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Abstract

This article investigates the abrupt jump in the number of suicide cases in Japan in 1998 and the subsequent persistency of this figure by utilizing a generalized decomposition formula. In particular, by considering the change in the demographic structure, we decompose the 1998 jump in the number of suicides and the cumulative changes from 1998 to 2007 by age and gender. Our results show that while the abrupt jump in the number of suicides in 1998 is mainly attributed to middle-aged males, who are 40 to 59 years old, the consistently high number of suicides after 1998 is because of the suicides of people from the younger generation, i.e., the age group from 20 to 39 years. This "juvenization" in suicides is also reflected by the change in the means for committing suicide. Finally, aging is also identified as an impediment in combating the high suicide numbers.

Keywords: Suicide, Decomposition, Degree of Contribution

JEL classification: I12; J17

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1. Introduction

Since the early 1990s, when the bubble in the domestic asset market burst, Japan has been suffering slow and even negative growth, accompanied by price deflation. Nonetheless, this did not have any immediate effect on the suicide numbers. While a slight increase in the male suicide rate was observed, the female suicide rate followed a decreasing trend until 1997. However, things changed dramatically in 1998 when a 35.16 percent jump in the number of suicides shocked the nation (Figure 1). Since then, in this country, which has a total population of 120 million, more than 30,000 people committed suicides each year for eleven consecutive years. Despite the facts that some recovery occurred in the economy in 2003 and 2004, and that numerous preventive measures had been implemented by the government and suicide research experts, the number of suicides remains high till date.

This discussion investigates the current suicide problem in Japan. We examine the number of suicides related to the 1998 abrupt jump and the subsequent persistency in suicide numbers. Using a generalized formula, we decompose the sharp jump in the number of suicides in 1998 by age group and gender, while considering the change in the population demographic profile. The same technique is applied to cumulative changes in the number of suicides from 1998 to 2007. The focus on the population demographic factor on suicide can be traced back to the Hamermesh and Soss' (1974) seminal work of economic studies on suicide. This work suggests a positive correlation between suicide and age. Our results show that while the abrupt jump in the number of suicides in 1998 is mainly attributed to middle-aged males, who are 40 to 59 years old, the suicides of people from the younger generation, aged from 20 to 39, actually contributed to the continuously high number of suicides later on. This "juvenization" in suicides is also reflected by the change in the means of committing suicides.

In recent times, there is a well-founded emerging concern on the associated effect of the ongoing global financial crisis on suicides. Considering Japan's past, it may be regarded that the

worst is yet to come. We hope the agonizing lessons of suicides in Japan can have a positive effect by acting as an early warning signal in suicide prevention. The rest of the paper is organized as follows. Section 2 introduces the decomposition methodology used in this study. Section 3 investigates the jump in suicide rates from 1997 to 1998 and its cumulative changes from 1998 to 2007 by applying the decomposition technique. Different means used in committing suicide are also examined. Finally, in conclusion, Section 4 presents some directions for future research and for developing effective suicide prevention measures.

2. **Decomposition Technique**

The decomposition method, which is frequently used in social science, analyzes the effect of multiple components on a variable of interest and the effect of changes in the components on the total changes of the variable. With regard to demography, Kitagawa (1955) decomposed the difference between two demographic measures into two components. Its extension to multiple component decomposition includes Cho and Retherford (1973), Das Gupta (1978), and Kim and Strobino (1984). In economics, the decomposition method dates back to Wassily Leontief, who analyzed the change in the production structure (Dietzenbacher and Los, 1998; Canudas-Romo, 2003). Oosterhaven and Van der Linden (1997) suggested polar decomposition, which was extended by Dietzenbacher and Los (1998) and Andreev et al. (2002). These methods provide very similar decomposition results. For a detailed review on decomposition, refer to Canudas-Romo (2003).

The decomposition technique used in this paper can be classified as a generalized version of the multiple component decomposition methods. For this purpose, let $y(t)$ be the function of variables $x(t)$, where $x(t) = \{x_{j,k}(t)\}$ is a $J \times K$ matrix. For instance, subscripts j and k may represent an individual (or a group) and a variable of interest respectively. In most applications,

$y(t)$ is expressed as being additive and/or multiplicative of $x(t)$. We describe a generalized formula for the decomposition of aggregate time series data in the following subsection.

2.1 Decomposition of the additive-product form of $y(t)$

Suppose $y(t)$ is in the additive-product form:

$$y = \sum_{j=1}^{J} \prod_{k=1}^{K} x_{j,k} \quad . \tag{1}$$

For example, nominal GDP is calculated by adding the product of the price levels and product quantities of sector *j*, i.e., $y = \sum_{j=1}^{J} x_{j,1} x_{j,2}$, where $x_{j,1}$ and $x_{j,2}$ are the quantities and prices of goods in sector *j* respectively. Then, the decomposition of its change over time, when the time interval is small, can be conducted by taking derivatives of the logarithm of $y(t)$ with respect to *t*:

$$\frac{\Delta y(t)}{y(t)} \cong \sum_{j=1}^{J} \sum_{k=1}^{K} \left(\frac{\prod_{l \neq k} x_{j,l}(t)}{y(t)} \Delta x_{j,k}(t) \right) = \sum_{j=1}^{J} \sum_{k=1}^{K} cd_{j,k}(t), \tag{2}$$

where $cd_{j,k}(t)$ is the effect (or degree of contribution) of changes in $x_{j,k}(t)$ on changes in $y(t)$. Equation (2) can be written as

$$\frac{\Delta y(t)}{y(t)} \cong \sum_{j=1}^{J} \frac{\coprod_{l=1}^{K} x_{j,l}(t)}{y(t)} \left[\sum_{k=1}^{K} \frac{\Delta x_{j,k}(t)}{x_{j,k}(t)} \right]. \tag{3}$$

Then, the growth of $y(t)$ can be interpreted as the weighted average of the sum of the growth rates of $x_{j,k}(t)$ over *J* groups.

2.2 Decomposition of the product-additive form of $y(t)$

Suppose $y(t)$ is in the following product-additive form:

$$y = \prod_{k=1}^{K} \left(\sum_{j=1}^{J} x_{j,k} \right)^{\gamma_k} . \qquad (4)$$

For example, the unemployment rate is calculated in the product-additive form with $(\gamma_1, \gamma_2) = (1, -1)$, where $x_{j,1}$ = the number of unemployed individuals of group *j*, and $x_{j,2}$ = the total number of people of group *j*. Then, the decomposition of its change over time is derived by taking derivatives of logarithm of y with respect to *t*:

$$\frac{\Delta y(t)}{y(t)} \cong \sum_{k=1}^{K} \sum_{j=1}^{J} \left(\frac{\gamma_k}{\sum_{j=1}^{J} x_{j,k}(t)} \Delta x_{j,k}(t) \right) = \sum_{k=1}^{K} \sum_{j=1}^{J} cd_{j,k}(t) , \qquad (5)$$

where $cd_{j,k}(t)$ is the effect (or degree of contribution) of changes in $x_{j,k}$ on changes in *y*. Equation (5) can be written as

$$\frac{\Delta y(t)}{y(t)} \cong \sum_{k=1}^{K} \gamma_k \sum_{j=1}^{J} \left[\frac{x_{j,k}(t)}{\sum_{j=1}^{J} x_{j,k}(t)} \frac{\Delta x_{j,k}(t)}{x_{j,k}(t)} \right] \qquad (6)$$

This can be viewed as taking the weighted average of variable *k*'s growth rate over *J* groups, and then taking its weighted average over *K* variables. Note that Equations (1) and (4) are identical in the case of $K = 1$ and $\gamma = 1$. The degrees of contribution $cd_{j,k}(t)$ in Equations (2) and (5) are also identical.

3. An Empirical Application of the Decomposition Method on Japanese Suicide Rates

Using the decomposition methods explained in the previous section, we explore Japanese suicide statistics from 1997 to 2007. The two datasets used for the analysis are from, first, the Vital Statistics published annually by the Ministry of Health, Labour and Welfare of Japan and, second, the Population Estimates by the Ministry of Internal Affairs of Japan. Examining the abrupt jump in the

number of suicides from 1997 to 1998 and the persistently high suicide numbers in the following ten consecutive years, we find that several structural changes occurred during this period.

3.1 The Jump in the Number of Suicides from 1997 to 1998

3.1.1 The Effect of Changes in the Suicide Rate and the Population Structure on Changes in the Number of Suicides

The number of suicides (*SCD*) is obtained by multiplying the suicide rate of group *j* (SR_j) with the population of group *j* (POP_j), and then summing them over *J* groups.

$$SCD = \sum_{j=1}^{J} SR_j \cdot POP_j \tag{7}$$

Equation (7) is a typical example of the additive-product form of Equation (1). By applying the technique in Equation (2) to Equation (7), we conduct the decomposition of the suicide growth rate from 1997 to 1998. As shown in Table 1, the suicide growth rate is 35.162 percent, while the sum of the degree of contribution is 34.834 percent.[1]

First, we observe that the age group of 40–59 years experienced the most dramatic increase in the number of suicides, followed by the age groups of 60–79 years and 20–39 years. Second, 78 percent of the suicide growth was caused by males; the group of males aged between 40 and 59 alone contributes 38 percent of the suicide growth rate. Third, from the demographic perspective, the effect of the change in population on the number of suicides is of a substantially smaller magnitude, as compared to the effect of the increase in the suicide rate. This is not a surprising observation because we are examining the change of one year, during which there should be little change in terms of the population structure. However, note that, for the age groups of 60–79 years and 80 years and above, the effects of population change on suicide growth is relatively higher than the effects of

[1] The discrepancy of 0.328 percentage points between the suicide growth rate and the sum of the degree of contribution, which we report as residual, emerges because of the approximation.

younger groups. Finally, despite the decline in the population of young people aged up to 19 years, which contributes negatively to suicide growth from 1997 to 1998, the combined degree of contribution of suicide rate and population is positive.

3.1.2 Decomposition of Changes in the Number of Suicides from 1997 to 1998 by Means of Suicides

The number of suicides (*SCD*) is obtained by summing up the various numbers of suicides categorized by the method.

$$SCD = \sum_{j=1}^{J} SCDM_j , \tag{8}$$

where $SCDM_j$ is the number of suicide by method *j*. Note that Equation (8) can be considered as an example of the additive-product form of Equation (1) with $K = 1$. In the data, there are 25 categories for the methods of suicides by each gender.[2] For the sake of simplicity, we reduced these to seven categories in this study.[3] The decomposition result is presented in Table 2. Table 2 suggests that most of the increased suicides from 1997 to 1998 have been committed by hanging oneself.

3.2 The Persistency of Suicides from 1998 to 2007

3.2.1 Suicide Rate and Population Structure on Total Suicide Growth Rate from 1998 to 2007

To examine the long-term effects of suicide rates and population structure over the years on the cumulative suicide growth, we apply Equation (2) to Equation (7) in order to obtain the degree of contribution of each year, $cd_{j,k}(t)$, and then sum them up over the years for cumulative measures.

[2] According to the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems, Japanese Version (ICD-10) from Japan's National Vital Statistics, 25 categories correspond to X60–X84.

[3] We follow the same categorization as that in Table 22 of the Vital Statistics Special Report (2004): Hanging (X70); gas poisoning (X67); drugs (X60–X66, X68, and X69); drowning (X71); jumping from a height (X80); jumping toward a moving object (X81); and others (X72–X79 and X82–X84).

The cumulative degree of contribution of $x_{j,k}(t)$ from t_1 to t_2 is $\sum_{t=t_1}^{t_2-1} cd_{j,k}(t)$. The results are shown in Table 3.

Table 3 indicates that the cumulative suicide growth rate, –1.918 percent, is small, which suggests that the number of suicides has been persistently high during the period 1998–2007 after the dramatic jump from 1997 to 1998. This suggests the existence of inertia in terms of the number of suicides. Regarding the age profile of the cumulative suicide growth, the result suggests that, unlike the jump from 1997 to 1998, which is mainly attributed to the increase of suicides among the relatively older generations (age groups of 40–59 years and 60–79 years), the increase in suicides among the relatively young generation (age group 20–39 years) has actually caused the persistency in the high number of suicides. Moreover, since the population of this age group has been decreasing, its contribution to the cumulative suicide growth rate is negative (–0.301 and –0.257 for males and females respectively). In other words, holding the population of this age group constant, the increase in the suicide rate for this age group would be even higher. This supports the hypothesis that after the abrupt jump in suicides in 1998, incidences of suicides shift from the middle-aged group to the young group, i.e., people in their 20s and 30s. Finally, population aging is also a serious problem that leads to persistency in the number of suicides. Holding the suicide rates constant, the population aging effect in the groups of males and females in the age groups of 60–79 years and 80 years and above alone would result in a cumulative growth rate of 8.919 percent.

3.2.2 Decomposition of the Crude Suicide Rate Change from 1998 to 2007 by Age and Gender

In addition to the decomposition of the change in the number of suicides, we may also decompose the change in the crude suicide rates by age and gender. The crude suicide rate is the ratio of the number of suicides to the population, given as follows:

$$CSR = \frac{\sum_{j=1}^{J} SCD_j}{\sum_{j=1}^{J} POP_j}, \tag{9}$$

where CSR is the crude suicide rate, SCD_j is the total number of suicides, and POP_j is the population of group *j*.[4] Equation (9) is a typical example of the product-additive form of Equation (4). By applying the technique in Equation (4) to Equation (9), we conduct the decomposition of the changes in the crude suicide rate.

Table 4 indicates the same qualitative results as explained in Table 3. Nonetheless, note that since the population appears in the denominator in Equation (9), the negative population effects among males and females in the age groups of 60–79 years and 80 years and above suggest that they positively contributed to the change in the crude suicide rate from 1998 to 2007.

3.2.3 Persistent Effect of Methods on the Total Suicide Growth Rate from 1998 to 2007

Table 5 shows the decomposition of the suicide growth rate from 1998 to 2007 by means of suicides and gender.[5] The results suggest there is a change in the methods of suicide from the traditional ones of hanging oneself, jumping from a height, and drug overdose to gas poisoning, for example, carbon monoxide poisoning by burning charcoal or via car exhaust, which is the only method that exhibits positive growth. This can be regarded as further evidence of the "juvenization" in suicides that was discussed in the previous subsection. There have been public discussions on circulation over the internet of the "menu" of committing suicides through gas poisoning. The

[4] The crude suicide rate can also be expressed in the additive-product form,

$$CSR = \sum_{j=1}^{J} SR_j \cdot PSHARE_j,$$

where $PSHARE_j$ is the population share of group *j*. The decomposition based on this additive-product form provides almost the same results as those in Tables 1 and 3. These results are available upon request.

[5] Note the difference in the growth rate as compared to that in Table 3. This is because the data includes suicide cases wherein information regarding the age and gender of the individuals committing suicide is not available.

younger generation has experienced the most severe impact because they have access to internet chat rooms and discussion forums.[6]

4. **Concluding Remarks**

The number of suicides in present day Japan is at all time high. This dramatic increase in the number of suicides began with an abrupt jump of 35.16 percent in 1998. Using a generalized decomposition formula, our results suggest that the abrupt jump was mainly caused by suicide among middle-aged males from the age group of 40–59 years. Despite the lack of comprehensive studies, it is strongly considered that the severe "credit crunch" in late 1997 was a chief reason for the abrupt jump. But then, a new problem arose when the number of suicides showed no sign of dropping since then, despite the fact that there was some recovery in the economy in 2003 and 2004. The decomposition of cumulative changes from 1998 to 2007 suggests the aspect of juvenization in suicides by the fact that the growth of suicides of the younger generation from the age group 20–39 years, maintained the high number of suicides. This juvenization is also reflected by the change in the means of suicide.

Naturally, one would search for the reasons underlying the growing number of suicides among the younger generation. One hypothesis attributes the rise to the structural change in the Japanese labor market. The 1999 and subsequent 2004 revisions of the Japanese Worker Dispatch Law resulted in a massive expansion of unskilled, non-regular workers in the Japanese labor market.[7]

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[6] A recent event in Japan underscores the change in the means of committing suicides. In early 2008, the "menu" of committing suicides by inhaling hydrogen sulfide created by mixing an ordinary household laundry detergent with a cleanser is widely known through internet discussion forums. On April 23, 2008, a 14-year-old girl gassed herself to death by following a method learned from the internet, and released fumes that caused 90 people in her apartment building to fall ill (April 25, 2008, Japan Times). Press reports indicated that during the first six months of 2008, more than 500 people had killed themselves by inhaling hydrogen sulfide (September 26, 2008, New York State Office of Homeland Security).

[7] Between 2000 and 2007, the number of regular employees in Japan declined by about 1.9 million, while the number of non-regular workers increased by around 4.5 million. The number of non-regular employees

Most of these workers are relatively young as compared to regular workers. Their jobs are typically low-paid, and the employees are not provided with any job security or appropriate benefits. Recent reports of suicides of such workers are relatively common[8]. Nonetheless, no comprehensive studies on the potential link of the juvenization of suicides in Japan with the change in the labor market structure have been conducted.

Finally, our results also indicate that aging is another serious threat that has caused the rise in the number of suicides. As shown by psychiatric studies such as Conwell and Brent (1995), depressive illness is more prevalent among older-aged suicide victims. This indicates another direction for combating the suicide numbers: the detection and treatment of depressive illness among older people, whose conditions are less likely to be correctly diagnosed and treated.

Suicide is a serious problem worldwide. Recently, a well-founded emerging concern has arisen regarding the associated effect of the ongoing global financial crisis on suicides. As an end to our discussion, we would like to restate that by studying Japan's past, it can be regarded that the worst is yet to come. We hope that the agonizing lessons of suicides in Japan can have a positive effect by acting as an early warning signal in suicide prevention.

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increased from 11,520,000 (23.2% of total labor force) in 1997 to 17,260,000 (33.7% of total labor force) in 2007 (Ministry of Internal Affairs and Communications, 2008).

[8] Kuwahara (2008).

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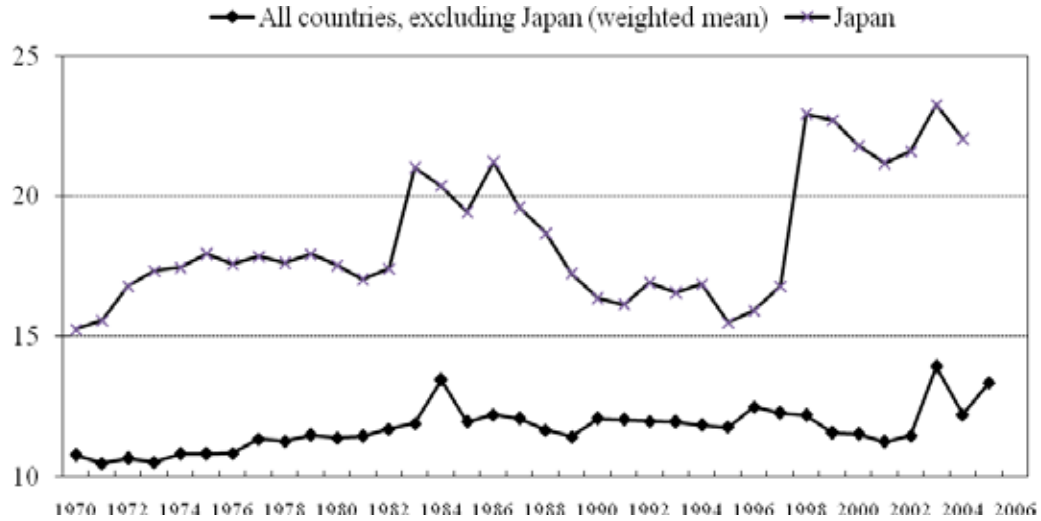
Figure 1 Suicide Rate in Japan and other OECD countries

(per 100,000 people; males and females)



(Source) WHO Mortality Database, 2006, World Health Organization

Table 1 Decomposition of Changes in the Number of Suicides from 1997 to 1998 into changes in Suicide Rates and Population Structure by Age and Gender

Age Group	Sum of the Degree of Contribution	Male		Female	
		SR	POP	SR	POP
00–19	1.156	0.828	–0.034	0.375	–0.014
20–39	7.135	5.297	0.124	1.671	0.043
40–59	15.148	13.097	0.106	1.890	0.056
60–79	9.856	6.391	0.467	2.737	0.262
80 and above	1.538	0.756	0.136	0.417	0.229
Total	34.834	26.370	0.799	7.090	0.575

Suicide Growth Rate: 35.162; Residual: 0.329

Table 2 Decomposition of Changes in the Number of Suicides by Means of Suicides and Gender from 1997 to 1998

	Male	Female
Hanging	24.083	6.619
Gas poisoning	1.349	0.085
Drug overdose	–0.136	–0.226
Drowning	0.260	0.136
Jumping from a height	1.328	0.817
Jumping toward a moving object	0.094	0.051
Others	0.468	0.145
Total	27.445	7.627

Suicide Growth Rate: 35.162; Residual: 0

Table 3 Decomposition of Changes in the Number of Suicides from 1998 to 2007 by Age and Gender

Age Group	Sum of the Degree of Contribution	Male		Female	
		SR	POP	SR	POP
00–19	–0.659	–0.336	–0.255	0.064	–0.132
20–39	2.606	2.117	–0.301	1.048	–0.257
40–59	–4.393	–2.530	–0.897	–0.745	–0.220
60–79	0.796	–2.261	3.914	–2.474	1.616
80 and above	0.167	–1.064	1.658	–2.159	1.731
Total	–1.483	–4.074	4.119	–4.266	2.738

Cumulative Growth Rate: –1.918; Residual: –0.434

Table 4 Decomposition of Changes in Crude Suicide Rate from 1998 to 2007 by Age and Gender

Age Group	Sum of the Degree of Contribution	Male		Female	
		SCD	POP	SCD	POP
00–19	1.933	–0.584	1.3242	–0.0722	1.2645
20–39	3.725	1.7648	0.5855	0.7725	0.6017
40–59	–3.221	–3.4995	0.6023	–0.9999	0.6761
60–79	–3.259	1.5941	–2.1078	–0.9039	–1.8413
80 and above	–2.104	0.5422	–0.7108	–0.5319	–1.4037
Total	–2.927	–0.182	–0.307	–1.735	–0.703

Cumulative Growth Rate: –2.919; Residual: 0.0083

Table 5 Decomposition of Changes in the Number of Suicides by Means of Suicides and Gender from 1998 to 2007

	Male	Female
Hanging	–0.740	–0.828
Gas poisoning	4.150	0.852
Drug overdose	–0.769	–0.334
Drowning	–0.583	–0.692
Jumping from a height	–1.036	–0.144
Jumping toward a moving object	–0.276	–0.141
Others	–1.354	–0.465
	–0.608	–1.751

Cumulative Growth rate: –2.334; Residual: 0