization, migration, employment, divorce rate, the proportion of children and the proportion of old adults as potential determinants of suicide rates across provinces of China from 1990 to 2015. The findings revealed a change in determinants of suicide during the period under consideration. Effects from GDP per capita and urbanization on provincial suicide rate were negative and prominent in 1990 and vanished up to 2015. The effects of employment on suicide rates have turned from positive to negative over the period under consideration. Scheiring et al. [6] provided a systemic overview of 39 cross-national studies of determinants of mortality in post-socialist Europe and found economic inequality, social welfare and religious composition as the most influential social determinants of mortality. Alvarez-Galvez et al. [7] studied determinants of suicide rates in Spain from 1980 to 2017. The findings pointed out protection against unemployment and protection in disability and family as important for reducing suicide rates. Ferretti and Coluccia [8] studied socioeconomic factors of suicide rates for 25 European Union countries and found the risk of poverty rates, annual growth rates for industry and low healthcare expenditures as factor determinants of suicide rates. Demirci et al. [9] found the 2008 economic crisis as a statistically significant driver of suicide cases in the United States. Sun and Zhang [10] studied the drivers of suicide rates in the United Kingdom from 1981 to 2011 and found unemployment rate, inflation rate and divorce rate related to suicide rates. Ceccherini-Nelli and Priebe [11] studied economic factors of suicide rates in the United Kingdom (1901-2006), United States (1900-1997), France (1970-2004) and Italy (1970-2001) and found a linkage between unemployment and suicide rates while the relationship between real GDP and suicide as well as between consumer price index and suicide was ambiguous. Seksenbayev et al. [12] examined a linkage between unemployment rates and suicide rates in 15 post-Soviet countries and found a significant relationship between suicide rates and unemployment rates in almost half of the 15 countries. Lari and Sefiddashti[13] studied drivers of suicide rates in the Eastern Mediterranean region from 1990 to 2019. The empirical findings suggested that male suicide rates were positively related to the inflation rate, unemployment rate, mental disorders prevalence and

urbanization while female suicide rates were related to the inflation rate, mental disorders prevalence and urbanization. Loureiro et al. [14] considered determinants of suicide mortality in 278 municipalities of Continental Portugal between 1980 and 2015 and pointed out a higher risk of suicide in rural areas as well as a higher risk of suicide during periods of economic and financial downturns. Piatkowska et al. [15] examined the effects of accession to the European Union on suicide rates in the Eastern European countries that joined the EU in 2004 and 2007. Empirical findings based on pooled cross-sectional time-series data from 1990 to 2011 suggested that EU entry has no effect on total suicide rates and suicide rates among males while the effect on female suicide rates was negative. Furthermore, significant and negative effects on suicide rates were found from economic growth and life expectancy at birth. Harman and Rievajová [16] used panel data for 79 counties of the Slovak Republic and found per capita income and unemployment rate as determinants of suicide rates. Kõlves et al. [17] analysed determinants of suicide rates in 13 countries of the former Soviet Union between 1990 and 2008. The empirical findings suggested a linkage between changes in suicide and socioeconomic disruptions during the transition period. Erdem and Mehmet [18] used annual data for 47 countries (including European countries) between 1996 and 2015 and found significant effects from unemployment, fertility, alcohol consumption, divorce and female labour force participation to suicide rates. Contemporary literature dealing with determinants of suicide rates within Europe illustrates different findings based on various empirical approaches. However, the panel data approach appeared as a dominant strategy. Furthermore, a similar set of potential regressors was evaluated for non-European countries. Swan [19] employed a dynamic panel data approach and found suicide rates in the United States between 1981 to 2016 determined by unemployment rates and inequality represented by changes in the top 10 % income index and Gini index of income. Andres et al. [20] examined socio-economic determinants of suicide in Japan between 1957 and 2009. The empirical findings suggested stronger effects from divorce rates and fertility rates in comparison to GDP per capita and unemployment. Emamgholipour et al. [21] examined determinants of suicide rates in each province of Iran from 2001 to 2016 and found unemployment, divorce, and industrialization rates as determinants of suicide rates. Jalles and Andresen [3] employed various specifications of panel data models to examine socioeconomic determinants of suicide rates across ten Canadian provinces between 2000 and 2008. The findings revealed the dependence of the results on the model specification as well as on the estimation method. Consequently, the robustness of the results to a selection of empirical approach needs to be taken into account.

RESEARCH METHOD

The research sample in this article consists of panel data with N cross-sectional units (countries) and T periods and the specification of the panel data model employed in this article is presented in equation (1).

$$y_{it} = C_j + \alpha_1 d_1 + \cdots + \alpha_{N+T-2} d_{N+T-2} + X_{j,it}\beta_j + \varepsilon_{it}. \quad (1)$$

y_{it} in equation (1) represents a vector of observations for the dependent variable. To take into account country and time heterogeneity fixed effects specification was followed. Fixed effects in periods were captured by $(T-1)$ dummy variables while fixed effects in countries were captured by $(N-1)$ dummy variables. Hence, $d_1, \cdots, d_{N+T-2}$ represent $(N+T-2)$ dummy variables and coefficients $(\alpha_1, \cdots, \alpha_{N+T-2})$ represent time and country individual effects, respectively. $X_{j,it-1}$ in equation (1) denotes regressors or potential drivers of suicide rates, β_j represents slope parameters while ε_{it} represents independently and normally distributed residuals. Literature dealing with determinants of suicide rates suggested many potential determinants of suicide rates and all potential determinants of suicide rates can hardly be included in the model specification when the standard frequentist approach was followed.

Hence, there is uncertainty related to the selection of regressors. At the same time, it is a well-known fact that omitted regressor in model specification implies biased model estimates. To deal with the issue of suicide determinants selection this article follows the Bayesian approach that explicitly considers the uncertainty. The Bayesian model averaging (BMA) followed in this article exhibited some desirable properties [22]. In the case of k potential independent variables, following BMA 2^k different models were estimated and weighted averages were constructed over all of them. The model weights arise from the Bayesian theorem as presented in equation (2).

$$p(M_\gamma|y,X)=\frac{p(y|\,M_\gamma,X)\cdot p(M_\gamma)}{p(y|X)=\sum_{i=1}^{2^k} p(y|M_i,X)\cdot p(M_i)}, \quad (2)$$

where $p(M_\gamma|y,X)$ denotes posterior model probability $p(y|\,M_\gamma,X)$ denotes marginal likelihood of the model or probability of the data given the model M_γ and $p(M_\gamma)$ denotes prior model probability or how probable researcher thinks model M_γ before looking at the data. Integrated likelihood that is constant over all models is denoted by $p(y|X)$. The marginal likelihood was obtained as presented in equation (3).

$$p(y|\,M_\gamma,X)=\int p(y|\alpha_\gamma,\beta_\gamma,\sigma,M_\gamma)p(\alpha_\gamma,\sigma)p(\beta_\gamma|\alpha_\gamma,\sigma,M_\gamma)d\,\alpha_\gamma d\beta_\gamma d\sigma, \quad (3)$$

where $p(y|\alpha_\gamma,\beta_\gamma,\sigma,M_\gamma)$ denotes the conditional probability of the data while $p(\alpha_\gamma,\sigma)$ and $p(\beta_\gamma|\alpha_\gamma,\sigma,M_\gamma)$ denote priors of the parameters for model M_γ. In this research, uniform priors were implemented often referred to as agnostic priors. Eventually, the importance of each potential regressor to explain the dependent variable was evaluated following posterior inclusion probability obtained as illustrated in equation (4).

$$p(x_r|y)=\sum_{x_r\in M_\gamma} p(M_\gamma|y),\ r=1,\cdots,k. \quad (4)$$

Following Raftery [23] posterior inclusion probabilities from 0,50 up to 0,75 were called weak. Posterior inclusion probabilities from 0,75 up to 0,95 were called positive. Posterior inclusion probabilities from 0,95 up to 0,99 were called strong while posterior inclusion probabilities above 0,99 were called very strong.

EMPIRICAL FINDINGS AND DISCUSSIONS

The research sample in this article was conditioned by the availability of reliable data sources. Components of the research sample and corresponding data sources were provided in the Appendix. To establish a potential link towards frequentist statistics along posterior inclusion probabilities (PIP) posterior means and corresponding standard deviations were reported as well. Firstly, pooled panel specification was considered. Pooled panel specifications do not control unobserved country heterogeneity or country fixed effects or fixed effects of periods. Hence, restrictions $\alpha_1=\alpha_2=\cdots=\alpha_{N+T-2}=0$ were imposed in equation (1) and estimates were obtained. The obtained estimates were summarized in Table 1.

Empirical estimates in Table 1 suggested that suicide rates increase with the increase in female participation in the labour force and the increase in divorce rates. An increase in unemployment and health expenditure seems to be related to decreased suicide rates. However, in case of unobserved heterogeneity pooled estimates might be inconsistent. So we first provide estimates for a specification where cross-sectional heterogeneity was controlled while heterogeneity across periods was not controlled. Therefore, restrictions $\alpha_{N+1}=\alpha_{N+2}=\cdots=\alpha_{N+T-2}=0$ were imposed in equation (1) and estimates were obtained. The estimates are provided in Table 2.

Following estimates in Table 2, GDP per capita and share of population ages 65 and above were found as regressors with very strong posterior inclusion probabilities. There was a negative linkage between suicide rates and GDP per capita indicating that more developed countries experienced lower suicide rates. A higher share of the population ages 65 and above was related

Table 1. Panel pooled determinants of suicide estimates.

Variable	PIP	Posterios mean (standard deviation)
Female participation	1,000	1,490 (0,133)
Health expenditure	1,000	-3,392 (1,055)
Divorce	0,999	0,114 (0,024)
Unemployment	0,793	-0,170 (0,107)
GDPPC	0,349	0,990 (1,563)
Urban population	0,264	-0,017 (0,032)
Dependency ratios 1	0,150	-0,058 (0,171)
Marriage rates	0,106	-0,036 (0,132)
Dependency ratios 2	0,076	-0,011 (0,059)
Fertility	0,066	-0,043 (0,659)
GDPPC growth	0,047	0,000 (0,020)

Table 2. Suicide determinants estimates based on panel data with cross sectional dummies.

Variable	PIP	Posterios mean (standard deviation)
GDPPC	1,000	-10,218 (1,341)
Dependency ratios 2	0,997	-0,394 (0,091)
Marriage rates	0,816	-0,408 (0,242)
Unemployment	0,704	-0,077 (0,059)
Divorce	0,566	0,020 (0,021)
Dependency ratios 1	0,162	-0,035 (0,094)
Female participation	0,077	-0,010 (0,046)
Fertility	0,064	-0,063 (0,362)
Urban population	0,051	-0,002 (0,019)
Health expenditure	0,045	-0,007 (0,108)
GDPPC growth	0,044	0,000 (0,006)

to lower suicide rates. Marriage rates appeared with positive inclusion probabilities and higher marriage rates were related to lower suicide rates. A variable representing divorce rates was found as regressor with weak inclusion probabilities and higher divorce rates were related to higher suicide rates. Eventually, specifications in equation (1) with no restrictions were estimated and results were summarized in Table 3.

Table 3 illustrates estimates from equation (1). Therefore, cross-sectional heterogeneity and heterogeneity across periods were controlled. Estimates in Table 3 suggested GDP per capita

Table 3. Suicide determinants estimates, based on panel data with cross-sectional and period fixed effects.

Variable	PIP	Posterios mean (standard deviation)
GDPPC	1,000	-9,971 (2,468)
Marriage rates	0,817	-0,428 (0,251)
Dependency ratios 1	0,606	-0,242 (0,223)
Divorce	0,533	0,020 (0,021)
Health expenditure	0,347	0,821 (1,265)
Unemployment	0,197	-0,017 (0,039)
GDPPC growth	0,161	0,013 (0,034)
Dependency ratios 2	0,160	-0,043 (0,114)
Fertility	0,047	-0,019 (0,328)
Urban population	0,038	0,000 (0,014)
Female participation	0,038	0,000 (0,026)

as regressor with very strong posterior inclusion probabilities. As was the case with estimates in Table 2, there was a negative linkage between suicide rates and GDP per capita indicating that more developed countries experienced lower suicide rates. Marriage rates appeared with positive inclusion probabilities and higher marriage rates were associated with lower suicide rates. Share of population ages below fifteen years and divorce rates were identified as regressors with weak inclusion probabilities. A higher share of the population ages below fifteen years was associated with lower suicide rates and higher divorce rates corresponded to higher suicide rates. A comparison of the results in Table 1, Table 2 and Table 3 suggested the presence of unobserved country and period heterogeneity that need to be controlled. The top five average suicide rates within the whole sample (Table 6 in the Appendix) were found in Lithuania, Latvia, Hungary, Slovenia and Estonia. So estimates for the subsample of post-socialist countries (Table 6 in the Appendix) were obtained and presented in Table 4.

Table 4. Suicide determinants estimates, based on panel data with cross-sectional and period fixed effects for post-socialist countries.

Variable	PIP	Posterios mean (standard deviation)
Divorce	0,992	0,101 (0,024)
Female participation	0,988	-1,041 (0,281)
Urban population	0,966	-0,545 (0,180)
GDPPC	0,936	-8,247 (3,432)
Unemployment	0,253	-0,031 (0,063)
Marriage rates	0,126	-0,057 (0,203)
Dependency ratios 1	0,121	-0,041 (0,147)
Health expenditure	0,100	0,136 (0,684)
Dependency ratios 2	0,087	-0,031 (0,160)
Fertility rates	0,081	-0,120 (0,732)
GDPPC growth	0,064	-0,001 (0,015)

The estimates for the subsample of post-socialist countries in Table 4 revealed divorce rates as the most prominent regressor explaining suicide rates in post-socialist countries with very strong posterior inclusion probabilities. Female participation and share of the urban population appeared as regressors with strong prior inclusion probabilities. Higher female participation in the labour force was related to lower suicide rates and higher urbanization was related to lower suicide rates. GDP per capita appeared as a regressor with positive inclusion probabilities suggesting that higher GDP per capita was related to lower suicide rates. Urbanization as a determinant of suicide rates is consistent with Singh and Siahpush [24]. Machado et al. [25] found urbanization as a protective against suicide in Brazil. Following Singh and Siahpush [24], rural areas may potentially be more vulnerable due to fewer people and lower per capita income as well as due to being less attractive to doctors as a place of work. Finally, estimates for the subsample of non-socialist countries (Table 6 in the Appendix) were estimated and presented in Table 5.

Estimates in Table 5 suggested share of urban population and female participation in the labour force as regressors with very strong posterior inclusion probabilities. Unlike the estimates for the subsample of post-socialist countries, higher female participation in the labour force was related to higher suicide rates and higher urbanization was related to higher suicide rates as well. Ventriglio et al. [26] pointed out emerging evidence for a linkage between urbanization and mental health issues and a positive relationship between urbanization and suicide rates. Chen et al. [27] and references herein suggested that the effects of female labour force participation on suicide rates were conditioned by socio-cultural context. Conclusively, in the subsample of non-socialist countries effects from a share of the urban population and female participation in the labour force to suicide rates were positive. At the same time, in the subsample of post-socialist countries effects from a share of urban population and female participation in

Table 5. Suicide determinants estimates, based on panel data with cross-sectional and period fixed effects for non-socialist countries.

Variable	PIP	Posterios mean (standard deviation)
Urban population	0,992	0,245 (0,063)
Female participation	0,961	0,456 (0,157)
Unemployment	0,443	0,053 (0,067)
Fertility	0,428	1,384 (1,805)
Dependency ratios 1	0,355	-0,136 (0,207)
Marriage rates	0,270	-0,074 (0,140)
Dependency ratios 2	0,066	0,008 (0,044)
Health expenditure	0,064	0,066 (0,390)
Divorce	0,059	-0,001 (0,004)
GDPPC	0,056	-0,095 (0,896)
GDPPC growth	0,044	0,000 (0,013)

labour force to suicide rates were negative. Consequently, positive and negative effects were mutually neutralized in the whole sample and there were no effects from urbanization and female participation in the labour force to suicide rates in the whole sample. Besides factors determinants of suicide rates empirical findings from this article clearly illustrated unobserved cross-sectional and periods heterogeneity. Furthermore, the findings pointed out differences between the subsamples and implications to empirical findings.

CONCLUSIONS

Several conclusions might be derived from the research presented in this article. Firstly, contemporary literature suggested a variety of socioeconomic factors potentially related to suicide rates. The relevance of socioeconomic factors in suicide rates seems to depend on countries and periods under consideration as well as on the empirical approach followed to obtain estimates. Following Bayesian Model Averaging (BMA) and panel data specification with cross-sectional and periods fixed effects, empirical findings for the subsample of post-socialist countries revealed divorce rates as the most prominent regressor explaining suicide rates with very strong posterior inclusion probabilities. Female participation in the labour force and share of the urban population appeared as regressors with strong prior inclusion probabilities. Effects of female participation in the labour force on suicide rates were negative as well as the effects of urbanization on suicide rates. GDP per capita appeared as a regressor with positive inclusion probabilities and the effects of GDP per capita on suicide rates were negative. For the subsample of non-socialist countries, empirical findings suggested a share of the urban population and female participation in the labour force as regressors with very strong posterior inclusion probabilities. Unlike the estimates for the subsample of post-socialist countries, effects from participation in the labour force to suicide rates as well as from urbanization to higher suicide rates were positive. Empirical findings for the whole sample of 25 European countries suggested GDP per capita as a regressor with very strong posterior inclusion probabilities and negative effects from GDP per capita on suicide rates. Marriage rates appeared with positive inclusion probabilities and effects from marriage rates to suicide rates were negative. Share of population ages below fifteen years and divorce rates were identified as regressors with weak inclusion probabilities. The effects from a share of the population ages below fifteen years to suicide rates were negative while effects from divorce rates to suicide rates were positive.

APPENDIX

Table 6. Data sources and sample description.

Variable	Period	Data Source
Suicide mortality rate (per 100 000 population)	2001-2019	World Development Indicators: https://data.worldbank.org/indicator
Urban population (% of total population)	2001-2019	
Labor force, female (% of total labor force)	2001-2019	
Unemployment, total (% of total labor force) (modeled ILO estimate)	2001-2019	
Current health expenditure (% of GDP)	2001-2019	
GDP per capita (constant 2015 US$) (growth rate)	2001-2019	
GDP per capita (constant 2015 US$)	2001-2019	
Fertility rates	2001-2019	https://ec.europa.eu/eurostat
Crude marriage rates	2001-2019	
Divorces per 100 marriages	2001-2019	
Dependency ratios 1 [Population ages 0-14 (% of total population)]	2001-2019	World Development Indicators: https://data.worldbank.org/indicator
Dependency ratios 2 [Population ages 65 and above (% of total population)]	2001-2019	World Development Indicators: https://data.worldbank.org/indicator
Whole sample	Subsample of European post-socialist countries	Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia
	Subsample of non-socialist countries	Austria, Belgium, Cyprus, Denmark, Finland, Germany, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland

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