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Article *in* Social Science & Medicine · July 2020

DOI: 10.1016/j.socscimed.2020.113256

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An empirical investigation of the relationship between business performance and suicide in the US

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ARTICLE INFO

Keywords:
Suicide
Stock market fluctuations
Economic conditions
Business performance
Economic insecurity
Psychological work stressors

ABSTRACT

Previous research suggests that mortality rates behave pro-cyclically with respect to economic growth, with suicides representing a notable exception that consistently increase in economic downturns. Over recent years, there is ample evidence in the literature that the working environment in the US has deteriorated significantly, suggesting that suicide rates may not necessarily behave in a counter-cyclical manner with business performance. Utilising recent suicide data, this study empirically tests the hypothesis that adverse working conditions over recent years may have resulted in a pro-cyclical relationship between business performance and suicide. Unlike previous studies, we use a stock market index, a leading macroeconomic indicator, to measure economic conditions from a business perspective. We employ the Autoregressive Distributed Lag (ARDL) co-integration methodology to study the long-run relationship between monthly S&P500 stock market data and age and gender-specific suicide rates during the period January 1999 to July 2017. Our results highlight substantial differences in age groups responses to fluctuations in business performance. We find a clear positive association between business performance and suicide rates for the youngest males and females aged 15–34 years, indicating that there is a human cost associated with improved business performance. Additionally, we investigate the association between economic insecurity, a unique aspect of the recent deterioration in the working environment, using the Implied Volatility Index "VIX" and age and gender-specific suicide rates. Our findings do not support a population-wide adverse impact of economic insecurity on suicide incidences. The exception was males aged 15–24, and females aged 55–64 for whom we find a significant positive association. Teaching work-life management and problem-solving skills to manage everyday work stressors may be important strategies to mitigate the psychological cost of business successes.

1. Introduction

In 2017 more than 47,000 Americans age 10 or older died by suicide, ranking it as the tenth leading cause of death, the fourth most common cause of death for individuals aged between 35 and 54 years and the second for ages 10–34 years, and one of just three leading causes of death that are increasing over time (Centers for Disease Control and Prevention, 2018). Between 1979 and 1999, the suicide rate in the US was decreasing. However, this downward trend reversed and the suicide rate has been increasing since 1999, with a noticeable acceleration coinciding with the onset of the 2007/8 financial crisis. A number of studies have suggested that the crisis was responsible for the acceleration in suicide rates during this period (Chang et al., 2013; Reeves et al., 2012) with some evidence that the excess suicide deaths are attributable to the dramatic rise in the unemployment rate during the crisis (Reeves et al., 2012).

However, this upward trend has continued post the financial crisis despite years of economic recovery (The National Bureau of Economic Research, 2012) and substantial declines in the unemployment rate (Bureau of Labour Statistics, 2017). This raises questions in relation to the impact of the financial crisis on suicide trajectories, and more specifically the increase in the unemployment rate, as being partially the force that drove the excess suicide deaths during the crisis. More generally, it drives us to re-think the well-documented strong inverse relationship between economic performance and suicide rates (Reeves et al., 2012; Ruhm, 2000; Wu and Cheng, 2010). Indeed, a number of

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https://doi.org/10.1016/j.socscimed.2020.113256
Received in revised form 30 June 2020; Accepted 24 July 2020
Available online 31 July 2020

recent studies have found little evidence of an association between the 2007/8 recession and the increase in the suicide rates (Fountoulakis et al., 2013; Harper et al., 2015; Harper and Bruckner, 2017). According to Harper and Bruckner (2017), suicide rates across different gender and age groups were following their long-run time trends during the crisis. Moreover, Harper et al. (2015) and Harper and Bruckner (2017) argue that prior findings on this association are subject to methodological flaws. For instance, failing to adjust empirical models for seasonality and time trends could yield misleading results on the impact of the financial crisis. Therefore, the relationship between macroeconomic conditions and suicide is sensitive to the correct model specification.

The incidence of suicide in the US is a serious public health issue and its continuous rise is puzzling scholars and policymakers, particularly as the US follows a different trend to the rest of the world. The US has rising suicide rates over the last two decades, whilst suicide rates are declining globally (Naghavi, 2019). As the suicide rate continues to rise, more research is needed to uncover its underlying causes.

2. Literature review and hypothesis development

An abundance of literature is available on the relationship between national economic conditions and suicide incidences, with the majority of previous studies concluding that better economic conditions are generally associated with lower suicide incidences (Reeves et al., 2012; Wu and Cheng, 2010). Ruhm (2000) studied the relationship between economic conditions (proxied by the unemployment rate) and mortalities from different causes of death over the period 1972 to 1991. His findings suggest that mortality rates behave pro-cyclically. He hypothesized that hazardous working conditions and job-related stress are among the mechanisms through which economic growth can have an adverse effect on mortality rates. However, suicide deaths were found to be an important exception i.e. suicide reacts counter-cyclically, which suggest that economic growth is associated with improved mental wellbeing.

However, in recent decades there is sufficient evidence to re-think the relationship between economic conditions and suicide, while taking a business perspective. Evidence in the literature suggests that the working environment in the US has deteriorated significantly (Quinlan et al., 2001), and these deteriorations are arguably rooted in the shift to economic globalization (International Labour Organization, 2016; Kawachi, 2008; Scheve and Slaughter, 2004). In an era of economic globalization, economies around the world have become more integrated which facilitates technology transfer, capital flights, as well as trade liberalization. This profound transformation in the way businesses are operating has increased firms' productivity and efficiency more than ever before (Mcmillan et al., 2011). However, research suggests that globalization has compromised companies' ethics (Zekos, 2004). For instance, nowadays, companies are promoting profits over the mental well-being of their employees (Navarro, 1998). Research shows that globalization and the associated increased competitions and pressures has resulted in employees being exposed to psychological work stressors in the form of low job control, job strain, high job demands, burnout, long working hours, economic insecurity, and job insecurity (Kawachi, 2008; Milner et al., 2018; Scheve and Slaughter, 2004). Extant research finds that these work-related stressors have an adverse effect on the psychological health of workers (Dollard et al., 2007; LaMontagne et al., 2010). Only recently, an emerging body of literature has investigated the association between chronic psychological work stressors and suicide. In fact, evidence suggests that these stressors are detrimental to mental health to the extent that they can precipitate suicide (Woo and Postolache, 2008). Milner et al. (2018) conducted a meta-analysis over the period 2010 to 2017 and confirmed that some aspects of the work environment can precipitate suicidal thoughts among workers. Specifically, Choi (2018) using longitudinal data from the US, found that long working hours and job strain were associated with suicidal ideation. Furthermore, Tsutsumi et al. (2007) found evidence of a linkage between low job control and suicide deaths of male workers. These findings were largely confirmed internationally (Loerbroks et al., 2016; Milner et al., 2018).

Taken together, while it has been documented in recent decades that economic globalization has prompted economic growth in the US (Dreher, 2006) and has boosted the productivity and profitability of companies (Mcmillan et al., 2011), it has been accompanied by significant deteriorations in the working environment. Therefore, it is reasonable to hypothesize that successful business performance in recent years may also be associated with long-term human cost i.e. suicide deaths. In other words, the relationship between business performance and suicide may not necessarily behave in a counter-cyclical manner as the relationship between economic performance and suicide does. This relationship we believe might exceptionally exist in recent years and not necessarily in preceding times.

Existing studies of the macroeconomic determinants of suicide tend to use the unemployment rate as a proxy of the population-wide consequences of economic cycles (Wu and Cheng, 2010), whilst GDP or income per capita are used to proxy national economic conditions (Tapia Granados, 2005). An abundance of research has documented the unemployment rate as being an important risk factor of suicide (Ruhm, 2000; Chang and Chen, 2017). However, there is recent evidence in the literature that the overall suicide rate in the US has become less responsive to the unemployment rate during recent years (DeFina and Hannon, 2015). This finding, therefore, casts doubt on whether the unemployment rate should continue to be considered as a potential suicide risk factor.

On the other hand, the findings on the impact of GDP or income per capita on the incidences of suicide have been inconclusive (Breuer and Rottmann, 2014; Neumayer, 2004; Reeves et al., 2015). Extant studies have explained these results that GDP has no direct spillover effect on people's daily life and is incapable of taking into account the economic insecurity that the population experience, especially during economic fluctuations (Nandi et al., 2012; Stuckler et al., 2009).

Despite the stock market being a well-known macroeconomic indicator (Cotti et al., 2015; Estrella and Mishkin, 1998), it has been neglected in the academic literature of suicide. Previous research has investigated the psychological effect of stock market fluctuations and documented an association between these fluctuations and higher incidences of hospitalizations for mental disorder (Lin et al., 2014), greater depression (McInerney et al., 2013), worsening in self-reported well-being (Deaton, 2012), and stress-related behaviour, for example; alcohol use and smoking (Cotti et al., 2015). Each of the effects mentioned above has consistently been documented as suicide risk factors (Chen et al., 2012).

It is worth noting that, while some of the aforementioned studies have initially proposed the stock market as a wealth measure, their empirical findings suggest that at the aggregate level, the impact of the stock market on these mental health issues goes beyond stock holdings, given that most of the US population are unlikely to have a direct or indirect investment in the stock market (Deaton, 2012; Lin et al., 2014). This further suggests that stock market movement can play the role of an alternative measure of economic conditions. Following this research, we specifically propose the stock market as a measure of business rather than economic performance. Moreover, we argue that the inclusion of this variable in economic studies of suicide is important for the following reasons. Firstly, the stock market distinctive from other macroeconomic indicators, for example the unemployment rate and GDP, reflects the general conditions of the business environment (Lin et al., 2014). Strong performance of the stock market reflects a healthy and successful business environment. These successes, in turn, are expected to have a beneficial spillover effect on the labour market in terms of potential job creation (Stock and Watson, 1989), compensations and benefits that have been recently tied to companies' stock performance "stock-based compensation" (Murphy, 2003). Thereby, stock market indices capture different aspects of the economy - business performance - that the

unemployment rate fails to capture (Cotti et al., 2015). On the other hand, business success can be associated with work-related stressors previously discussed. Therefore, we expect that the stock market might have two opposite effects on suicidality, one negative effect through the channel of a healthy business environment and its consequential benefits, and another positive effect through the channel of the work stress mechanism. The empirical analysis should determine which mechanism underpins the relationship between stock market movements and suicide incidences.

Secondly, previous studies argued that stock market volatilities may represent an alternative macroeconomic measure that better captures economic insecurity (Reeves et al., 2015; Nandi et al., 2012), a prominent feature of the recent deterioration in the working environment that is increasingly receiving attention. In fact, stock market indices are leading indicators of economic conditions, whilst the unemployment rate is a lagging indicator (Stock and Watson, 1989). For instance, during the financial crisis of 2007–2009, the stock market crashed in October 2008, and a few months later the unemployment rate started to increase dramatically and only peaked in October 2009 (Bureau of Labour Statistics, 2012). Thus, stock market volatilities raise concerns about labour market prospects, and hence send signals of job insecurity and fear of job loss. This has been proven to have a detrimental impact on the mental health of the employed (Witte, 1999). Stuckler et al. (2011) report that suicide rates tend to increase with the very early signs of economic distress, even before the actual rise in the unemployment rate. Furthermore, an anticipated rise in the unemployment rate may increase the fear of redundancy. A recent study in the UK suggests that the uncertainty surrounding the future of one's job could potentially precipitate suicide (Vandoros et al., 2019). On the other hand, the unemployed will tend to be more pessimistic as their labour market prospects are now bleak. Garcy and Vågerö (2012) found that the longer the unemployment period, the stronger its effect on the suicide rate.

Consequently, it appears reasonable to anticipate that stock market volatilities may represent a suicide risk factor irrespective of employment status. However, no previous study has investigated the relationship between stock market volatilities and suicide mortalities. To the best of our knowledge, the only population-level study that examined the association between stock market volatilities and suicide mortalities has been limited to the state of New York (Nandi et al., 2012).

Taken together, the aim of the present study is to examine the relationship between business performance and suicide rates in recent years. We use the stock price index as an alternative proxy for the economic conditions that capture the business environment in the US. This is specifically designed to examine the hypothesis that adverse working conditions over recent years may have resulted in a pro-cyclical relationship between business performance and suicide. Additionally, we employ stock market volatilities to investigate the association between economic insecurity– a unique aspect of adverse working environment – and suicide rates. We contribute to the literature by providing an empirical test linking the stock market and its volatilities to suicide rates. In doing so, we represent the first population-level study that investigates the relationship between business performance and suicide. Additionally, we expand upon Nandi et al. (2012) and we present the first nationwide-level study on the association between stock market volatilities and suicide rates from 1999 to 2017. By using recent suicide data, we contribute to the open debate on forces driving the continuous rise in suicide rates in recent decades.

3. Data and methodology

3.1. Data

We obtained data on the monthly number of deaths by suicide stratified by age and gender for the period 1999–2017 from the Centers for Disease Control, and Prevention WONDER mortality database. We abstracted monthly population estimates by gender and age from the US Census Bureau to calculate monthly suicide rates. Some months were missing, therefore, we interpolated the missing observations under the assumption of linear growth as per Harper and Bruckner (2017). This resulted in a sample of 223 observations spanning January 1999 to July 2017. Our dependent variable is the monthly suicide rate. We use two measures of stock market performance. The first is the S&P500 stock market index, whilst the second is stock market volatility captured by the VIX. The S&P500 is a leading American stock market index created by Standard & Poor's based on the market capitalizations of 500 large-cap common stocks traded in the US. Therefore, it is a reliable measure of business performance in the US. The S&P500 is measured using monthly closing values. The VIX is the volatility index of the Chicago Board Options Exchange (CBOE) based on the S&P500 index options prices and reflects the market's expectations of future volatility. The VIX will serve as a proxy for economic insecurity, the fear of job losses, and the anticipation of financial instability that precede the actual rise in unemployment rates. Indeed, the VIX is sometimes referred to as "the fear index" (Whaley, 2000). We also included data on the monthly unemployment rates in the US extracted from the Bureau of Labour Statistics.

3.2. Methodology

In order to empirically examine the long-run relationship between business performance and suicide rates, we employ the Autoregressive Distributed Lag (ARDL) co-integration methodology, also known as bounds test, developed by Pesaran et al. (2001). This co-integration framework has been extensively used in empirical studies on suicide (Andrés et al., 2011; Chang and Chen, 2017) due to its methodological advantages over other traditional co-integration frameworks. Particularly, the ARDL approach does not require the time series to be mutually integrated of order I(1) as a pre-requisite. It permits testing for co-integration when the variables are purely I(0), purely I(1) or mutually co-integrated which helps to avoid any potential "pre-testing bias". However, this approach is not valid if the series are integrated of order 2 i.e. I(2) variables. Additionally, the ARDL framework provides unbiased long-run coefficient estimates. This advantage is the most relevant for the purpose of this study and will help to examine the long-run relationship between business performance and sex and age-specific suicide rates.

Our baseline empirical model for the long-run relationship is as follows:

$$SR_{t,\ j} = \phi_0 + \sum_{i=1}^{p} \phi_{1i}\ SR_{t-i,j} + \sum_{i=0}^{q} \phi_{2i}\ INDEX_{t-i} + \sum_{i=0}^{r} \phi_{3i}\ VIX_{t-i} + \sum_{i=0}^{s} \phi_{4i}\ Unem_{t-i} + \tau\ \ Trend_t + \omega\ \ D_t + \sum_{k=2}^{12} \phi_k\ M_{kt} + v_t \quad (1)$$

where $SR_{t,j}$ is monthly gender and age-specific suicide rates (male and female aged 15–24 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years); $INDEX_{t-i}$ is the S&P500 Index; VIX_{t-i} is the Implied Volatility Index of the S&P500; $Unem_{t-i}$ is the unemployment rate. Suicide mortalities are shown to exhibit seasonal patterns (Christodoulou et al., 2012; Harper et al., 2015) and time trends (Andrés, 2005). We, therefore, included month dummies (M_{kt}), where January represents the reference month and ($Trend_t$) to control for time trend. The financial crisis of 2007–2008 occurred during our sample period. A number of studies have suggested that the financial crisis has resulted in excess suicide deaths during this period (Chang et al., 2013; Reeves et al., 2012). We, therefore, use a dummy variable (D_t) to account for the months of the financial crisis. According to the The National Bureau of Economic Research (2012), the financial crisis started in December 2007 and ended in June 2009. Thus, the dummy variable will take the value of 1 during these months, and zero otherwise. v_t is the classical error term.

The ARDL representation of the empirical model from Equation (1) is

as follows:

$$\Delta\ SR_{t,j} = \theta_0 + \sum_{i=1}^{m1} \theta_{1i}\ \Delta SR_{t-i,j} + \sum_{i=0}^{m2} \theta_{2i}\ \Delta INDEX_{t-i} + \sum_{i=0}^{m3} \theta_{3i}\ \Delta VIX_{t-i} + \sum_{i=0}^{m4} \theta_{4i}\ \Delta\ Unem_{t-i} + \theta_5\ SR_{t-1,j} + \theta_6\ INDEX_{t-1} + \theta_7\ VIX_{\ t-1} + \theta_8\ Unem_{t-1} + \tau\ Trend_t + \omega\ D_t + \sum_{k=2}^{12} \phi_k\ M_{kt} + \varepsilon_t \quad (2)$$

where Δ is the difference operator; θ_0 is the intercept term, and ε_t is the error term, an independent and identically distributed stochastic process. We first identify the optimal number of lags *p*, *q*, *r*, and *s* for the dependent and the independent variables by estimating Equation (1). The optimal lag lengths are possibly different across regressors and can be obtained by minimizing either Akaike Information Criterion (AIC) or Schwarz Bayesian Criterion (SBC). Once the optimal number of lags is identified, the long-run relationship between the variables can be tested using the bounds test approach to co-integration, which involves estimating Equation (2) and testing the following hypothesis, ($H_0: \theta_5 = \theta_6 = \theta_7 = \theta_8 = 0$) i.e. no level relationship, against the alternative hypothesis, ($H_1: \theta_5 \neq \theta_6 \neq \theta_7 \neq \theta_8 \neq 0$). The aforementioned co-integration test is a Wald-type test with *F*-statistic that follows a non-standard distribution. Pesaran et al. (2001) computed two sets of asymptotic critical values for a given significance level and whether the tested model contains a trend and/or intercept. Alternatively, the long run relationship can be tested by means of the *t*-test advanced by Banerjee et al. (1998), which tests the following null hypothesis of no co-integration, ($H_0: \theta_1 = 0$) against the alternative hypothesis, ($H_0: \theta_1 < 0$). If the relevant test statistic (the computed F-statistic or the t-statistic) is greater than the upper bound critical value, then the null hypothesis can be rejected (the underlying variables are co-integrated). If it falls below the lower bound critical value, then the null hypothesis cannot be rejected (no co-integration among the underlying variables). Lastly, if the *F*-statistic or the *t*-statistic falls between the upper and the lower bounds of the critical values, the result is inconclusive.

Following Pesaran et al. (2001), the second step of the ARDL co-integration procedure is the reparameterization of the ARDL model into the conditional error correction model (ECM). The reparametrized model estimates the short-run dynamics and the long-run relationship between the underlying variables. The specification of the ECM is as follows:

$$\Delta\ \ SR_{t,j} = \alpha_0 + \sum_{i=1}^{k1} \alpha_{1i} \Delta SR_{t-i,j} + \sum_{i=0}^{k2} \alpha_{2i} \Delta INDEX_{t-i} + \sum_{i=0}^{k3} \alpha_{3i} \Delta VIX_{t-i} + \sum_{i=0}^{k4} \alpha_{4i} \Delta\ Unem_{t-i} + \gamma ECT_{t-1} + \tau\ \ Trend_t + \omega\ \ D_t + \sum_{k=2}^{12} \phi_k\ M_{kt} + \mu_t \quad (3)$$

where the ECT_{t-1} is the error correction term. According to Pesaran et al. (2001), ECT_{t-1} will replace the lagged level variables in Equation (2). The coefficient of the error correction term (γ) measures its quantitative importance. A negative and significant error correction term is alternative evidence of co-integration among the variables under consideration, as this indicates the short-run adjustment toward long-run equilibrium (Banerjee et al., 1998).

4. Results

The summary statistics are presented in Table 1. The mean suicide rates for males are four times higher than for females. In general, for both males and females, the suicide rates are higher among older individuals in the age groups 35–44, 45–54, and 55–64 years. Our explanatory variables (the S&P500, the VIX, and the unemployment rates) experienced large variations during the sample period, explained by the occurrence of the financial crisis during this time.

Table 1
Summary statistics, January 1999–July 2017.

Variables (N = 223)	Mean	Std. Dev.	Min.	Max.
Dependent Variables				
Male				
Age 15–24	1.434	0.166	1.093	2.042
Age 25–34	1.847	0.203	1.394	2.544
Age 35–44	2.027	0.181	1.636	2.528
Age 45–54	2.266	0.302	1.543	2.969
Age 55–64	2.084	0.332	1.386	2.855
Female				
Age 15–24	0.318	0.082	0.168	0.576
Age 25–34	0.444	0.085	0.277	0.712
Age 35–44	0.610	0.085	0.419	0.909
Age 45–54	0.738	0.128	0.403	1.055
Age 55–64	0.600	0.134	0.289	0.947
Independent Variables				
Unemployment Rate (Male)	6.263	2.028	3.700	11.100
Unemployment Rate (Female)	5.819	1.479	3.8	9.000
S&P500	1406.535	390.908	735.090	2470.300
VIX	20.329	7.972	59.890	10.260

The results of the unit root tests reveal that none of the time series is I (2) (results available upon request), which validate the use of the ARDL co-integration methodology. We, therefore, proceed and test the existence of a linear co-integration relationship between the various gender and age-specific suicide rates and the three economic measures of interest (namely, the S&P500, the VIX, and the unemployment rate). We first estimated Equation (1) and the Akaike Information Criterion was used to identify the optimal lag lengths. The ARDL column in Table 2 shows the optimal number of lags for the suicide rate, the unemployment rate, the S&P500, and the VIX, respectively. Subsequently, Equation (2) is estimated, and the bounds test is applied to determine the existence of a co-integration relationship among the underlying variables.

The results of the ARDL bounds test along with some diagnostics checks are displayed in Table 2. Our regression models fit reasonably well and pass the diagnostic tests against serial correlation, non-normal errors and heteroscedasticity. The Pearson correlation coefficients are as follows: S&P500 and VIX (−0.534), S&P500 and the male unemployment rate (−0.327), S&P500 and the female unemployment rate (−0.277), VIX and the male unemployment rate (0.277), and the VIX and the female unemployment rate (0.199). Bivariate correlations are low to moderate, indicating that multicollinearity is not a problem in this analysis. The results show that the computed F statistics (F_{PSS}) and the T statistics (t_{BDM}) are above the upper bound values in all models, strongly supporting a co-integration relationship at the 1% level of significance. The associated long-run coefficient estimates are reported in Table 3.

In relation to the association between the S&P500 and age and gender-specific suicide rates, the results shown in Table 3 suggest the existence of a positive long-run relationship between the S&P500 and suicide rates for young males and females aged 15–24 and 25–34, at the 5% level of significance. In the long-run, a 1000 point increase in the S&P500 is associated with 0.242 and 0.204 additional suicide deaths per 100,000 people among males aged 15–24 and 25–34, respectively, whilst the effect was found to be smaller in magnitude for females with corresponding estimates of 0.07 for the 15–24 age group, and 0.09 for the 25–34 age group. These findings are in contrast with prior research (Ruhm, 2000; Tapia Granados, 2005) that found that better economic conditions are associated with lower suicide rates. However, they are consistent with the theoretical expectations previously formulated in the literature that raise the possibility that over recent years, the adverse working environment may potentially have generated a positive relationship between business performance and suicide. The results suggest an insignificant association between the S&P500 and suicide rates for

Table 2
ARDL Co-integration results.

Variable	*ARDL*	Bounds Test		χ^2_{sc}	*p value*	χ^2_{H}	*p value*	χ^2_{N}	*p value*	χ^2_{FF}	*p value*	*Decision*
		F- Statistic	T- Statistic									
Male												
Age 15–24	(2,1,4,2)	11.20***	−6.684***	0.419	0.658	0.982	0.492	0.866	0.648	16.910	0.0001	Co-integration
Age 25–34	(1,0,3,2)	27.590***	−10.356***	0.861	0.424	1.165	0.283	1.460	0.481	10.257	0.002	Co-integration
Age 35–44	(1,0,0,0)	44.429***	−13.319***	0.223	0.799	1.187	0.276	1.352	0.508	26.075	0.000	Co-integration
Age 45–54	(3,0,0,2)	8.169***	−5.656***	1.812	0.166	0.971	0.501	1.613	0.446	7.205	0.007	Co-integration
Age 55–64	(1,0,1,0)	39.102***	−12.468***	1.054	0.350	1.204	0.259	1.335	0.512	5.921	0.015	Co-integration
Female												
Age 15–24	(3,0,1,1)	9.546***	−6.072***	0.820	0.442	1.654	0.041	1.202	0.548	15.954	0.0001	Co-integration
Age 25–34	(4,2,1,1)	9.361***	−5.890***	0.146	0.864	1.511	0.067	1.894	0.387	2.960	0.087	Co-integration
Age 35–44	(1,0,0,0)	57.736***	−15.164***	0.887	0.413	35.558	0.005	0.554	0.758	1.211	0.272	Co-integration
Age 45–54	(3,0,0,0)	14.073***	−7.323***	0.054	0.947	1.349	0.156	0.055	0.972	1.149	0.284	Co-integration
Age 55–64	(3,4,0,0)	12.839***	−6.893***	0.293	0.746	0.929	0.559	0.778	0.677	0.001	0.972	Co-integration

Note: χ^2_{sc}, χ^2_{H}, χ^2_{N}, and χ^2_{FF} denote statistics for LM tests for serial correlation, White test for heteroskedasticity, Jarque Bera test for normality, and Ramsey's Reset test for misspecification, respectively. The critical values for the F- Statistic and the t- Statistic are taken from Pesaran et al. (2001) and Banerjee et al. (1998), respectively. *, **,*** denote significance at 10%, 5% and 1% significance level, respectively.

Table 3
The ARDL – long run coefficient estimates.

Variable	Unemployment		S&P500		VIX	
	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic
Male						
Age 15–24	−0.005	−0.334	0.242	2.560**	0.006	1.970**
Age 25–34	0.005	0.370	0.204	2.569**	0.003	1.055
Age 35–44	0.001	0.152	0.025	0.390	0.002	1.403
Age 45–54	0.024	1.436	−0.075	−0.656	0.001	0.315
Age 55–64	0.036	3.082***	0.127	1.615	0.001	0.292
Female						
Age 15–24	0.004	0.588	0.070	2.246**	0.000	0.343
Age 25–34	0.009	1.690*	0.090	3.340***	0.000	−0.014
Age 35–44	0.001	0.138	0.035	1.256	0.000	0.527
Age 45–54	0.009	1.184	0.001	0.013	−0.002	−1.754*
Age 55–64	−0.001	−0.127	0.035	0.924	0.002	2.196**

*, **,*** denote significance at 10%, 5% and 1% significance level, respectively.
The coefficients of the S&P500 have been multiplied by 1000.

older males and females aged 35–44, 45–54 and 55–64.

Turning to the association between the VIX and age and gender-specific suicide rates, we found a significant long-run positive association between the VIX and suicide rates for the youngest male population aged 15–24 only, where a 1 point increase in the VIX is associated with 0.006 additional suicide mortalities per 100,000 people. In contrast, for females, the results suggest a significant positive long-run association between the VIX and the suicide rate for the elderly group aged between 55 and 64 years, such that a one point increase in the VIX is associated with 0.002 additional suicides per 100,000 people. The empirical analysis also detected a negative association between the VIX and the female suicide rate in the 45–54 age group. The male results are in accordance with Fiori et al. (2016) who provided evidence that the younger segment of the population is particularly vulnerable to economic insecurity. Overall, the results are generally consistent with Nandi et al. (2012), who found that stock market volatilities are not associated with suicide rates.

The coefficients of the unemployment rate are statistically insignificant, with the exception of the male group aged 55–64, where the coefficient estimate was found to be 0.036 and statistically significant at the 1% level of significance and for the female group aged 25–34, where the coefficient was much smaller in magnitude (0.009) and marginally significant at the 10% significance level. These findings are in notable contrast to the well documented positive relationship between suicide and unemployment (Tapia Granados, 2005; Ruhm, 2000; Wu and Cheng, 2010; among others), but in line with more recent research suggesting that over recent times, the suicide rate has become less responsive to changes in unemployment rates (DeFina and Hannon, 2015).

Table 4 and Table 5 present the results of the ECM for males and females, respectively. The reported parameter estimates of the ECM are all statistically significant and have the expected negative sign in all models, which further support the co-integration relationships between the various suicide rates (gender and age-specific) and the explanatory variables. A notable exception is that the coefficient of the ECM for the female group aged 35–44 is greater than one, which indicates that the model does not converge to long-run equilibrium. We will not further interpret the short-run coefficient estimates (available upon request) as per Andrés et al. (2011) given that the main interest of this study is the long-run association between business performance and suicide rates, as this relationship is more informative for policymakers.

Monthly suicide rates exhibit seasonal patterns with a noticeable increase in warm months (May–August). However, the seasonal pattern is particularly discernible for males aged 35–44 and females aged 25–34. Generally, this is in line with previous studies that have confirmed the seasonality of suicide rates in the US (Christodoulou et al., 2012; Harper et al., 2015). Overall, our results demonstrate that the financial crisis was not associated with additional suicide incidences, with the exception of young males aged between 15 and 34 years. These findings are generally consistent with prior studies, which found limited evidence of a shift in suicide trajectories attributable to the financial crisis (Fountoulakis et al., 2013; Harper and Bruckner, 2017). Lastly, in terms of the time trend, the results support a strong significant upward time trend across all models during the period of the study (1999–2017). These results suggest that it is important to account for national time trend when modelling suicide rates (Andrés, 2005).

Table 4
ECM estimates – male.

	Age 15–24		Age 25–34		Age 35–44		Age 45–54		Age 55–64	
Variable	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic
Dummy	−0.083	−2.648***	−0.068	−2.460**	−0.031	−1.057	0.039	1.067	0.032	0.837
Trend	0.001	3.902***	0.001	7.168***	0.001	8.237***	0.002	5.292***	0.003	10.839***
February	−0.158	−4.510***	−0.199	−5.681***	−0.162	−4.038***	−0.316	−6.995***	−0.238	−5.308***
March	0.004	0.124	0.025	0.726	0.067	1.704*	0.051	1.111	0.120	2.737***
April	0.042	1.177	−0.036	−1.022	−0.009	−0.219	−0.062	−1.410	0.075	1.654
May	−0.001	−0.011	0.065	1.907*	0.110	2.745***	0.039	0.810	0.155	3.293***
June	−0.172	−4.876***	0.016	0.463	0.085	2.010**	−0.082	−1.764**	−0.006	−0.130
July	−0.057	−1.683*	0.120	3.346***	0.127	3.038***	0.014	0.299	0.042	0.917
August	−0.001	−0.035	−0.001	−0.048	0.182	4.226***	−0.032	−0.678	−0.000	0.065
September	−0.051	−1.464	−0.059	−1.616	0.003	0.064	−0.145	−2.948***	−0.079	−1.588
October	0.015	0.425	−0.029	−0.831	0.022	0.517	−0.176	−3.697***	−0.092	−1.895*
November	−0.107	−3.019***	−0.133	−3.76***	−0.128	−3.134***	−0.290	−6.534***	−0.189	−4.257***
December	−0.178	−5.166***	−0.109	−3.187	−0.103	−2.571**	−0.239	−5.67***	−0.162	−3.677***
ECT_{t-1}	−0.586	−6.745***	−0.708	−10.584***	−0.942	−13.838***	−0.545	−5.759***	−0.857	−3.677***
R- squared	0.677		0.62		0.65		0.70		0.667	

*, **,*** denote significance at 10%, 5% and 1% significance level, respectively.
The coefficients of the S&P500 have been multiplied by 1000.

Table 5
ECM estimates – female.

	Age 15–24		Age 25–34		Age 35–44		Age 45–54		Age 55–64	
Variable	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic	Coefficient	T- Statistic
Dummy	−0.01	−0.965	0.017	−1.396	0.009	0.623	0.018	1.338	−0.039	−2.105**
Trend	0.001	5.860***	0.000	6.102***	0.001	9.317***	0.001	6.895***	0.001	6.859***
February	−0.040	−2.738***	−0.041	−2.715***	−0.042	−2.100**	−0.090	−4.494***	−0.051	−2.502**
March	0.019	1.321	0.024	1.565	0.006	0.317	0.006	0.310	0.042	2.035**
April	−0.007	−0.534	0.018	1.194	−0.001	−0.035	0.014	0.720	0.037	1.744*
May	0.012	0.849	0.055	3.597***	0.023	1.184	0.019	0.886	0.069	3.202***
June	−0.041	−2.883***	0.056	3.639***	0.007	0.375	0.001	0.050	0.023	1.085
July	−0.023	−1.720*	0.063	4.002***	0.051	2.499**	−0.004	−0.204	0.042	2.011**
August	−0.012	−0.858	0.042	2.660***	0.049	2.329**	0.005	0.277	0.018	0.837
September	−0.008	−0.609	0.005	0.316	0.005	0.273	−0.023	−1.112	0.011	0.495
October	0.000	0.008	0.028	1.793*	0.011	0.511	0.003	0.136	−0.004	−0.210
November	−0.021	−1.484	−0.000	−0.005	−0.033	−1.638	−0.065	−3.283***	−0.023	−1.136
December	−0.063	−4.449***	−0.010	0.666	−0.064	−3.208***	−0.069	−3.502***	−0.042	−2.053**
ECT_{t-1}	−0.603	−6.254***	−0.861	−6.166***	−1.069	−15.107***	−0.719	−7.113***	−0.818	−7.306***
R- squared	0.58		0.65		0.60		0.58		0.61	

*, **,*** denote significance at 10%, 5% and 1% significance level, respectively.
The coefficients of the S&P500 have been multiplied by 1000.

5. Discussion

Empirical results from this study reveal that there is a positive association between business performance (represented by the S&P500) and suicide rates of young male and female populations aged 15–24 and 25–34. This is in line with the theoretical hypothesis developed in the literature and further indicate that the work stress mechanism is playing the dominant role in this relationship. A potential explanation for this finding is that a business environment characterized by adverse working conditions and organizations that promote profits over the mental well-being of employees, might have diminished the protective role of a successful business environment on suicide. In other words, while work is good for mental health, adverse working conditions can cause harm to one's mental health (WHO, 2019).

The statistically insignificant relationship between the S&P500 and suicide rates for male and female individuals aged 35–44, 45–54, and 55–64 does not necessarily mean that the successful business performance has no adverse impact on suicide rates for these age groups. Instead, it suggests that neither the work stressors mechanism nor the beneficial impacts of business growth dominate in the data. As demonstrated by Neumayer (2004), we expected that the two mechanisms operate in any society, thereby an insignificant coefficient implies that neither of the two effects dominates in these age groups.

Two notable findings emerge. First, the results highlight substantial differences in age group responses to fluctuations in business performance. Following the hypothesized mechanism of work stressors, it is not surprising that the younger population are particularly vulnerable to business successes since this age group is in the early stages of their employment. It may be the case that they have not yet developed a coping strategy to manage work stressors or succeeded in maintaining a healthy work-life balance. Indeed, Sturges and Guest (2004) found that younger employees' worries about career advancement, drive them to work for long hours and ultimately, they fail to achieve this work-life balance. By contrast, older people are more successful at achieving a work-life balance (Parkes et al., 2008). Second, our results suggest that women are not resilient to fluctuations in business performance as opposed to fluctuations in general economic conditions. The majority of studies that have previously examined the impact of economic fluctuations on suicide rates have consistently documented that females are less sensitive than males to these fluctuations (Garcy and Vågerö, 2012; Neumayer, 2003). One possible reason for females' vulnerability to business performance is that in recent years women have been seen to invest more in their education and they are now more tied to their careers than previous generations (Diebolt and Perrin, 2013). Therefore, their behaviours towards business growth and the associated work stressors may potentially be analogous to men's behaviour.

In terms of the association between stock market volatility and suicides, our results indicate that not only age matters, also gender plays a significant role in the relationship between economic insecurity and suicide. There are three possible interpretations as to why the young male population aged 15–24 was found to be less resilient to economic insecurity than the older population. First, younger individuals seeking entry to the labour market for the first time will be more responsive to the uncertainty and economic insecurity since it might potentially constitute a barrier to their entry. Second, for young people at the beginning of their professional careers with a low level of human capital, they may be subject to low employability and are expected to respond more aggressively to economic insecurity because if they lost their jobs, there is a low probability of being re-employed (Caroli and Godard, 2016). Third, young people did not have enough time to accumulate wealth to buffer potential changes in income. Thus, uncertainty about future income may matter more for young male individuals, especially if they are expected to fulfil their masculine role as breadwinners (Neumayer, 2003).

By comparison, females in the age group 55–64 were found to be particularly vulnerable to economic insecurity. It is plausible that at this late stage of their employment career, economic insecurity may pose a threat of involuntary retirement - an issue that has been previously linked to negative psychological symptoms (Mosca and Barrett, 2016). A particularly striking finding is that, while males near retirement are resilient to the threat of job loss, this threat is sufficiently powerful to precipitate the suicide of their female counterparts. Loneliness and diminishing in the importance of the female traditional role in late midlife, for instance, motherhood, are potential mechanisms that could explain the particular vulnerability of females aged 55–64 to economic insecurity. Elucidating the mechanisms behind this gender disparity remains a fruitful area of further research. Additionally, the negative association between economic insecurity and suicide rates of females in the 44–54 age group runs counterintuitive, which in turn highlights the need for more research to investigate the mechanisms behind this effect. Perhaps, we may find, that this mechanism is revealed once we consider the social norm effect i.e. the prevalence of economic insecurity in recent years. Lastly, it is also possible that the VIX is not the most relevant measure to capture the economic insecurity experienced by individuals. Future research could potentially use other measures that were previously found to be better able to capture economic insecurity in other countries, for example, the Economic Policy Uncertainty Index in the UK (Vandoros et al., 2019).

Our results indicate an insignificant relationship between unemployment and suicide for different sex and age groups with the suicide rate for males aged 55–64 being a notable exception where the unemployment coefficient was found to be significant. These results allow two plausible interpretations. One interpretation implies that unemployment is no longer a suicide risk factor. However, we believe that we should pay careful attention to the interpretations of these results in order to avoid misinterpretations and consequential misleading policy recommendations. There is evidence in the literature that unemployment benefits protect against suicidality (Breuer and Rottmann, 2014). In fact, research documented that the generous welfare system of the federal government is providing a strong safety net for the unemployed and their families (Tiehen et al., 2012). Therefore, it is reasonable to interpret our results that the strong safety net in the US, in turn, could potentially have off-set the impact of financial losses on suicide rates (DeFina and Hannon, 2015). This finding echoes with a recent study in the UK that also suggests that the generous employment protections policies contributed to the disconnect between unemployment and suicides during recent years (Vandoros et al., 2019). Thus, our empirical finding supports the hypothesis that a strong safety net can play a substantial role in undermining the unemployment-suicide relationship. Nevertheless, the significant positive effect of unemployment on males aged 55–64 suggest that the stigma, the threat to social status, and the well-being losses associated with job loss continue to play an independent role in this relationship over and above the detrimental impact of financial losses (Bartley, 1994).

Equally important, the relationship between the economic state and suicide is subject to the perspective from which the economic state is analysed. Having relied on the unemployment rate, we would reach a conclusion of a disconnection between the economy and the suicide. However, when taking a more business perspective, we found that the relationship may exist but through different channels (Cotti et al., 2015).

5.1. Limitations

There are some limitations in this study that should be taken into consideration. Firstly, the limitation inherent in any population-level study, the so-called ‘ecological fallacy”. This is a problem that arises when drawing inferences based on aggregate level data and assumes they are applicable to individual behaviour. Nevertheless, population-level studies have the advantage of identifying population-level risk factors. Hence, it might be more salient in crafting and implementing public health policies aimed at reducing suicide rates. Secondly, previous studies of the economic determinants of suicide tend to control for other variables that are widely documented to enhance suicidality. For instance, the divorce rate and the fertility rate have been included in a number of studies as important socio-economic determinants of suicide (Chang and Chen, 2017). However, we were not able to control for these variables due to the lack of their availability at a monthly frequency, and interpolating monthly values from annual data may result in measurement errors (Classen and Dunn, 2012). However, the time series analysis employed in this study has the advantage of isolating the unique effects of the explanatory variables and avoiding any estimation bias (Dooley et al., 1989). Thirdly, our research does not differentiate between different professions. It may be the case that some professions are under more stress and poorer working conditions than others, thus, some professions may be at a higher risk of suicide (Tiesman et al., 2015). This provides avenues for future research to empirically examine the relationship between business growth and suicide at sub-population and individual levels to take into consideration profession-specific risk factors for suicide.

5.2. Policy recommendations

In terms of policy recommendations, we suggest the following, first, the positive association between the stock market index and suicide rates for the young male and female segment of the population 15–34 indicates a human cost associated with business successes. Given that suicide is the second leading cause of death for ages 10–34 years, the findings of this study should draw policymakers’ attention to potential suicide risk factors. Therefore, job design interventions to improve working conditions may be an important strategy for mitigating the adverse effect of business growth on suicide mortalities for young male and female populations (WHO, 2006). Mental health screening at work, teaching work-life management, stress management, and problem-solving skills to manage everyday work stressors could play a similar protective role against suicide (International Labour Organization, 2016), especially in early career. Moreover, our findings highlight the importance of recognizing that economic insecurity and the related fear of job loss should be considered as important risk factors for suicide above the actual realization of job loss for the young male population (15–24) and for the older female population (45–64). Thus, the national surveillance of psychosocial risk factors in the workplace should monitor the dynamic change in macroeconomic determinants that send signals of fear to the population (such as stock market volatility) and timely intervention before the actual realization of job losses, should be considered as a primary suicide prevention strategy. Moreover, policies that promote employment protection may help mitigate the impact of economic insecurity.

6. Conclusion

To our knowledge, this is the first population-level study to link the stock market and its volatility to suicide rates of different gender and age groups in the US. Using recent data on suicide rates, we established a clear positive link between business successes (represented by increases in the S&P500) and suicide rates for the young male and female population (15–34). Hence, there is a human cost associated with business growth. Our findings add to the emerging body of literature that suggests that over recent years, globalization and the associated work stressors may also be risk factors for suicidality. The findings of this study suggest that the suicide rates for the young male and female population (15–34) act pro-cyclically with respect to business performance. In other words, it does not track with the counter-cyclical relationship between economic performance and suicide in the same manner.

Credit author statement

Rawayda Abdou: Conceptualization, Methodology, Formal analysis, Validation, Investigation, Writing - original draft preparation. Damien Cassells: Supervision, Conceptualization, Writing - Reviewing and Editing, Funding acquisition. Jenny Berrill: Supervision, Writing - Reviewing and Editing. Jim Hanly: Writing - Reviewing and Editing.

Ethics approval

The study did not involve human subjects, so ethics approval was not required.

Declarations of competing interest

None.

Acknowledgments

This study was supported by a Fiosraigh Scholarship from the College of Business, Technological University Dublin, Ireland.

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