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Economic factors and suicide rates: associations over time in four countries

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Abstract
Objective Suicides account for more than 30,000 deaths per year in the US alone. Suicide rates change over time, and the factors influencing them remain poorly understood. Economic factors, in particular unemployment, have been suggested as a major influence. However, the evidence for this has been inconsistent, which may be partly explained by shortcomings of the statistical methods used.
Methods Time series analytical techniques (unit root and co-integration tests) were applied to test the associations over time between economic factors, i.e. unemployment, real gross domestic product per capita (RGDP) and the consumer price index (CPI) and death rates by suicide as collected by national agencies in the UK (1901–2006), US (1900–1997), France (1970–2004) and Italy (1970–2001). Traditional correlation analyses were used when appropriate.
Results Co-integration and correlation tests showed a long-run association between economic factors and suicide rates. Increase/decrease of unemployment predicted an increase/decrease of suicide rates over long historical periods and in different nations. RGDP and the CPI were also linked with suicide rates, but this was not consistently so and the direction of the association varied.
Conclusions Unemployment is a major factor influencing suicide rates over long periods of time and in different national contexts. It needs to be considered as a confounding factor in evaluations of suicide prevention strategies.

Keywords Suicide · Economic factors · Unemployment · Time factors

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Introduction

Suicide is a major public health problem. In 2005, it was the eleventh leading cause of death in the US, accounting for 32,637 deaths [9]. The overall age-adjusted rate was 10.8 suicide deaths per 1,00,000 people [9]. Although suicide can be the epilogue of many psychiatric disorders, the majority of people who kill themselves are not patients of psychiatric services (approximately 75% in England and Wales, according to Swinson [36]. Furthermore, suicide rates significantly change over time and differ across countries [38] and there is little evidence that these variations are predominantly caused by changes of either the sensitivity of recording suicide verdicts or psychiatric causes, i.e. morbidity and service provision. Already a long time ago, these considerations had suggested the need to investigate other factors explaining these variations [21].

Among other factors, economic ones have repeatedly been suggested as influential. Although not the first author to suggest non-psychiatric risk factors of suicide, Durkheim [12] is generally regarded as the founder of the scientific study of the influence of the socio-economic environment on suicidal behaviour [14, 20]. According to Durkheim's theory, suicide rates are expected to increase during periods of rapid economic change and decrease

during periods of economic stability [23]. Other theories suggest that suicide rates either rise or fall in line with the business cycle [23].

Numerous studies have analysed associations between economic factors and suicide rates [11]. The existing evidence points towards an association of unemployment and suicide rates, although most of the positive evidence is based on cohort studies rather than time series studies in the general population [18, 33]. The findings for other economic factors are less consistent. It remains unclear whether the inconsistencies reflect true variations or are explained by differences in the methodologies employed. A particular problem was the shortcomings of traditional statistical methods for the analysis of time series data.

The recent development of more robust statistical techniques to analyse economic time series data allows revisiting the hypothesis of the influence of economic factors on suicide rates. This study used these techniques which have previously been applied to demonstrate historical trends in the association of economic factors and psychiatric hospital beds [10]. We explored the association of three major economic factors, i.e. unemployment, real gross domestic product per capita (RGDP) and consumer price index (CPI) with suicide rates. To obtain more reliable and generalisable results, we applied a consistent methodology to long-term data from four countries, the UK, the USA, France and Italy.

Methods

For this study, data sets on unemployment, RGDP and CPI as well as on death rates by suicide and intentional self-harm were identified in the UK, US, France and Italy. We searched for separate suicide rates for males and females, but used combined rates when separate rates were not available.

Data sets

United Kingdom (1901–2006)

The European Health for All database [39] provides suicide rates for the UK from 1970 onwards only [38]. Since we aimed to analyse the longest possible time series, we used the age-standardised suicide rates for males and females in England and Wales for the period 1901–2006 as a proxy for the UK [27, 28]. All deaths with a coroner's verdict of intentional self-harm were included, and deaths of undetermined intent (open verdict) were excluded.

Economic data refer to the whole UK. RGDP and CPI were obtained from Officer [30, 31]. There is no unemployment index continuously documented for the whole study period. For the period up to 1965, we used the adjusted estimates of overall percentages unemployed, 1855–1965 [25], and for the years from 1971 to 2006 the ONS time series MGSX [29]. Because we did not obtain unemployment data for the period 1966–1970, the association of unemployment and suicide rates was analysed separately for the periods prior to and following this gap.

United States (1900–1997)

All data were obtained from the Historical Statistics of the US [8]. Suicide rates are reported as crude rates and combined for both sexes. We were unable to find separate age-standardised rates for females and males for that period of time.

France (1970–2004) and Italy (1970–2001)

Age-standardised suicide rates (overall and stratified by age and sex), unemployment and RGDP for both countries were obtained from the European Health for All database. CPI for France was obtained from OECD Statistics V.4.4 [32] and for Italy from the National Institute of Statistics [17].

Statistical analysis

Special properties of time series data

Time series (i.e. a sequence of random variables ordered in time) of economic factors are commonly non-stationary (i.e. they do not return quickly and frequently to their mean) and are a unit root process I(1) (i.e. they become stationary after first differencing).

In our data sets, suicide rates follow either ascending or descending curves over long-term periods of time. Thus, they may have the same metric properties as economic factors, i.e. be non-stationary unit root processes. To estimate the long-term association between non-stationary variables, the ordinary least square (OLS) statistical estimation procedure should not be used. In fact, the regression of one non-stationary variable on other non-stationary variables can result in the phenomenon of spurious regressions with a high risk of false positive findings. The use of differencing and detrending techniques to impose stationarity (in order to use OLS statistical techniques) is also inappropriate and has a persistent risk of incurring either type I or type II statistical errors (the latter mostly with differencing).

Unit root and co-integration analysis

However, not every association between two variables with unit roots is spurious and so-called "co-integration

analysis" is the appropriate method to test such associations. According to Hamilton [16], "Co-integration means that although many developments can cause permanent changes in the individual elements of $\mathbf{y_t}$, there is some long-run equilibrium relation tying the individual components together, represented by the linear combination a'y_t".

Analytical procedures

The data analysis followed the approach used in a previous analysis of time trends in economic factors and psychiatric hospital beds [10] and was performed in three steps: First, variables were transformed. Second, they were tested for the presence of a unit root. Third, if the condition of unit root was met, co-integration tests were used, initially in bivariate and then in multivariate models.

Data transformation

All data were transformed in their natural logs. In addition, variables were subjected to moving average transformation whenever they showed a cyclical component. A cyclical component can easily overwhelm the stochastic trend component, thereby giving a reduced chance for revealing a possible co-integration relationship. Both the original and the moving average transformed variables were used in unit roots and co-integration analyses.

Panel unit root tests

We used four unit root tests to examine the time series properties of data in this study since panel unit root tests have substantially higher power than single unit root tests: the Phillips-Perron I and II tests [34] to test the unit root (with drift) hypothesis against the (trend) stationarity hypothesis; the Dickey-Fuller test with GLS detrending [15]; and the Bierens' non-parametric test of the unit root with drift hypothesis against non-linear trend stationarity [4]. The lag length p of the auxiliary regression was determined by the Schwarz criterion. p values were simulated on the basis of a Gaussian AR(q) model for $z(t) - z(t-1)$ in batches of 500 replications.

Co-integration tests

Only variables fulfilling unit root criteria were tested for co-integration. Several co-integration tests have been developed in recent years and none has emerged as a gold standard. Johansen's co-integration analysis [19] is one of the most frequently used and involves the computation of the lambda-max test of the null hypothesis that the co-integration rank is equal to r against the alternative that the co-integration rank is equal to $r + 1$ and also of the trace test of the null hypothesis that the co-integration rank is equal to r against the alternative that the co-integration rank is k [19].

We also performed the Bierens' non-parametric co-integration test [5], which we believe offers some advantages over the Johansen's one and may be more accurate. Like the Johansen's LR method, this non-parametric approach uses test statistics obtained from the solutions of a generalised eigenvalue problem. The two methods test the same hypotheses, but in Bierens test the two matrices in the generalised eigenvalue problem involved are constructed independently of the data-generating process. Bierens showed that his non-parametric approach performed better than Johansen's lambda-max test, even when the correct VAR order had been identified [5].

Bivariate and multivariate co-integration tests

Co-integration tests were first performed between suicide rates and each of the other economic variables (bivariate tests).

We also performed co-integration tests including all variables or a particular combination of them until a significant co-integration model could be identified (multivariate tests).

Unit root and co-integration tests were computed using EasyReg International software [6].

Complementary correlation analysis

All variables were transformed in their first difference and tested for unit root properties. To reduce the likelihood of obtaining spurious results, only pairs of first difference variables meeting the criteria of stationarity were entered in a correlation analysis for ranks (Spearman's correlation test). We assumed that a significant association between variables with both co-integration and correlation analysis should be regarded as a robust finding.

Results

In each country, the three economic factors and suicide rates showed considerable variation over time.

Unit root tests

In the UK data set, unemployment, RPI, RGDP and suicide rates for females fulfilled the criteria for unit roots and only these variables were further analysed with co-integration tests (detailed results of unit root tests are available from the authors).

In the data sets from the US, France and Italy all variables (or their moving average) fulfilled the criteria for unit roots and could be used in co-integration models.

Bivariate co-integration tests

The results of bivariate Bierens' co-integration tests are reported in Table 1.[1]

A significant co-integration between unemployment and suicide rates was observed in France and US. In Italy and the UK a significant co-integration was identified between unemployment and suicide rates for females.

A significant co-integration between CPI, RGDP and suicide rates was found in the UK, France and Italy. However, the direction of changes in suicide rates predicted by RGDP in the UK was the opposite of the one predicted in France and Italy.

In US, suicides were significantly co-integrated neither with CPI nor RGDP.

In summary, using the Bierens' test, in all nations one or more suicide rates were significantly co-integrated with unemployment, CPI and RGDP.

Johansen's test (Table 2) confirmed a significant co-integration of economic variable with suicide rates.[2] In particular, all economic variables were co-integrated with suicide rates in both sexes in Italy.

Multivariate co-integration

When all these co-integrating variables were entered in a Multivariate Bierens' test of co-integration (Table 3) it was possible to identify one co-integrating model including either all the variables (France, Italy, and UK) or suicide rates, unemployment and RGDP (US).

In a multivariate Johansen's test of co-integration both the lambda-max and trace tests indicated one co-integrating equation at the 0.05 significance level, which included, as seen with the Bierens' test, all variables (France, Italy, and UK) or suicide rates, unemployment and RGDP (US).

Correlation analysis

In the UK, unemployment (Feinstein index) was also positively correlated with suicide rates in males ($\rho = +0.45$; $p < 0.001$). A modest positive correlation ($\rho = 0.30$; $p = 0.016$) was found between unemployment and suicide rates in females. In the US, unemployment was positively correlated with suicide rates ($\rho = +0.57$; $p < 0.001$).

With respect to RGDP, findings were inconsistent as it was positively correlated with suicide rates in France ($\rho = +0.30$; $p < 0.05$) and negatively in the UK ($\rho = -0.27$, $p = 0.005$) and the US ($\rho = -0.30$; $p < 0.005$).

In the US, CPI was negatively correlated with suicide rates ($\rho = -0.32$, $p < 0.001$).

A modest significant inverse correlation was found in the UK between CPI and suicide rates in females ($\rho = -0.19$, $p = 0.048$).

Correlation analyses were not computed in the Italian and French data sets, because two or more variables were non-stationary after differencing.

Discussion

This study used time series analysis to explore the impact of economic factors on suicide rates over long periods of time and using a consistent methodology to analyse data sets from different countries. The study shows a significant association between economic factors and suicide rates, almost equally in males and females. Unemployment has the largest impact on suicide rates. In all four countries and over long periods of time increases of unemployment are linked with higher suicide rates, and decreases of unemployment with lower suicide rates. RGDP and CPI were also associated with suicide rates, but this association was less consistent and applied mainly to France and Italy.

[1] In Table 1, we report the co-integrating vector only if the null hypothesis of no co-integration (i.e. $r = 0$) was rejected at the 5% significance level, whereas the null hypothesis $r = 1$ was not rejected at the 10% significance level. For instance the standardised co-integrating vector reported for France female population, *S*–*U* bivariate comparison "$S - 0.30\text{MA7}(U)$" means that the generalised Eigenvectors of A with respect to $(A + c[A^{-1}]/n^2)^{-1}$ for $n = 4$ and $c = 1$ are

$$\begin{matrix} 0.30 & 1 \\ 1 & -0.30 \end{matrix}$$

The last Eigenvector spans the space of co-integrating vectors and the space of co-integrating vectors is spanned by the following standardised vector

$$\begin{matrix} 1 & \rightarrow \text{Suicide, females, both sexes} \\ -0.30 & \rightarrow \text{Mov.Aver.7}[U] \end{matrix}$$

Regarding the direction of the association, if the sign of socio-economic variables was the opposite of *S*, the model predicted changes in the same direction, whilst the same sign predicted changes in the opposite direction.

[2] In Table 2 we report a summary of pair-wise Johansen's tests of co-integration among rates of suicide and economic variables. For brevity we reported only the error correction term whenever the null hypothesis of no co-integration (i.e. $r = 0$) was rejected at the 5% significance level (lambda-max test) and the null hypothesis $r = 1$ is not rejected at the 10% significance level (trace test) of a vector error correction model (VECM) with intercepts and co-integrating restrictions. The Standardised co-integrating vector is not reported in the tables but it can be easily derived from the error correction term. For instance in the co-integration model of *S* and *U* in France, the error correction term is $S(-1) - 0.66\text{MA7}[U](-1) - 0.001(t - 1)$, and therefore the standardised co-integrating vector is $S - 0.66\text{MA7}[U] - 0.001t$, where MA7 stands for moving average after 7 periods.

Table 1 Bierens' test of co-integration among rates of suicides (*S*) and selected economic variables with estimation of the standardised co-integrating vector (all parameters are expressed in ln)

	Unemployment[a]		Consumer price index	Real GDP
France				
Suicide, females	$S - 0.30\text{MA7}(U)$		$S - 0.54\text{CPI}$	$S - 0.90\text{RGDP}$
Suicide, males	$S - 0.37\text{MA7}(U)$		$S - 0.48\text{CPI}$	$S - 0.82\text{RGDP}$
Italy				
Suicide, females	$S - 0.64\text{UN}$		$S - 0.34\text{CPI}$	$S - 0.55\text{RGDP}$
Suicide, males	0		$S - 0.29\text{CPI}$	$S - 0.39\text{RGDP}$
UK				
Suicide, females	Not performed[b]	$S - 0.11\text{UN}$	$S - 0.12\text{RPI}$	0
Suicide, males	Not performed	Not performed	Not performed	Not performed
US				
Suicide, both sexes[c]	$S - 0.02\text{MA14}(U)$		0	0

[a] For unemployment in UK, we tested two different time series: Feinstein index and ONS MGSX, respectively

[b] Variables not fulfilling unit root criteria were not analysed

[c] Separate historical statistics for suicide rates in males and females are not available

Table 2 Johansen's test of co-integration among rates of suicides (*S*) and selected economic variables Johansen's tests estimation of the error correction term of the co-integrating vector (all parameters are expressed in ln)

	Unemployment[a]		Consumer price index	Real GDP
France				
Suicide, females	$S(-1) - 0.66\text{MA7}[U](-1) - 0.001(t-1)$		$S(-1) - 0.56\text{CPI}(-1) + 0.052(t-1)$	$\text{RGDP}(-6) - 0.57S(-6) - 0.062(t-6)$
Suicide, males	$S(-1) - 0.60\text{MA7}[U](-1) - 0.004(t-1)$		$\text{CPI}(-8) + 0.93S(-8) + 0.02(t-8)$	$S(-6) - 0.85\text{RGDP}(-6) + 0.040(t-6)$
Italy				
Suicide, females	$S(-8) - 0.80U(-8) + 0.01(t-8)$		$S(-2) - 0.44\text{CPI}(-2) + 0.0(t-2)$	$S(-1) - 0.81\text{RGDP}(-1) + 0.09(t-1)$
Suicide, males	$S(-1) - 0.79U(-1) - 0.01(t-1)$		$S(-2) - 0.44\text{CPI}(-2) + 0.04(t-2)$	$S(-1) - 0.96\text{RGDP}(-1) + 0.08(t-1)$
UK				
Suicide, females	Not perf[b]	$S(-9) + 0.26U(-9)$	0	0
Suicide, males	Not perf[b]	Not perf[b]	Not perf[b]	Not perf[b]
US				
Suicide, all ages, both sexes[c]	1: $S(-15) - 0.38\text{MA14}[U](-15) + 0.002(t-15)$		0	$\text{MA4[RGDP]}(-6) + 0.60S(-6) - 0.022(t-6)$

[a] For unemployment in UK, we tested two different time series: Feinstein index and ONS MGSX, respectively

[b] Variables not fulfilling unit root criteria were not analysed

[c] Separate historical statistics for suicide rates in males and females are not available

The study has some potential major limitations. First, co-integration and correlation tests assess associations and do not establish true causality. Thus, the link between economic factors and suicide rates might be an indirect one, caused by other unidentified factors. Second, official suicide rates may be influenced by the methods of reporting and documenting suicides [1]. Yet, whilst the practice of suicide documentation may vary substantially between countries and therefore complicate international comparisons, the practice is less likely to change dramatically within one country over time, and such changes are unlikely to explain the substantial variations in suicide rates that we tested for their association with economic factors in each of the four countries. Also we believe unlikely that the quality of the suicide data could be influenced by economic factors.

Third, this paper is narrowly confined to the analysis of economic factors and it may not do justice to all the potential causal factors identified for suicide. Although we recognise the importance of other aetiological factors (such as alcohol consumption, personal income, availability of

Table 3 Multivariate Bierens' non-parametric tests of co-integration among rates of suicides and economic variables (all variables are natural logs)

Data set	France	Italy	UK	US
Variables	$Y(1) = \text{MA7}[U]$	$Y(1) = U$	$Y(1) = U$(MGSX)	$Y(1) = \text{MA14}[U]$
	$Y(2) = \text{CPI}$	$Y(2) = \text{CPI}$	$Y(2) = \text{RGDPP}$	$Y(2) = \text{CPI}$
	$Y(3) = \text{RGDP}$	$Y(3) = \text{RGDP}$	$Y(3) = \text{RPI}$	$Y(3) = \text{MA4}[\text{RGDP}]$
	$Y(4) = S$	$Y(4) = S$	$Y(4) = S$	$Y(4) = S$
			(all ages, fem)	
Number of co-integrating vectors (R)[a]	1	1	1	0
The space of co-integrating vectors is spanned by the following standardised vectors	$-0.79 \rightarrow \text{MA7}[U]$	$-0.13 \rightarrow U$	$0.11 \rightarrow U$(MGSX)	
	$0.25 \rightarrow \text{RGDP}$	$-0.53 \rightarrow \text{CPI}$	$1.00 \rightarrow \text{RGDPP}$	
	$1.00 \rightarrow \text{CPI}$	$1.00 \rightarrow \text{RGDP}$	$-0.01 \rightarrow \text{RPI}$	
	$0.13 \rightarrow S$	$0.13 \rightarrow S$	$0.09 \rightarrow S$	
			(all ages, fem)	
Variables of alternative model with best fit	$Y(1) = U$			$Y(1) = S$
	$Y(2) = \text{CPI}$			$Y(2) = \text{MA4}[\text{RGDP}]$
	$Y(3) = \text{RGDP}$			$\text{Y}(3) = \text{MA14}[\text{U}]$
	$Y(4) = S$			
Number of co-integrating vectors (R)[a]	1			1
The space of co-integrating vectors is spanned by the following standardised vectors	$0.02 \rightarrow U$			$0.84 \rightarrow S$
	$1.00 \rightarrow \text{RGDP}$			$1.00 \rightarrow \text{MA4}[\text{RGDP}]$
	$-0.72 \rightarrow \text{CPI}$			$0.01 \rightarrow \text{MA14}[U]$
	$0.08 \rightarrow S$			

[a] The null hypothesis of number of co-integration (i.e. $r = 0$) is rejected at the 5% significance level, whereas the null hypothesis $r = n$ is not rejected at the 10% significance level

health care and antidepressant prescription rates) we were unable to include these additional factors for pragmatic reasons, i.e. unavailability of time series data of adequate quality and/or duration. Furthermore, the aim of this study was to establish if economic factors have any role at all in influencing suicide rates, a role which so far has still been disputed in the literature.

Strengths of the study are the use of modern statistical methods with long time series applied to data sets from multiple countries with different cultures and economies. The findings are consistent with some but not all previous reports in the literature. In one of the most comprehensive time series study (US, 1900–1996), Tapia Granados [37] found an increase of suicide rates during recessions. Based on an analysis of data from 1968 to 2002 in Australia, Berk et al. [2] suggested that suicide rates in different age groups were positively or negatively associated with GDP growth. In the US, Gibbons [14] reported that higher suicide rates are significantly associated with lower income and lower prescriptions of SSRI antidepressants. However, low income people were also less likely to receive treatment with SSRI antidepressants and their relative importance as risk factors could not be established. Yet, the wide availability of antidepressant medicines is a relatively recent phenomenon and cannot explain the link between economic factors and suicides over the last 100 years.

The association between unemployment and suicide has often been suggested in the literature, although previous evidence was based on less rigorous methods than applied in this study (for reviews see Platt [33] and Jin [18]). Blakely et al. [7] suggested that being unemployed may be associated with a two- to threefold increase of the relative risk of suicide. Moreover, unemployment explained correlations of other factors such as education, car access, and household income with suicide rates. With respect to England and Wales, Biddle [3] failed to find a correlation of unemployment for the period 1992–2005, possibly because they used different statistical methods or a time series of inadequate duration. The relationship between unemployment and suicide is probably complex and mediated by several different factors. Some studies suggest that people's alcohol consumption increases during unemployment and Luoto [24] found unemployment weakly but significantly relates to the upper consumption level of alcohol use among single people during the recession but not in the preceding period of economic growth. In turn, heavy alcohol consumption is a well-known risk factor for suicide. The relationship between unemployment and suicide can also be mediated by divorce. The divorce rate tends to fall following periods of low unemployment rates and tends to rise following periods of economic recession [35]; suicide rates are related to the divorce rates [22].

The relative interplay of these factors have been studied by Norstrőm [26]: a good third of the male suicides in Sweden were attributable to the alcohol factor and the impact of unemployment was also found to be fairly strong. For the author the indirect effects of unemployment were at least as important as the direct ones.

In conclusion, our findings suggest that the heterogeneity of methods may explain much of the inconsistencies of findings on economic factors and suicides in the literature. Although we used data sets from four countries with different traditions and partly different economic cycles, we identified a similar impact of unemployment on suicide rates. Unemployment is linked to suicide rates in males and females even at times when females were less likely to seek and expect employment. This indicates that the impact of unemployment may go beyond those directly affected by redundancies. One may speculate that unemployment can create an overall societal atmosphere that leads to higher suicide rates in various parts of the population and through different mechanisms.

In the evaluation of suicide rates and suicide prevention strategies, unemployment rates should be considered as a potentially confounding factor. Future research should further explore the mechanisms that link unemployment and suicide rates and identify protective factors, so that targeted prevention methods can be developed.

Conflict of interest None.

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