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Does unemployment have asymmetric effects on suicide rates? Evidence from the United States: 1928–2013

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ABSTRACT

This study applied the recently developed asymmetric causality test and asymmetric generalised impulse-response method to demonstrate the dynamic relationship between unemployment and suicide rates in the U.S. over the period of 1928–2013. The results suggest that there exist asymmetric effects of unemployment on suicide rates. An economic recession (in terms of an increase in unemployment rate) is more likely to increase the suicide rate among an old age group (55–64 years old) than among other age groups, while an economic expansion (in terms of a decrease in unemployment rate) is more likely to reduce the suicide rate of young (15–24 and 25–34 years old) and middle age groups (35–44 and 45–54 years old) than their counterpart. Therefore, policy implications generated from our results include the following: that intervention to prevent suicidal behaviour should be directed more towards the older age group during economic recession and that we may expect that an economic expansion may not result in a great reduction of suicide rates for the old age (55–64 years) group.

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1. Introduction

Suicide is a worldwide public health issue. According to the recent estimates from the World Health Organization, over 800,000 people die by suicide annually and it accounted for 1.4% of all deaths worldwide in 2012 (World Health Organization [W.H.O.], 2014). In the United States (U.S., hereafter), suicide is not only a significant public health issue, but also an important health economic issue. In 2013, suicide caused approximately 41,149 deaths, making it the 10th leading cause of death amongst the US population (American Foundation for Suicide Prevention [A.F.S.P.], 2014). In addition, the American Foundation for Suicide Prevention reported the economic cost of suicide deaths in the U.S. amounted to an annual $44 billion, and that this economic burden of suicide is most likely to fall on the working age population (A.F.S.P., 2014). Because of the prevalence and the significant economic burden of suicide, the World Health Organization has included suicide as one

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of the priority conditions in public health (W.H.O., 2014) and, thus, investigating determinants of suicide remains an active field of social science and medicine (Chen, Choi, Mori, Sawada, & Sungano, 2012; Milner, Hjelmeland, Arensman, & Leo, 2013; Milner, McClure, & Leo, 2012).

In fact, there is a great deal of literature investigating factors influencing suicide decisions and mortality rates. For example, Milner et al. (2013) and Chen et al. (2012) provided a very comprehensive review of socio-economic determinants of suicide. In addition, due to the recent global economics crises occurring in 2007, many recent studies have tried to evaluate the impact of economic crises on suicide (Barr, Taylor-Robinson, Scott-Samuel, McKee, & Stuckler, 2012; Baumbach & Gulis, 2014; Chang, Stuckler, Yip, & Gunnell, 2013; Coope et al., 2014; Phillips & Nugent, 2014; Reeves et al., 2012, 2015). Following this strand of research, some studies specifically investigated the effect of economic austerity (generosity) policies on suicide (Antonakakis & Collins, 2014; Branas et al., 2015; Cylus, Glymour, & Avendano, 2014) and other studies established the relationship between business cycle and suicide (Blasco-Fontecilla et al., 2012; Chang, Cai, & Chen, 2017; Chen, Chang, & Lin, 2018; Korhonen, Puhakka, & Viren, 2016; Luo, Florence, Quispe-Agnoli, Ouyang, & Crosby, 2011; Wu & Cheng, 2010). Since unemployment has been identified as a superior gauge of the population-level consequences of economic fluctuation (Granados, 2005; Wu & Cheng, 2010), much research has been done to examine the relationship between unemployment and suicide (Breuer, 2015; Chang & Chen, 2017; Chen, Cho, Lai, & Lee, 2010; DeFina & Hannon, 2015; Fountoulakis, Gonda, Dome, Theodorakis, & Rihmer, 2014; Lannani, Ghosn, Jougla, & Rey, 2015; Nordt, Warnke, Seifritz, & Kawohl, 2015; Norström & Grönqvist, 2015; Wu & Cheng, 2010).

Sociological theories elucidating the linkage between unemployment and suicide have consisted of two hypothetical models, the vulnerability model and the indirect causative model (DeFina & Hannon, 2015; Luo et al., 2011). The former model claims that unemployment would increase the risk of suicide due to the individual losing many supportive resources such as friends, co-workers and various types of healthcare that people may rely on to cope with stressful events, and the latter model states that unemployment may cause financial problems, relationship difficulties and diminishment of social status, with these being stressful enough to precipitate suicide (DeFina & Hannon, 2015; Luo et al., 2011). These two distinct sociological theories highlight the way in which the suicide rate is pro-cyclical with respect to the business cycle (measured by the change of unemployment rate). In addition, Hamermesh and Soss (1974) developed the microeconomic theory of suicide. In their model, the lifetime utility function is determined by permanent income and age. The individual commits suicide when his/her perceived total discounted lifetime utility is equal to zero, a status that he/she derives no benefit from continuing life. Based on a utility maximisation principle, Hamermesh and Soss's (1974) theory predicts that the suicide rate is inversely associated with the individual's permanent income. It follows that both sociological and microeconomic theories of suicide predict the positive relationship between unemployment and suicide. Nevertheless, previous studies on socio-economic determinants of suicide found positive, negative or no association between unemployment and suicide (see Chen et al., 2012; DeFina & Hannon, 2015; and Luo et al., 2011 and references therein for details). It is important to address that the ambiguous relationship between unemployment and suicide may result from the fact that economic fluctuation may have an asymmetric effect on suicide. The effect of a positive economic shock on suicide may differ from the effect of a negative economic shock on suicide. Failure to accommodate for asymmetric suicide cycles in the model specification results in an ambiguous relationship between unemployment and suicide.

Although the asymmetric effect of economic fluctuation on suicide has long been implied in the theoretical frameworks of the socio-economic determinants of suicide (Lester, 2001), the research incorporating asymmetric suicide cycles in the determinants of suicide is limited in the literature. To the authors' best knowledge, Wu and Cheng (2010) is the first published research dealing with the possibility of asymmetric suicide cycles in order to reveal the asymmetric effects of unemployment on suicide. Recently, Chang and Chen (2017) employed the linear and non-linear A.R.D.L. cointegration methodologies to examine the potential symmetric and asymmetric responses of suicide rates to unemployment rates in the U.S. Nevertheless, the former study is not grounded in a time series theoretical foundation in terms of the Granger causality and fails to provide precautionary information in terms of the propagation mechanism of an economic shock across a period of time. The later study analyses asymmetric responses of suicide rates based on the asymmetric dynamic multiplier effects only in the long-run. In order to establish an empirical model with a strong theoretical foundation, we first applied the newly-developed asymmetric causality test proposed by Hatemi (2012a) to identify the Granger causal relationship between unemployment and suicide rates in the U.S. from the period of 1928–2013, and then estimated the asymmetric generalised impulse–response function introduced by Hatemi-J (2014) to capture the propagation mechanism of an economic shock across a period of time. Hence, our empirical methods allow us to test for two hypotheses, the asymmetric suicide cycle and the pro-cyclical suicide hypotheses. The former hypothesis claims that there exist asymmetric effects of economic fluctuation (measured by the change of unemployment rate) on suicide; and the latter model states that suicide rate is pro-cyclical with respect to unemployment rate during the period of 1928–2013 in the U.S.

This study makes several contributions beyond those of the existing research on the socio-economic determinants of suicide in two respects. First, although asymmetric Granger causality has been studied extensively in the fields of finance (Hatemi, 2012a, b), macroeconomics (Gozhor, 2015; Tiwari, 2014) and crime (Mocan & Bali, 2010), this study investigated the asymmetric Granger causal linkage between unemployment and suicide rates in the U.S. within the period from 1928 to 2013 for the first time, contributing to literature on the socio-economic determinants of suicide. Second, unlike the previous studies investigating socio-economic determinants of suicide in which the responses of suicide to an economic shock across a period of time are not available, this study transformed unemployment and suicide rates into cumulative positive and negative changes of unemployment and suicide rates that allow us to estimate the impulses to an asymmetric innovation. Our model specification incorporating asymmetric suicide cycles will provide a more complete picture of the relationship between unemployment and suicide than have previous studies.

This study is organised as follows: Section 2 describes the empirical model and data. Section 3 presents the results of the examination of causal linkages running from unemployment to suicide in the U.S. from the period of 1928–2013. Section 4 provides the conclusion and policy implications from this study.

2. Empirical model and data sources

2.1. Empirical model

The main purposes of this study are two-fold: the first one is to explore the causal linkage between unemployment and suicide rates, and the second one is to illustrate the propagation mechanism of an economic shock across a period of time. To this end, the recently developed asymmetric causality test proposed by Hatemi (2012a) and the asymmetric generalised impulse responses method introduced by Hatemi-J (2014) were used for the study. In general, our empirical procedures include the following steps: First, we transformed our data into both cumulative positive and negative changes, as follows:

$$\begin{cases} s_{1t} = s_{1t-1} + \varepsilon_{1t} = s_{1,0} + \sum_{i=1}^{t} \varepsilon_{1t}^{+} + \sum_{i=1}^{t} \varepsilon_{1t}^{-} = s_{1t}^{+} + s_{1t}^{-} \\ u_{2t} = u_{2t-1} + \varepsilon_{2t} = u_{2,0} + \sum_{i=1}^{t} \varepsilon_{2t}^{+} + \sum_{i=1}^{t} \varepsilon_{2t}^{-} = u_{2t}^{+} + u_{2t}^{-} \end{cases} \quad \text{for } t = 1, 2, 3, \ldots, \mathrm{T} \tag{1}$$

where s_{1t} and u_{2t} represent suicide and unemployment rates, respectively. $s_{1,0}$ and $u_{2,0}$ are the initial values.ε_{1t} and ε_{2t} denote white noise disturbance terms. Positive shocks are defined as $\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0)$ and $\varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0)$, and negative shocks are defined as $\varepsilon_{1i}^{-} = \min(\varepsilon_{1i}, 0)$ and $\varepsilon_{2i}^{-} = \min(\varepsilon_{2i}, 0)$. It follows that we can express the white noise disturbance to be the sum of positive and negative shocks (Namely, $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$ and $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$). Hence, the cumulative positive and negative changes of suicide (unemployment) rates are defined as $s_{1t}^{+} = \sum_{i=1}^{t} \varepsilon_{1t}^{+}$ $(u_{2t}^{+} = \sum_{i=1}^{t} \varepsilon_{2t}^{+})$ and $s_{1t}^{-} = \sum_{i=1}^{t} \varepsilon_{1t}^{-}$ $(u_{2t}^{-} = \sum_{i=1}^{t} \varepsilon_{2t}^{-})$, respectively.

Second, in case of testing for causal linkage between positive cumulative shocks, we specified the vector autoregressive model for order p, VAR(p) below:

$$y_t^{+} = v + B_1 y_{t-1}^{+} + B_2 y_{t-2}^{+} +, \ldots., B_p y_{t-p}^{+} + \xi_t^{+} \tag{2}$$

where, $y_t^{+} = (s_{1t}^{+}, u_{2t}^{+})$, $v = (s_{1,0}, u_{2,0})$ and ξ_t^{+} are the 2×1 vectors of our target variables, intercept and error terms, respectively. The matrix B_r is a 2×2 matrix of parameters for lag order r ($r = 1, 2, \ldots, p$). The optimal lag order (p) was selected using the HJC criterion proposed by Hatemi-J (2003). In order to derive the testing statistics of the asymmetric causality between positive cumulative shocks, our VAR(p) can be written in compact form as follows:

$$Y = DZ + \delta \tag{3}$$

where both $Y = (y_1^{+}, y_2^{+}, \ldots.., y_T^{+})$ and $\delta = (\xi_1^{+}, \xi_2^{+}, \ldots.., \xi_T^{+})$ are defined as $n \times T$ matrices; $D = (v, B_1, B_2, \ldots, B_p)$ denotes a $n \times (1 + np)$ matrix; $Z = (Z_0, Z_1, \ldots, Z_{T-1})$ presents a $(1 + np) \times T$ matrix; $Z_t = (1, y_t^{+}, y_{t-1}^{+}, \ldots, y_{t-p+1}^{+})'$ represents a $(1 + np) \times 1$ matrix. According to equation (3), the Wald statistic testing for the null hypothesis of non-Granger causality is given by

$$Wald - Statistic = (C\beta)'[C(Z'Z)^{-1} \otimes S_U C']^{-1}(C\beta) \tag{4}$$

where, $\beta = vec(D)$ is a column stack of matrix D and C is an indicator matrix with the following elements: ones for restricted parameters and zeros for unrestricted parameters. S_U is the variance–covariance matrix of the unrestricted VAR(p) model. Equation (4) is asymptotic to the χ_p^2 distribution (p is the degree of freedom), if the assumption of normality in error terms is satisfied. Because time series data usually violate the assumption of normality and exhibit the autoregressive conditional heteroskedasticity (ARCH) effect, Hatemi (2012a) suggested the bootstrapping simulation method to generate critical values that are robust to the existence of non-normality and A.R.C.H. effect in the time series data.

Third, in order to follow the effect of a shock in unemployment rates within our V.A.R. system on suicide rates, we re-specified equation (2) in a moving average representation form as follows:

$$y_t^+ = \sum_{t=0}^{\infty} \theta_i + \sum_{i=0}^{\infty} A_i \xi_{t-i}^+ \text{ for t} = 1, 2, 3, \ldots, \text{T} \tag{5}$$

where θ_i is constant and the matrix A_i is a 2×2 matrix of parameters that were obtained by a recursive method introduced by Hatemi-J (2014). Based on the parameter matrix (A_i), Hatemi-J (2014) showed the asymmetric generalised impulse response of the effect of a standard error shock in the j^{th} equation at time t on y_{t+n}^+ as follows:

$$AGIR(n) = \sigma_{jj}^{-0.5} A_n \Omega e_j \text{ for n} = 1, 2, 3, \ldots \tag{6}$$

where Ω is the variance–covariance matrix in the VAR system and σ_{jj} is the variance element in the Ω matrix. e_j is an indicator vector where its j^{th} element equals one. We plotted the standard generalised responses of suicide rate to unemployment rate in order to see the effect of unemployment on suicide rates. The Monte Carlo simulation method with 10,000 repetitions was used to construct the 95% confidence intervals of the impulses, in order to see whether or not the estimated impulses are statistically significant.

Fourth, in the case of testing for causal linkage between negative cumulative shocks and the asymmetric generalised impulse response between negative cumulative shocks, we repeated our empirical procedure from step 2 through step 3.

2.2. Data sources

The data used in this study include the unemployment rate and various suicide rates from 1928 to 2013 in the U.S. The U.S. historical unemployment rate from the periods of 1928–1946 and 1947–2013 were obtained from Mitchell (2003) and the U.S. Labour Force Statistics database, respectively. Since the burden of suicide is most likely to fall on the working age population (A.F.S.P., 2014), suicide rates used in this study consisted of the overall suicide rate, and working age suicide rates. The overall suicide rate was adjusted by a fixed set of age-specific weights from the year 2000 standard population. Working age suicide rates include five age-specific suicide rates, which correspond to suicide rates among individuals aged 15–24 years, 25–34 years, 35–44 years, 45–54 years and 55–64 years. One may argue that the age group should start from 18 years instead of 15 years, because there is a large proportion of unemployed population (due to schooling) in the age group of 15–17 years. Nevertheless, it is important to address that the historical vital statistics only provide mortality data with either 5-year or 10-year intervals. This restriction of data availability prevents us from regrouping our data starting from individuals aged 18 years. In addition, the unemployment rate used in this study is to measure the unemployment status

Table 1. Descriptive statistics[a].

	Mean	S.D.	Min	Max
Age-adjusted suicide rate	13.244	2.514	10.391	22.092
Age 15–24 years suicide rate	8.560	3.186	3.829	13.671
Age 25–34 years suicide rate	12.959	2.495	8.196	17.139
Age 35–44 years suicide rate	15.960	2.420	12.099	23.070
Age 45–54 years suicide rate	19.995	5.192	14.189	36.862
Age 55–64 years suicide rate	22.170	8.084	12.061	48.780
Unemployment rate (%)	7.163	4.762	1.200	24.900

[a]The whole sample period going from 1928 to 2013, resulting in a total of 86 annual observations in level. Suicide rates are defined as the number of suicides/100,000 population.
Source: Please see 2.2 Data sources in the main text.

for the whole labour force population rather than for the individual age-specific group, so the unemployment rate used in this study is more likely to measure the whole macroeconomic condition in the U.S. rather than the economic status for some age-specific groups. It follows that the research bias from different definitions of age-specific groups could be minor. Moreover, the definitions of our age-specific groups are consistent with those used for the labour force population. All of the suicide rates from the period of 1928–2007 were obtained from Luo et al. (2011). The suicide rates from the period of 2008–2013 were retrieved from the Centres for Disease Control and Prevention W.O.N.D.E.R. compressed mortality database.

3. Results

3.1. Descriptive statistics

Table 1 displays the descriptive statistics for unemployment rate, the various suicide rates and their positive and negative cumulative positive and negative sums over the period of 1928 to 2013. In order to better present these data, we show in Figure 1 the trends of all variables used in this study. As indicated in Figure 1a, we found that both unemployment rate and age-adjusted overall suicide rate, in general, are pro-cyclical with respect to the business cycle, and several spikes reflected bad years for the U.S. economy, such as the period of Great Depression (1929–1933) and the end of the New Deal policy (1937–1938), two oil crises (1973–1975 and 1980–1982), the Gulf War crisis (1990–1992), the dot-com bubble recession (2001–2002) and the subprime loan crisis (2007–2009). Figure 1b shows that working age-specific suicide rates are also pro-cyclical with respect to the business cycle and their variations are greater than the variation generated from the age-adjusted overall suicide rate. In general, the suicide rates of the old age group (55–64 years) and two middle-aged groups (35–44 years and 45–54 years) exhibited a remarkable decline from 1928–2013. In contrast with the decreasing suicide rates of the old age and middle-aged groups, the suicide rates of the two younger groups (15–24 years and 25–34 years) increased dramatically in the postwar period, and reached a peak during the periods between the two oils crises. Figures 1c and d show the time plots of the positive and negative cumulative sums of unemployment and suicide rates over the period from 1928 to 2013. These two plots suggest a very stable trend of the positive and negative cumulative sums during the period from 1928 to 2013.

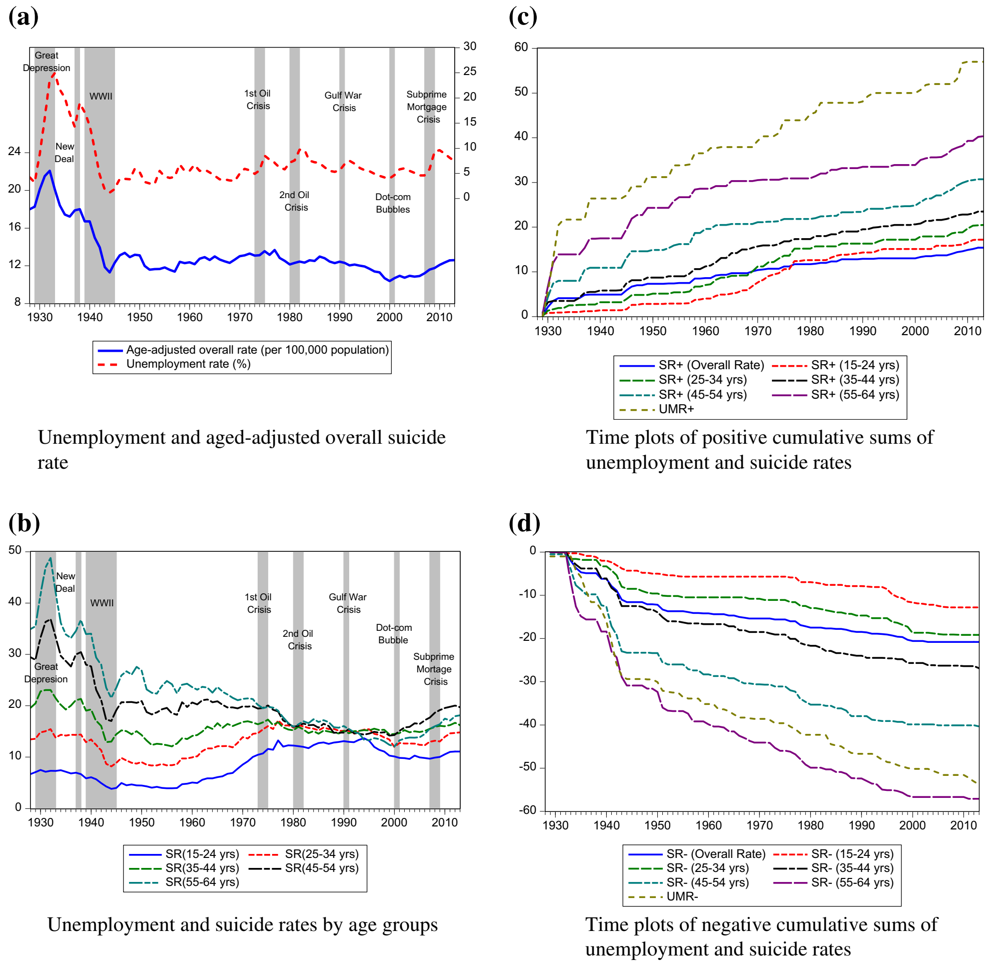

Figure 1. Unemployment and suicide rates. Source: Plotted by the authors.

Table 2. Results for the Phillips and Perron unit roots test.

	Level		Difference	
	De-mean	De-trend	De-mean	De-trend
Age-adjusted suicide rate	−2.046	−1.840	−5.726**	−5.675**
Age 15–24 years suicide rate	−0.885	−1.508	−8.270**	−8.238**
Age 25–34 years suicide rate	−1.242	−1.506	−8.818**	−8.815**
Age 35–44 years suicide rate	−2.045	−1.851	−8.002**	−8.080**
Age 45–54 years suicide rate	−1.946	−1.572	−6.120**	−6.136**
Age 55–64 years suicide rate	−1.543	−1.739	−5.398**	−6.005**
Unemployment rate (%)	−2.589	−2.822	−5.558**	−5.545**

**represents 1% significance level.
Sources: Calculated by the authors.

3.2. *Asymmetric causality test*

Table 2 presents the results for the Phillips-Perron unit root tests, and all the variables used in this study were proved to be I(1) series (i.e., unit roots exist in our data). Therefore, we

Table 3. Results for testing causality using bootstrap simulations.[a]

	Null hypothesis	Testing statistics	Bootstrap C.V. at 5%	Bootstrap C.V. at 1%	Lag
Age-adjusted suicide rate (overall rate)	UM≠ > SR	1.490	4.055	6.976	1
	UM^{+}≠ > SR^{+}	0.586	3.972	7.209	1
	UM^{-}≠ > SR^{-}	7.596*	4.126	8.261	1
Age 15–24 years	UM≠ > SR	0.103	3.966	6.925	1
	UM^{+}≠ > SR^{+}	0.242	3.991	6.890	1
	UM^{-}≠ > SR^{-}	4.239*	3.983	7.757	1
Age 25–34 years	UM≠ > SR	0.079	4.067	7.417	1
	UM^{+}≠ > SR^{+}	0.345	3.898	6.815	1
	UM^{-}≠ > SR^{-}	9.817**	4.212	8.822	1
Age 35–44 years	UM≠ > SR	1.048	4.174	7.396	1
	UM^{+}≠ > SR^{+}	2.543	3.991	7.008	1
	UM^{-}≠ > SR^{-}	12.155**	4.131	8.405	1
Age 45–54 years	UM≠ > SR	2.578	4.068	7.052	1
	UM^{+}≠ > SR^{+}	1.061	4.000	7.206	1
	UM^{-}≠ > SR^{-}	5.203*	4.041	7.931	1
Age 55–64 years	UM≠ > SR	3.632	3.988	7.079	1
	UM^{+}≠ > SR^{+}	4.661*	4.055	7.575	1
	UM^{-}≠ > SR^{-}	1.536	4.128	8.097	1

[a]Lags used in the symmetric and asymmetric causality tests were chosen using the Hatemi-J information criteria, respectively. As suggested by Toda and Yamamoto (1995), an additional unrestricted lag was included in the V.A.R. model in order to accommodate the unit root property of the unemployment and suicide rates. ** and * represent 1% and 5% significance levels, respectively. UM ≠ > SR means unemployment does not Granger cause suicide rates.
Sources: Calculated by the authors.

first estimated our V.A.R. model as in equation (3). As suggested by Hatemi (2012a), lags for V.A.R. model estimation are determined by the Hatemi-J information criteria. Additionally, in order to accommodate the unit root property of the unemployment and suicide rates, we included an additional unrestricted lag in the V.A.R. model to calculate the symmetric and asymmetric causality testing statistics and bootstrapped their critical values at the 5% or 1% significance level. Table 3 summarises the results for testing asymmetric causality using the bootstrap simulations with 10,000 repetitions. Note that our model specification transformed our data into both cumulative positive and negative changes. Hence, the Granger causality running from a negative (positive) change in the unemployment rate to a negative (positive) change in suicide rate reflects the fact that an economic boom (recession), indicated by a decrease (an increase) of unemployment rate, will significantly increase (decrease) the individual's income and social integration and, in turn, it will further reduce (increase) suicide rates. Therefore, the economic mechanism underlying the Granger causality running from unemployment to suicide rates is directly related to Hamermesh and Soss's (1974) theory of suicide, predicting that a decrease of permanent income due to unemployment will increase suicide rates. Additionally, sociological theories (such as the vulnerability and the indirect causative models) arguing that unemployment will increase the risk of suicide due to creating many difficulties in social integration (DeFina & Hannon, 2015; Luo et al., 2011) also provide theoretical rationales underlying the direction of causality running from unemployment to suicide rates.

As indicated in Table 3, the null hypothesis that unemployment does not Granger cause suicide cannot be rejected at 5% (or better) significance level. This result suggests that there is no symmetric causality between unemployment rate and suicide rates in the U.S. during the period of 1928–2013. Nevertheless, we did find significantly asymmetric causalities between unemployment and suicide rates. Specifically, we found that a negative change in the unemployment rate Granger causes a negative change in the age-adjusted overall suicide rate. The same results were found in most working age groups including the groups of individuals aged 15–24 years, 25–34 years, 34–44 years and 45–54 years. In addition, the asymmetric causality test revealed that a positive change in the unemployment rate Granger causes a positive change in the suicide rate of the 55–64 year old group. These results suggest that an economic boom (indicated by a decrease of unemployment rate) will significantly reduce the age-adjusted overall suicide rate and some age-specific suicide rates among individuals aged 15–24 years, 25–34 years, 35–44 years and 45–54 years, but an economic recession (indicated by an increase of unemployment rate) will significantly increase the 55–64 year suicide rate. It is worth addressing that the pro-cyclical suicide hypothesis (presented in the Introduction section) hypothesises that suicide rate is pro-cyclical with respect to unemployment rate (DeFina & Hannon, 2015; Hamermesh & Soss, 1974; Luo et al., 2011). Thus, these aforementioned results not only support the pro-cyclical suicide hypothesis, but also coincide with the asymmetric suicide cycle hypothesis, suggesting that asymmetric effects of economic fluctuation (measured by the change of unemployment rate) on suicide exist in the U.S. over the period of 1928–2013. In fact, the evidence obtained from our asymmetric causality tests are consistent with the findings from Wu and Cheng (2010), suggesting that there is an asymmetric relationship between unemployment rate and suicide rate in the U.S. Nevertheless, it is important to address that Wu and Cheng (2010) restricted their asymmetries to the relationship between the positive (or negative) change in employment rate and suicide rates, while we focused our asymmetries on the relationship between the positive (or negative) change in employment rate and the positive (or negative) change in suicide rates. In contrast to Wu and Cheng's (2010) empirical procedure, which is not grounded in a time series theoretical foundation, our procedure is based on the framework of the asymmetric causality test proposed by Hatemi (2012a).

3.3. Asymmetric generalised impulse and responses

Since the asymmetric Granger causality running from unemployment to suicide rates has been identified in the U.S. over the period of 1928–2013, we could conduct the standard impulse–response analyses for the propagation mechanism of an economic shock across a period of time. Note that the asymmetric Granger causal relationship between unemployment and suicide rates is underpinned by Hamermesh and Soss's (1974) theory of suicide and other sociological theories (DeFina & Hannon, 2015; Lester, 2001; Luo et al., 2011), so the theoretical rationales underlying the asymmetric Granger causality could apply directly to the asymmetric impulse–response analyses. Figures 2a–f present the standard impulse–response analyses for the propagation mechanism of an economic shock across a period of time. The first difference data were incorporated into our analyses due to the existence of the unit roots. We only reported the significant causal relationship between unemployment and suicide, as shown in Table 3. As indicated in Figures 2a–f, all the impulse–response analyses generate a significant result in the short run (e.g., 3 years), and the impulse–response analyses reach a significant result in the long run (e.g., more than 3 years) for the groups aged 25–34 years, 35–44 years, 45–54 years, and 55–64 years. The effects of unemployment on suicide rates get stronger as the age of workers increases. In addition, Figures 2a–e illustrate that a negative change in unemployment rate results in a negative change in the age-adjusted overall suicide rate, and the age-specific suicide rates for the groups ranging from age

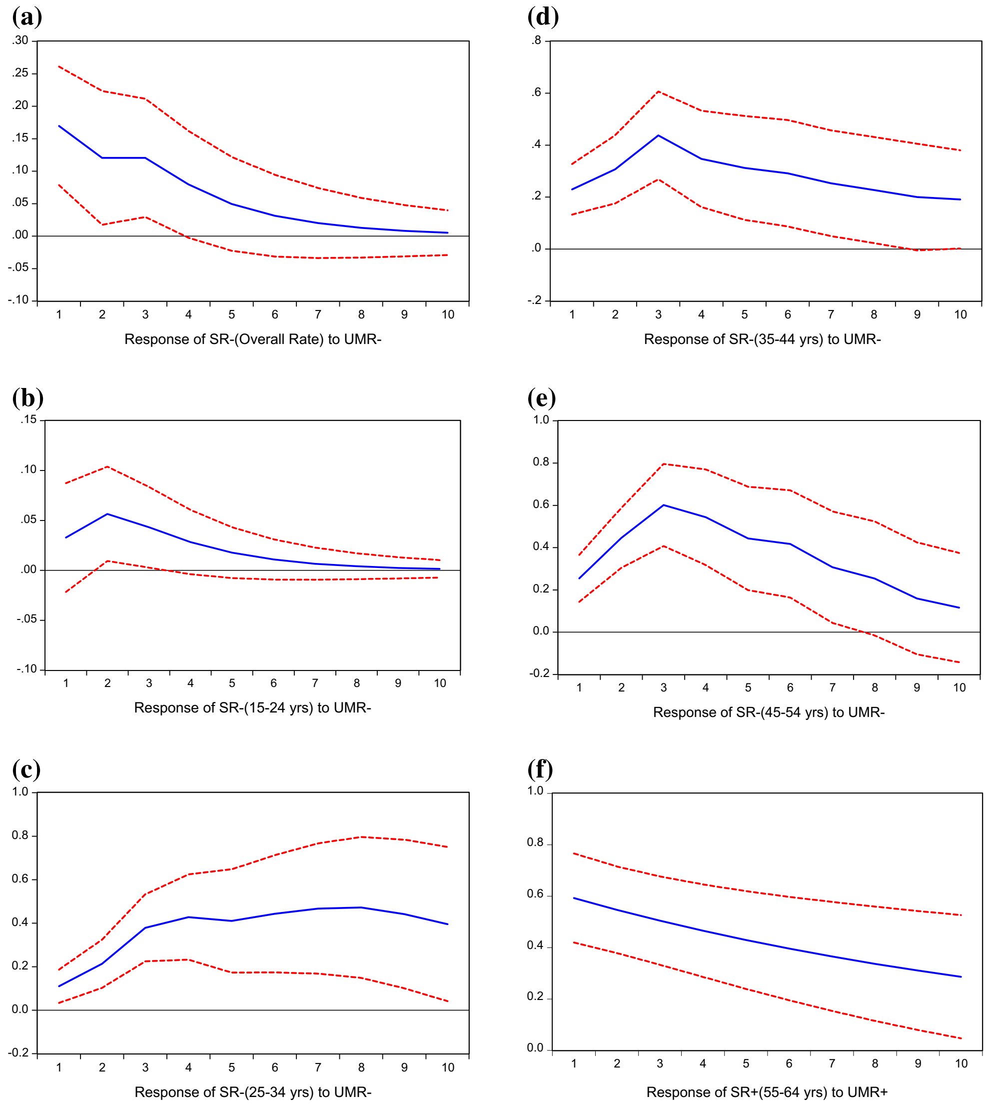

Figure 2. Standard generalised responses of suicide rate to unemployment rate. Sources: Plotted by the authors.
†Red-dot lines represent 95% confidence intervals using a Monte-Carlo simulation method with 10,000 repetitions.

15–24 years through age 44–54 years. Besides the negatively asymmetric effect of unemployment on the suicide within the working age group, including individuals aged 15–54 years old, became more significant in terms of the magnitude of response, as workers increase their ages. Moreover, Figure 2f demonstrates that a positive change in unemployment rate results in a positive change in the age-specific suicide rate for the group aged 55–64 years.

In sum, two important implications can be drawn from our standard impulse–response analyses. First, the standard impulse–response analyses once again confirmed that our data are consistent with the prediction from the pro-cyclical suicide hypothesis, as we could observe that unemployment rates are positively associated with the age-adjusted overall suicide rates and five age-specific suicide rates in an asymmetric way (in terms of the significant asymmetric relationship identified by the asymmetric causality tests in Table 3). Recent studies (see Chang et al., 2013; Chen et al., 2012; DeFina & Hannon, 2015; and references therein) suggested that there may exist a changing relationship between unemployment and suicide. We argue that this changing relationship may be due to the bias of not taking the asymmetric suicide cycle into account. Second, as shown in Figures 2a–f, the plot for the response of a positive change in suicide rate to a positive change in unemployment rate is only available for the aged 55–64 years group (due to the significant causal relationship identified in Table 3). Thus, the response of a positive change in suicide rate to a positive change in unemployment rate is not statistically significant for the other age groups. These results imply that a negative economic shock (in terms of an increase in unemployment rate) would impose a greater impact on the old age group (individuals aged 55–64 years) than its counterparts. In addition, the plots for the response of a negative change in suicide rate to a negative change in unemployment rate are available for all age-specific groups, except the old age group (due to the significant causal relationship identified in Table 3). These findings suggest that a positive economic shock (in terms of a decrease in unemployment rate) would place a greater impact on the young groups (the groups ranging from age 15–24 years through age 25–34 years) and middle age groups (the groups ranging from age 35–44 years through age 45–54 years) than their counterpart (individuals aged 55–64 years).

4. Conclusion

Suicide is a paradoxical decision, and it has a definite negative impact on friends, families and society. Many theoretical works from the fields of economics and sociology (such as Hamermesh and Soss (1974) and Lester (2001)) have suggested that unemployment is the most important factor that influences suicide. Therefore, health economists and sociologists have long been concerned about the linkage between unemployment and suicide. Previous studies showed a changing relationship between unemployment and suicide rates (see Chang et al., 2013; Chen et al., 2012; DeFina & Hannon, 2015, and references therein). We argue that the failure to take asymmetric suicide cycles into account results in this ambiguous relationship between unemployment and suicide rates.

In this study, we adopted the newly-developed asymmetric causality test proposed by Hatemi (2012a) and the asymmetric generalised impulse–response method introduced by Hatemi-J (2014) to demonstrate the dynamic relationship between unemployment and suicide rates over the period of 1928–2013 in the U.S. Our results suggest that there exist asymmetric effects of unemployment on suicide rates. Specifically, we found that the age-adjusted overall suicide rate falls during an economic boom period (in terms of a decrease in unemployment rate). An economic recession (in terms of an increase in unemployment rate) is more likely to increase the suicide rate among those in the old age group than among those in other age groups, while an economic expansion (in terms of a decrease in unemployment rate) is more likely to reduce the suicide rates of the young and middle age groups than their counterpart. Thus, several policy implications can be drawn from our empirical results. First, since the young and middle age groups represent a large proportion of the working population, any economic policy that could successfully stimulate the economy and reduce the unemployment rate could serve as an effective intervention to decrease the suicide rates of young and middle age groups and the age-adjusted overall suicide rate. Second, other strategic interventions designed to reduce suicidal behaviours should put more emphasis on the old age group during economic recession, while we may expect that economic expansion may not result in a great reduction in suicide rates for the old age group.

Finally, the limitation of this study is inherent in its bivariate type of analysis. We are aware that other social, cultural and medical factors all may have some influence on suicides. Since the historical time series for those factors are too short to conduct a rigorous time series analysis, one direction for the future study is to wait for more complete time series data to overcome the limitation of this study. The other direction for the future study is to collect the individual data that incorporate important socio-economic variables to investigate the relationship between long-term unemployment (measured by various indicators such as unemployment duration, see Stankunas, Kalediene, Starkuviene, & Kapustinskiene, 2006, for example) and suicide rates across various vulnerable groups.

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