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# Economic cycle, fertility, and seasonal pattern of suicide rates in South Korea from 1995 to 2015

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## Abstract

**Aim** The aim of this study is to investigate mixed risk factors associated with suicide rates in South Korea.

**Methods** Data on suicide in South Korea from 1995 to 2015 were investigated to understand risk factors for suicide using time series analysis.

**Results** We found that increasing GDP per capita growth rates and fertility rates were associated with decreasing suicide rates. Using the moving average method (monthly data), we found a negative correlation between suicide rates and the Korea Composite Stock Price Index (KOSPI). Moreover, a seasonal pattern of suicide rates was found in South Korea. The suicide rate was highest in May and lowest in January. The months of outliers occurred against the seasonal pattern observed in 1998, 2003, 2005, 2007, and 2008. These might be associated with the economic crisis or other miscellaneous risk factors.

**Conclusion** These results provide evidence that there is a significant relationship between suicide rates and the socioeconomic factors mentioned above in South Korea. The results obtained in this study may help to create public policies for lowering suicide rates in South Korea.

**Keywords** Suicide · Macroeconomic factors · Fertility · South Korea · Stock market index

## Introduction

Durkheim claimed that suicides are closely related to economic factors (e.g., urbanization and industrialization) and social integration (Durkheim 1951; Pierce 1967; Zhang et al. 2010). Hence, suicide has been attributed to not only individual characteristics but also socioeconomic factors (Partonen et al. 2004).

An empirical link between macroeconomic factors and suicide rates has long been investigated in the mental health and psychology literature. Zivin et al. (2011) provided a review of the association between economic downturns and mental health. Many studies have used unemployment rates as the proxy for macroeconomic development or depression. Some studies have reported a positive correlation between unemployment and suicide rates (Blakely et al. 2003; Yip and Caine 2010) while several studies have found a meaningful correlation between them when analyzing men (Platt et al. 1992) and women (Dooley et al. 1989) separately. On the other hand, some studies have revealed that higher unemployment rates are associated with lower suicide rates (Neumayer 2004; Ruhm 2000). For South Korea, unemployment and suicide rates were positively correlated in periods of economic crisis (Kim et al. 2004; Park and Lester 2006). However, the unemployment rates may not reflect the real economic status of a country since the government wants to announce a low unemployment rate to the public (Kim 2018). Furthermore, a thorough investigation might be needed not only during the crisis periods but also during the period of stable economic status in South Korea.

Previous studies have found a significant association between suicide rates and social integration. In other words, weak social cohesion might be related to higher suicide rates. Social cohesion indicates *connectedness* and *solidarity* (Kawachi and Berkman 2000) between society and its members. Several indicators, such as fertility, divorce, and marriage rates, may reflect social cohesions. Lester (1995) claimed that aggregated divorce rates could be an index of the quality of life not only for divorced but also for married,

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widowed, and single people, since the suicide rates among the divorced people have been found to correlate with those among other types of families. Lester and Yang (1992) found that higher fertility rates were related to lower suicide rates using time series analysis from 1933 to 1984 in the US. For South Korea, Park and Lester (2006) found results similar to those of other studies in that suicide rates decreased when fertility and marriage rates increased while increasing divorce rates led to higher suicide rates. However, those previous studies have investigated the factors of social cohesion (e.g. marriage, fertility, and divorce rates) as a single contributor to suicide rates without considering other factors, such as economic growths and seasonal patterns in suicide rates.

On the other hand, many researchers have revealed seasonal patterns in suicide rates. For example, suicide rates tend to peak in spring and summer in many countries (Petridou et al. 2002), such as Finland (Partonen et al. 2004), Ireland (Corcoran et al. 2004), Italy (Preti and Miotto 1998), and Slovenia (Oravecz et al. 2006), among many others. Although this distinct pattern has been repeatedly observed in many countries, its specific causes remain unknown. Previous studies have focused only on seasonal variations in suicide rates across different demographic subgroups (e.g., age, gender, and residence) (Partonen et al. 2004; Woo et al. 2012) and did not consider the macroeconomic cycle, which is one of most driving factors related to suicide rates.

Several studies conducted in South Korea found an association between celebrity suicides and the national suicide rates (Chen et al. 2014; Fu and Chan 2013). Fu and Chan (2013) found significant effects of 3 incidences among 11 celebrity suicides. Based on time series analysis, they concluded that the deaths of E.J. Lee (in February 2005), D.B. Jeong (in February 2007), and J.S. Choi (in October 2008) significantly affected the national suicide rates. According to their analysis, eight celebrities killed themselves from September 2008 to March 2009, and they claimed that Choi's suicide had the greatest effect on the national suicide rates. However, that period coincided with the global economic crisis in 2008. In other words, these studies may have neglected the influence of other factors on suicide rates in South Korea.

According to the Organization for Economic Cooperation and Development (OECD) statistics (OECD 2017), suicide rates decreased gradually by 30% from 1990 to 2015. However, the suicide rate in South Korea has increased three-fold during the same period. In 2015, South Korea had the second highest suicide rate after Lithuania, with about 29 deaths per 100,000 (OECD 2017). Most studies in South Korea have focused on quantifying suicide rates regarding subgroups (e.g., gender, age, and marital status) (Kwon et al. 2009; Park and Lester 2006), macroeconomic factors (e.g., the economic crisis and unemployment rate) (Chan et al. 2014; Khang et al. 2005; Kim et al. 2004), and the effect of celebrity suicides (Chen et al. 2014; Fu and Chan 2013). However,

these studies only considered a single factor. Moreover, those studies used a priori knowledge, such as the period of the global economic crisis (Chan et al. 2014) and occurrence of celebrity suicides, to support their research hypotheses (Chen et al. 2014; Fu and Chan 2013). Consequently, this may result in publication bias. In other words, the published results may not be the same as the unpublished ones (Song et al. 2013).

In this article, we aim to understand and characterize the combined risk factors associated with suicide rates using the economic cycle, social integration, and seasonal pattern of suicide in South Korea from 1995 to 2015. We used the gross domestic product (GDP) per capita growth rate, stock market index of South Korea (Korea Composite Stock Price Index: KOSPI), and fertility rate provided by the World Bank Indicator and the National Statistical Office of Korea (NSO) to examine the link between suicide rates and risk factors.

## Data and methodology

Monthly suicide rates (NSO 2017a) and KOSPI (NSO 2017b) were provided by the NSO, and the GDP per capita growth rate (World Bank Indicator 2017a) and fertility rate (World Bank Indicator 2017b) were obtained from the World Bank Indicator. The data were available for 1995 to 2015.

The data were analyzed using the time series regression method. The dependent variable was the suicide rate (number of suicide occurrences per 100,000). The independent variables were GDP per capita growth rate, yearly averaged KOSPI, and fertility rate.

To describe the relationship between suicide rates and independent variables, we can build the equation:

$$y_t = X_t\beta + \varepsilon \qquad (1)$$

where $y$ is the suicide rate, $X$ is the design matrix, which consists of the three contributing factors described above, $\beta$ is the coefficient matrix, and $\varepsilon$ represents residuals. Note that subscript $t$ indicates the time variable. After building Eq. (1), two methods, ordinary least squares (OLS) and the multiple linear regression model (MLR), were applied in this study.

Because of the relatively low-frequency data (yearly), monthly analyses of suicide rates and monthly KOSPI were conducted. Since stock market indices were non-stationary (Taylor and Tonks 1989), the linear mean trend in the KOSPI (monthly data) was removed. Then, the augmented Dickey-Fuller test was conducted to examine a unit root non-stationarity (Krämer 1998). In case of stationarity, the moving average method was applied to the detrended KOSPI to remove the effects of random variation. In this study, we used the 6-month moving average, which is equivalent to the 200-day moving average. Many previous studies have found that the 200-day moving average is an effective

method to estimate stock market indices (Gunasekarage and Power 2001; Kilgallen 2012). The seasonal pattern of suicide rates was removed using the 13-term (13-coefficient) moving average filter, which eliminates the seasonal pattern (January to December) of suicide rates (Doherty 2001).

## Results and analysis

### Time series analysis using yearly data

Table 1 shows the relationship between suicide rates and other variables. The suicide rates increase when KOSPI increases, but higher fertility rates and higher GDP per capita growth rates are related to lower suicide rates in South Korea. In general, these results are consistent with those of other studies that have utilized macroeconomic (Chan et al. 2014; Stuckler et al. 2009) and social cohesion perspectives (Park and Lester 2006; Pierce 1967). Interestingly, two macroeconomic factors (i.e., GDP per capita growth rates and KOSPI) showed different patterns concerning suicide rates. The negative correlation between suicide rates and GDP per capita growth rates indicates that the GDP per capita growth rate might represent the proxy of unemployment rates. In other words, the GDP per capita growth rates might increase when the unemployment rates decrease (Chan et al. 2014). In contrast to the GDP per capita growth rate, KOSPI had an opposite effect on suicide rates, which could have been due to different characteristics between the GDP per capita growth rates and KOSPI. In other words, KOSPI was calculated from the prices of stocks while GDP per capita growth rates were obtained from the first differences of the GDP per capita. GDP per capita (World Bank Indicator 2017c) is defined as the GDP divided by the number of people. This definition may link GDP per capita to KOSPI. We conducted the OLS between GDP per capita (not GDP per capita growth rates) and KOSPI. The correlation coefficient and the coefficient of determination ($R^2$) were 0.91 and 0.83, respectively. This indicates a strong relationship between GDP per capita and KOSPI (yearly data) in the time series. On the other hand, Zhang et al. (2010) found a

negative correlation between suicide rates and GDP per capita in China from 1982 to 2005. These contradicting results may imply that a single economic indicator (especially yearly data) does not adequately account for suicide rates.

### Time series analysis using monthly data

As described in the previous section, the stock market index and suicide rates provide higher frequency data (daily or monthly). Therefore, the analysis of monthly KOSPI and monthly suicide rates could complement the study based on yearly data. The monthly suicide rates and the KOSPI for 21 years from 1995 to 2015 are illustrated in Fig. 1. The monthly suicide rates are defined as the number of suicide occurrences per 100,000 in a month. In general, two variables had a positive relationship in the time series. In other words, the suicide rates increase with increasing KOSPI values. Subsequently, we applied a 0- to 24-month time lag to investigate the relationship between them. Figure 2 shows that the maximum correlation coefficient ($r$) is achieved with almost no lag time ($r = 0.67$). However, the correlation values have a local maximum of a 12-month lag time. This might result from the seasonal pattern of suicide rates.

On the other hand, several studies have attributed the high suicide rates in South Korea to the effects of celebrity suicide on the public. To examine different sources of suicide rates, the annual variation in the relative risk (RR) of suicide was used in this study. RR is defined as the suicide rate divided by the reference suicide rate. In this study, January was set as the reference month (i.e., January's RR = 1). Figure 3 shows the annual variation in the RR of suicide in this study. In general, the suicide rate peaks in May, then decreases gradually, and minimizes in January. The outliers (red crosses in Fig. 3) of the suicide pattern were observed in 1998, 2003, 2005, 2007, and 2008. Some studies claimed that increased suicides in South Korea in 2008 resulted from the new method of suicide (charcoal burning) of a celebrity (Jae-Hwan Ahn, died in September 2008) (Chen et al. 2014) or the effect of Lee's suicide (died in October 2008) (Fu and Chan 2013). However, the global financial crisis began in 2007 and consequently caused the global economic collapse in 2008 (Williams 2010). Therefore, the considerable relative risk of suicide rates in September and October 2008 might not have been affected only by celebrity suicides but also by the economic downturn. Furthermore, the outlier that was observed in 1988 may thus have been due to the 1997–1998 Korean financial crisis (Chang et al. 2009). On the other hand, the relative risk of suicide was significantly higher in August and September 2003. Although Fu and Chan (2013) investigated 13 celebrity suicides, they failed to recognize the

**Table 1** Results of the time series regression model of suicide rates in South Korea from 1995 to 2015

| Independent variable | Coefficient | Standard error |
|---|---|---|
| GDP per capita growth rate (%) | −0.47705*** | 0.165165 |
| KOSPI | 0.00705*** | 0.001079 |
| Fertility | −18.29820*** | 3.936230 |
| Adjusted $R^2$ | | 0.89 |

Significance levels: **$p < 0.05$; ***$p < 0.001$

**Fig. 1** Time series of the monthly suicide rates (red, left axis) and the KOSPI (blue, right axis) in South Korea from 1995 to 2015
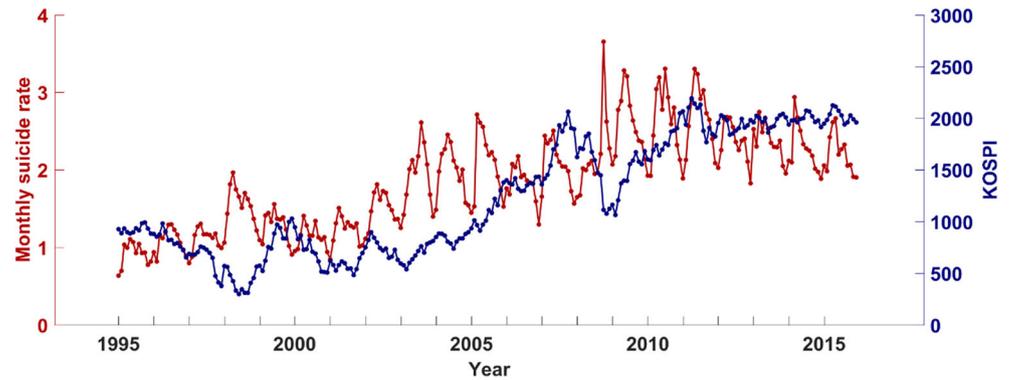
significant suicide pattern in 2003 because they collected the data from 2005 to 2009. However, Yip et al. (2006) found significant increases in suicides in Hong Kong after Leslie Cheung's suicide (died in April 2003). He was a Hong Kong singer and actor, and he was very famous not only in Hong Kong but also in South Korea in the 1990s. Hence, his suicide might have affected the suicide rates in Korea in 2003.

To further utilize the high-frequency data, the fluctuating deviations in KOSPI and seasonal variations in suicide rates (as seen in Fig. 1) were removed from the monthly data. Figure 4 shows the relationship between the adjusted suicide rates and adjusted KOSPI. As Fig. 4 shows, in general, the adjusted suicide rates had a negative relationship with the adjusted KOSPI. However, after 2010, the trends of the adjusted suicide rates and KOSPI showed a similar pattern (i.e., gradually decreased). To verify these trends, we analyzed the

data across four sub-divided periods, shown in Fig. 4. Table 2 describes the OLS results across periods 1 to 4. Before October 2010, a negative relationship between the two variables was observed. After October 2010, both of the two variables gradually decreased. However, it should be noted that the results do not indicate a causal relationship between the examined risk factors and suicide rates. Rather, it can be assumed that macroeconomic factors and social cohesion are in some way linked to suicide rates (Pierce 1967).

## Discussion and conclusions

We must firmly recognize that female suicide rates are much higher in Korea than in other OECD countries (OECD 2017). This implies that complex risk factors have a strong effect on women in South Korea. In other words, risk factors are more disadvantageous to women than men. Jang et al. (2005) claimed that caring for a child can result in considerable costs for an individual in South Korea: (1) the cost increases for childbirth and childcare, (2) childcare limits the economic activities of mothers and reduces their earned income, (3) women's career discontinuity due to childcare decreases the value of human capital in job markets. This implies that the disadvantages women face in the labor market are directly or indirectly related to childcare issues (Jang et al. 2005; Mincer and Polachek 1974). Hence, the situations described above decrease women's self-actualization and economic prosperity, which might be one of the reasons why Korea has one of the lowest fertility rates in the world. Moreover, Kim (2016) claimed substantial inequality in career choices between children from high- versus low-income families. In other words, someone born to a wealthy family is more likely to have a high-paying occupation, such as a doctor or lawyer. On the other hand, Hultberg et al. (2017) reported that out of 300,000 students who graduated from universities and colleges, 200,000 obtained permanent jobs each year. This reflects the mismatch between the job demand and supply and thus
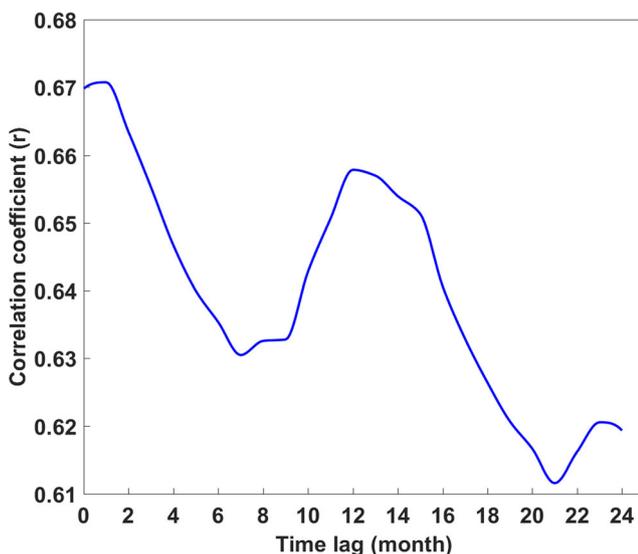
**Fig. 2** Variations of correlation coefficients ($r$) between monthly suicide rates and monthly KOSPI for a 0- to 24-month time lag
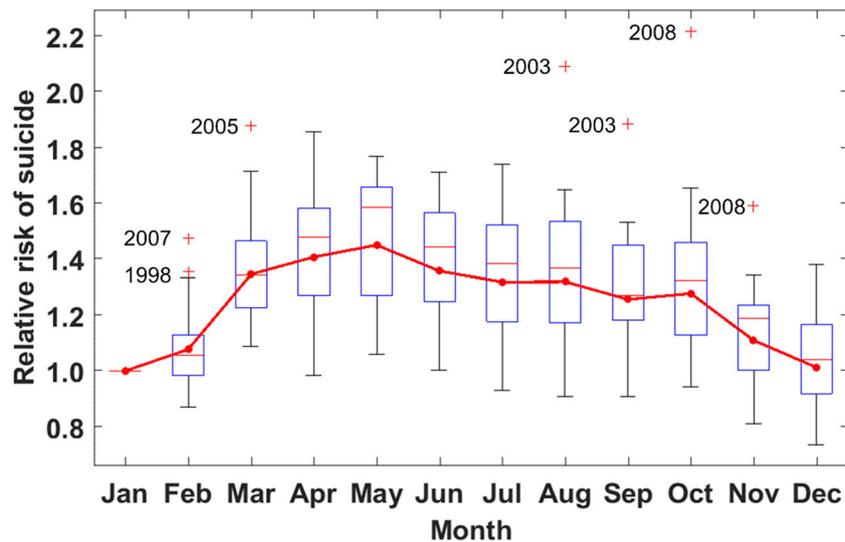
**Fig. 3** Annual variation (box plot) in the relative risk (RR) of suicide in this study. The blue box indicates the interquantile range [IQR = third quantile ($Q3$) – first quantile ($Q1$)] of suicide. The red line represents the median value for each month over the 21-year period. The black bar indicates the lower ($Q1$–1.5 × IQR) and upper ($Q3$ + 1.5 × IQR) whisker boundaries. Approximately 99.3% of the data fall between the lower and upper whisker boundaries (Krzywinski and Altman 2014). The red cross is recognized as outliers (i.e., greater than the upper whisker boundary). The red dot indicates the mean RR

indicates severe unemployment rates of people who have at least a bachelor's degree in South Korea.

This study investigated the relationship between the suicide rate and associated factors in South Korea using the ordinary time series regression method. We observed that higher GDP per capita growth rates and fertility rates were related to lower suicide rates, while the suicide rate increased with the yearly averaged KOSPI. Since we had a limited number of yearly observations (21-year data), we used monthly data for further investigations, the relative risk method for the suicide rates, and the moving average method for the KOSPI. We found not only the seasonal pattern in suicide rates but also several outliers that might have resulted from other risk factors. In general, suicide rates peaked in May and were the lowest in January. Several outliers observed in 1998 and 2008 might

have resulted from the 1997–1998 Korean financial crisis and the global economic crisis in 2008. The abruptly soaring suicide rates in August and September of 2003 might be attributed to the suicide of a famous Hong Kong singer and actor, Leslie Cheung. Although many studies investigated the effect of celebrity suicide on the overall suicide rate in South Korea, this hypothesis has not been supported in the previous literature. Furthermore, this study differentiated two macroeconomic factors associated with suicide rates, the GDP per capita growth rate and the KOSPI. The former had a negative correlation with the suicide rates while the latter had a positive correlation using the yearly data. Furthermore, the monthly analysis was achieved using monthly data of suicide rates and KOSPI using the moving average method. The relationship indicated that the two variables had a negative



**Fig. 4** Time series of the seasonally adjusted suicide rates (red, left axis) and the adjusted KOSPI (blue, right axis) in South Korea from 1995 to 2015. The adjustment methods can be found in the Methodology section. The green vertical lines were added to divide the period (periods 1 to 4)
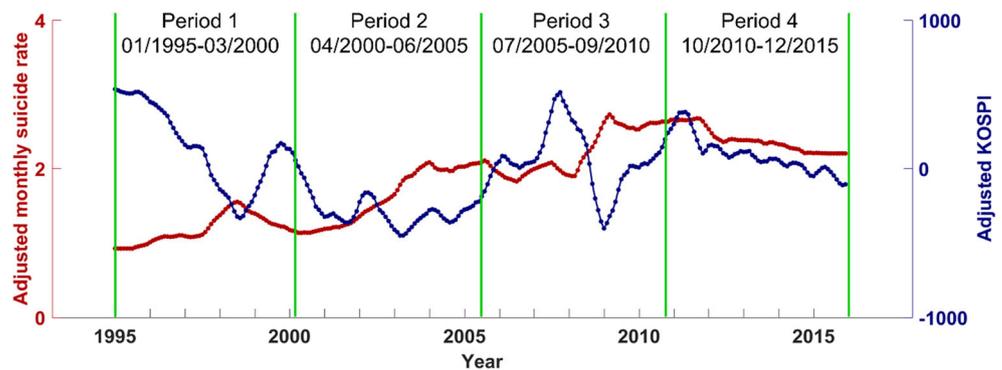
**Table 2** Relationship between the adjusted suicide rates and the adjusted KOSPI across four sub-divided periods

| Period | Coefficient | Standard error | Adjusted $R^2$ | Correlation coefficient |
|---|---|---|---|---|
| 01/1995 to 03/2000 | −0.00067*** | 0.000024 | 0.92 | −0.96 |
| 04/2000 to 06/2005 | −0.00140*** | 0.000497 | 0.10 | −0.37 |
| 07/2005 to 09/2010 | −0.00076*** | 0.000156 | 0.26 | −0.52 |
| 10/2010 to 12/2015 | 0.00121*** | 0.000072 | 0.82 | 0.90 |

Significance levels: **$p < 0.01$; ***$p < 0.00001$

correlation before 2010, suggesting that monthly KOSPI is a similar indicator to the GDP per capita growth rate (but the observation frequency is different).

In conclusion, we found a significant correlation between high suicide rates and low fertility/low macroeconomic factors (i.e., GDP per capita growth rates and monthly KOSPI). However, policymakers should consider not only the numerical values of statistics but also the fundamental problems. The high suicide rate can be decreased by mitigating economic and gender inequality and supporting women and childcare in South Korea.

## Compliance with ethical standards

**Conflict of interest** The author declares that he has no conflict of interest.

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