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Sunshine and Suicides in Japan: revisiting the relevance of economic determinants of suicide*

Abstract: This paper investigates how exposure to sunshine affects the suicide rate in Japan, especially in relation to economic variables. Using prefecture-based data on socioeconomic variables for the years 1993–2009, the paper confirms existing research in finding a significant correlation between suicides and unemployment, for both men and women. The interaction between sunshine and unemployment is also significant, and further analysis reveals that unemployment is not an important factor for suicide in high-sunshine prefectures, whereas in low-sunshine areas the effect of unemployment on the suicide rate rises. The divorce rate is highly significant and positive for men, but significant and negative for women, suggesting that many Japanese women consider divorce liberating. Current suicide research in Japan with its strong emphasis on economic variables may benefit from an inclusion of measures of general well-being.

Keywords: suicide, divorce, socioeconomic factors, sunshine, SAD

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日照と自殺の関係：日本における自殺に関する経済的要因の再考察

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本稿は日照がいかに日本における自殺率、特に経済変数との関係性を調査するものである。1993年から2009年（都道府県統計）の社会経済変数基礎データで調べたところ、先行研究の結果も明らかしたように、男女とも対象とした自殺と失業に関する有意な相関関係が確認された。また日照と失業との間

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にも有意な関連が見られ、さらなる分析によると、失業は日照時間が長い都道府県では自殺の重要な要因ではないが、日照時間の短い地域では失業は自殺率の上昇に影響する。離婚率に関しては、男性においては自殺との有意かつ正の相関があることに対し、女性においては有意の逆相関が見られ、多くの日本人女性は離婚を解放と思っていることを示唆する。以上の結果を踏まえて、経済変数に重点を置いてきた日本の自殺研究は、幸福の指標を含めたアプローチにも恩恵を受けると思われる。

1 Introduction

Japan's suicide rate ranks among the highest in the world. In the early 2000s, more than 30,000 Japanese committed suicide annually, which translates into an average suicide rate of 23 per 100,000. International comparisons are notoriously difficult due to differences in categorizing causes of death. That said, according to WHO data the United States reported a suicide rate of 17.7 for males and 4.5 for females (in 2005), compared to Germany with 17.9 and 6, respectively (in 2006), and Japan with 36.2 and 13.2 (in 2009).[1] That is, Japan's rates are more than twice as high. Put differently, a Japanese is 4.5 times more likely to die from suicide than from a traffic accident, and 40 times more likely than from homicide (Johnson 2010; Leonardsen 2010). This sad reality has triggered new research efforts as well as new government initiatives to help. In 2001 the Ministry of Health, Labour and Welfare for the first time budgeted suicide prevention measures, and in 2004 issued a new Treatment Guideline on Depression. In 2006 the government passed a new "Basic Law on Suicide Prevention" (*Jisatsu taisaku kihon-hō*), followed by a new Outline of Policies for Suicide Prevention in 2007.

Yet, despite deep public concern and wide media coverage, we actually do not know much about suicides in Japan. The WHO (2010) deplores that 90 % of worldwide suicide research in public health is spent on 10 % of the suicide population, i.e., in the United States and Western Europe. Academic research on suicide falls into two main categories: papers focusing on mental health issues, and those looking at socioeconomic variables. Until 2006, Japan's government reported a single approximate reason for suicide (before switching to three), and in that year 48 % of suicides were reported to be related to "health" reasons; in 2011 the number stood at 37 % (CAO 2012). Even though these levels

1 See World Health Organization, "Mental Health" data, at http://www.who.int/mental_health/prevention/suicide_rates/en/ (accessed 30 March 2013).

are similar to other countries, research regarding the connection between mental health and suicides in Japan is relatively limited, perhaps because depression as a disease has only recently begun to be fully recognized, and people so afflicted often do not seek help (Yokokura 2012). The number of mental health professionals in Japan remains comparatively small (McCurry 2008). And because clinical data are limited, most research has to rely on surveys that focus on ideation (e.g., Takada et al. 2009). The government's new suicide prevention policies also aim at this dilemma, by looking for ways to increase medical support, offering hotlines, and changing the public opinion on mental health (e.g., Yamamura et al. 2009).

Next to "health," in 2006 a comparatively very high 22% of suicides in Japan were attributed to "economy"-related problems, and another 6% to "work" (CAO 2012). This high number – of almost one-third of all suicides – has led to a dominant research focus within Japan on the relation between economic factors and suicide. Not only may it be easier to design quantitative studies using economic variables, but some of the solutions also appear to be more straightforward (e.g., Sugano 2012 suggests to simply reduce unemployment). An additional trigger for economic studies was the significant jump in suicides in 1998, when the annual number of cases skyrocketed by 34%, from 24,391 to 32,863, in just one year.[2] This coincided with the arrival of the full-fledged banking crisis and a sudden rise in unemployment in 1998, leading many authors (including myself) to draw a direct causality between economic distress and suicide (e.g., Schaede 2008; Sawada et al. 2010; Chen et al. 2009, 2012b). As it turns out, it is quite likely that the 34% jump in just that one year is at least partially attributable to a reform by the National Police Agency in terms of methods of categorization and statistical capture, for a variety of crimes and social distress.[3] The coincidence of this reform with the onset of severe economic crisis may have led to exaggerated inferences regarding the

2 Detailed data on suicides can be found at http://www.npa.go.jp/toukei/index.htm (subheader 自殺の状況), accessed on 30 March 2013.

3 In 1998, the National Policy Agency revised its system of categorizing and counting petty crimes (e.g., robbery), major crimes (homicides), and social distress (child abuse, suicide, etc.). Unfortunately, little is known about the specifics of this policy change, which were not made public in an easily traceable way, except for a fleeting mention in the *Keisatsu Hakusho* ('Police White Paper') of 1997 and 1999. One example of a change that would affect the suicide statistics is the introduction of a new category of *karō-jisatsu* 'suicide due to overwork' as separate from *karōshi* 'death from overwork'. Also, see comments by Todd Kreider on *NBR Japan Forum*, postings of 11 November 2011 and 9 September 2012. The biggest evidence in favor of the administrative explanation of the 1998 jump is that the suicide rate has since plateaued at the new level with an annual variance very similar to that at the previous plateau.

economic impact on suicides in Japan. Andres et al. (2011) suggest that socio-econometric factors such as divorce or family structure may be more important than unemployment in explaining Japan's suicide rate. Regardless, there is now a sizeable literature in Japan on economic factors associated with suicide (in particular, Chen et al., 2009, 2012a, 2012b), and its stark claims, in turn, have fed into a bias in policy attempts toward economic measures.

This paper adds to this literature by taking a closer look at the power of economic explanations. How much do economic variables really explain in relation to other matters? Are there perhaps factors of personal well-being that are as, or perhaps even more, important? If so, is the focus on economic measures, such as employment creation, justified? Is Japan really as dependent on employment for happiness as it is sometimes suggested?

To explore these questions, I use prefecture-level data for a variety of socio-economic variables for the years 1993–2009, and I add one aspect of general well-being that is largely independent from the economy: the number of annual hours of sunshine by year by prefecture.[4] I use this exogenous variable to proxy well-being based on research in medicine that has unequivocally shown that decreased exposure to sunlight is related to mood disturbance and even significant health challenges. In its severe form the affliction is called SAD (seasonal affective disorder) (e.g., Eagles 2003). It has been shown that people in Japan, likewise, suffer from mood swings associated with sunshine (e.g., Ozaki et al. 1995; Okawa et al. 1996). Existing research shows an association between sunshine and suicide for several countries other than Japan (e.g., Thorson and Kasworm 1984; Lester 1988; Neumayer 2003b). The inquiry in this paper is whether exposure to sunshine affects the suicide rate in Japan, and if so, how much in relation to socioeconomic variables such as divorce, and economic aspects such as unemployment. I will account for the possible change in suicide categorization by separating the analysis in pre-1998 and post-1998 time periods. Finally, I use several economic variables that are different from existing studies, such as the job-offerings-to-job-openings ratio (to measure unemployment), the prefectural growth rate, and the growth rate in wages.

The paper finds that sunshine is the single most consistent variable across all analyses, and it affects men and women equally. Unemployment is also highly significant for both, yet the effect is stronger for men by a factor of over three. An analysis of the interaction effect between sunshine and jobs shows that in prefectures with more sunshine hours the job-openings ratio has no

4 As sunshine hours could influence economic output in prefectures with a high level of agriculture, I will control for economic growth in my analysis. As will be shown below, there is no correlation between local economic output and sunshine.

additional effect on the suicide rate, whereas low exposure to sunshine amplifies the effect of limited job offerings on suicide. This means that changes in the employment situation alone do not explain Japan's suicide rate. Moreover, the divorce rate effect is large and significant, and it is surprising in that it is negative for women: more divorces are associated with fewer suicides. As far as I can tell, this is a new finding for Japan, and it differs from results for other countries.

The paper begins with a brief summary of existing research on Japan, and previous results regarding socioeconomic variables and suicide (Section 2). Section 3 introduces the data. Section 4 presents analyses and results, and Section 5 concludes and offers suggestions for future research.

2 Socioeconomic studies of suicide

The socioeconomic literature on suicides, both in Japan and elsewhere, has grown significantly in recent years. This section highlights only a few aspects relevant to the current analysis. On the economic side the main focus has been on how monetary factors, such as low income or recession, may affect the decision to commit suicide.[5] To this economic logic are then added sociological variables, principally as suggested through Durkheim's (1951 [1897]) notion of social embeddedness, such as through marriage and work integration.

Depending on the data used and the countries studied, results for these socioeconomic studies vary widely. For example, Kunce and Anderson (2002), using US state-level data from 1985–1995, find no strong results for socioeconomic factors at all, whereas Neumayer (2003a) produces strong results for WHO panel data for Europe. In a meta-analysis of 24 papers and 189 regression results, Chen et al. (2012a) found little to conclude: results for all variables were mixed by country, gender, and study design. These differences in results may bespeak of data challenges in comparative settings, or they may simply reveal that patterns differ strongly by country (WHO 2010). On the basis of a series of their own studies, Chen et al. (2009, 2012b) claim that economic variables (such as GDP growth and unemployment) explain the male (though not the female)

5 The roots of this literature are in economics, based on early work such as by Hamermesh and Soos (1974) who proposed a utility maximization approach to understanding suicides. They argued, roughly, that the utility of life rises with income and human capital formation; thus, the less the income (through joblessness, lower wages, etc.), the less "useful" is life. Moreover, lifetime utility is also supposed to decrease with age. Empirical research so far has largely failed to support this theory, in particular in regards to poverty.

suicide rate better for Japan than for other OECD countries, where sociological factors are said to loom larger.

Among economic variables, perhaps the one studied most often is unemployment (e.g., Platt 1984). Interestingly, evidence of a relationship between unemployment and suicides is generally mixed. Whereas Yang and Lester (1995) offer evidence of a relation for the United States and Finland, Minoiu and Andres (2008), focusing on the United States between 1982 and 1997, find a significant association between suicide and divorce and social welfare programs, but neither income nor unemployment. Meanwhile, for Germany between 1980 and 2000, Neumayer (2004) finds that the unemployment rate is negatively related with suicides, perhaps pointing to differences in unemployment insurance systems across countries.

For Japan, it is well-known that morbidity among working-age males is comparatively high, due to the stress associated with exceedingly long working hours and other well-chronicled pressures of work life in Japan (e.g., Kondo and Oh 2010). Attempts at breaking out of this pattern are often thwarted by an employment system that creates financial and skill tie-ins to just one company, and a rigid and limited mid-career labor market. Moreover, what is called "lifetime employment" typically only lasts until age 55, and after many years of slow economic growth, in the late 1990s opportunities for good second and third jobs began to dry up. For those who lose their job, the situation is worse. Unemployment benefit payments are generally limited to 330 days, while mid-level labor market mobility has long been severely curtailed and public assistance programs continue to be difficult to access (Schaede and Nemoto 2006; Schaede 2006). Yamamura et al. (2009) and Koo and Cox (2008) find that unemployment is associated in significant ways with the suicide rate for both men and women. In contrast, Watanabe et al. (2006) found a significant correlation only for men. Using municipality- and age-based data for Japan between 1983 and 2007, Kuroki (2010) shows that unemployment is positively associated with suicide rates for males, especially in working age, but negative for females.

In addition to unemployment, a few other variables can be used to assess economic matters. An obvious candidate to index the macro situation is the local economic growth rate. Perhaps surprisingly, in their meta-analysis Chen et al. (2012a), as well as Ruhm (2000) for the United States and Neumayer (2004) for Germany, found that the association is mostly positive: in many countries suicides increase during booms. Another indication of overall economic activity is the corporate bankruptcy rate, and Watanabe et al. (2006) show a significant positive correlation between corporate bankruptcy rates and suicides in Japan for the 1990s.

As a measure of personal financial distress, the personal bankruptcy rate is sometimes used. Here, too, comparative empirical studies find differences, probably due to differences in legal recourse and post-bankruptcy rights across countries. For Japan, Sawada et al. (2010) make a strong claim that economic hardship and the mental burden of debt contributed to the jump in suicides between 1997 and 1998. However, personal bankruptcy became effectively possible only in the late 1990s, with legal and court reforms and the emergence of attorneys specializing in the field. It is therefore difficult to assess the effects of personal bankruptcies for Japan prior to those reforms, and a long-term evaluation of the effects of personal debt will have to wait for more data. To include a measure indicative of changes in the personal economic situation, this paper will instead use the rate of per capita wage growth.

On the sociological side, the conventional hypotheses are about whether a person is embedded in social structures that offer stability and support (Durkheim 1951 [1897]). The divorce rate is often used to measure social integration, and almost all empirical research so far has found that divorce is positively associated with suicide for men and women (Chen et al. 2012a in a meta-analysis; Minoiu and Andres 2008 for the United States; Andres et al. 2011 for Japan). Not only may there be the sense of hurt and being left behind, but there may also be economic hardship and a sense of insecurity, as well as reduced social integration and status (Stack 2008). Some more recent studies have found the male suicide rate to be more sensitive to the divorce rate than the female, possibly because marriage regulates the life of wives more than that of husbands, or the benefits of marriage are higher for men (e.g., Neumayer 2003a; Rodriguez 2005). For Japan, using WHO data for an early study of the relationship between suicide and the divorce rate between 1950 and 1980, Stack (1992) found no association. Watanabe et al. (2006) confirm this for the years 1998–2004, while for the period 1978–2002 they find a positive correlation for males. Chen et al. (2009), in a comparative study using UN data, report a positive correlation only for males aged 25–44. This paper uses Japanese government data to explore this association, for males and females separately.

A related measure is the female participation in the workforce: the more active in professional life, it is argued, the lower the suicide rate for women. However, workforce participation for women is typically strongly correlated, negatively with marriage and positively with divorce (e.g., Bentzen and Smith 2002; Stevenson and Wolfers 2006; Ogawa and Ermisch 1994). To avoid collinearity issues, I use only the divorce rate in this paper.

Age and population density are two further factors often considered in studies of suicide. Higher age is associated with a higher suicide rate in all

countries (Chen et al. 2012a). According to Japan's National Police Agency, in 2010, 37 % of all suicides were committed by people over 60 years old; and 56 % by people over 50 years old (NPA 2011). As already mentioned, the increase in suicides in Japan after 1998 was to a large portion attributable to a rise in suicides among working-age males (40–59 years) (Chen et al. 2012b; Sugano 2012). We will revisit this issue by looking at the percentage of the population in a given prefecture older than 65 years. In terms of population setting, higher density bespeaks of urbanization and modernization, and this could affect suicides in two opposite ways: larger cities are likely to have more support groups, including better access to mental health practitioners, as well as more planned activities and chances for human interaction. Less populated areas may offer a slower pace of life, more intimate human interactions, and stronger roots in neighborhoods. It is not surprising that empirical results for urbanization are generally mixed.

Finally, this paper adds a new variable that can be thought of as a proxy for mood (happiness), separate from economic or social conditions: sunshine. In public health, there is a significant body of research regarding the relationship between exposure to sunshine and general well-being, which can be so severe that the clinically diagnosable affliction is known as SAD (seasonal affective disorder). For example, Eagles (2003) shows that the disturbance of mood related to decreased sunlight exposure can affect the growth of children, the birthrate, as well as mortality and suicide. In the western hemisphere, SAD is often thought of as a cyclic illness of fall/winter depression.

In general, research results on sunshine and suicides are also mixed. As far back as in 1972, Robbins et al. show a positive correlation between suicides and cold temperatures. Thorson and Kasworm (1984) identify lack of sunshine as a significant factor in suicides. In contrast, Lester (1988) and Yang and Lester (1995) could find little evidence that sunshine matters in the United States, and this result was confirmed by Minoiu and Andres (2008) for the years 1982–1997 (even though they found a higher suicide rate in US mountain states). In contrast, Neumayer (2003b) reports a strong, negative correlation between suicides and sunshine in Germany. For Japan, a 1995 study by Ozaki et al. of 1,276 civil servants showed that a strong association exists in Japan between exposure to sunshine and mood and that, unlike in Western countries, SAD in Japan peaks twice a year: in November (winter) and July (rainy season). Sakamoto et al. (1993) show that hours of sunshine have a greater impact on the suicide rate than latitude or temperature. To the best of my knowledge, socioeconomic studies of suicides in Japan so far have not included sunshine, or the interaction of sunshine with economic variables.

3 Data overview

The data used in this paper are prefecture-based for the years 1993–2010, and were mostly sourced from Japanese government websites. The main data sources are Vital Statistics of Japan (*Jinkō dōtai tōkei*), which can be found at www.stat.go.jp, and prefecture-level data from the Cabinet Office (www.esri.cao.go.jp), as detailed below. All data are expressed as ratios, either by normalizing absolute values by prefecture population, or by using growth rates. The wage growth rate is only available beginning in 1997, and several variables were only recorded through 2009 at the time of this writing. Overall, the data allow an analysis from 1993, for the years prior to the "jump," through 2009.

Table 1: Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Suicide rate (per 100,000)	846	23.1	5.0	12	44.6
Male suicide rate	846	34.0	8.7	15	66.1
Female suicide rate	846	13.1	2.7	6	25.2
Sunshine hours per year	799	1899.8	232.6	1324.3	2423.4
Divorce rate (per 1,000)	846	1.8	0.3	1.0	2.9
Ageing (pop over 65)	846	0.2	0.04	0.1	0.3
Density (persons per km2)	846	642.4	1113.5	65.9	6016.2
Kyujin ratio*	846	0.7	0.3	0.2	1.9
Wage growth p.c. (yoy, %)	611	−0.7	1.9	−9.5	4.2
GPP growth rate (yoy, %)**	799	0.3	2.4	−10.9	9.8
Bankruptcy rate (per 1,000)	846	0.1	0.04	0.03	0.3

* *Kyujin* = Job-openings-to-job-seekers ratio
** Gross perfectural product

Table 1 introduces summary statistics. The suicide rate by prefecture is expressed per 100,000 persons, and is available separately for men and women, downloaded for each year from Vital Statistics of Japan.[6] The mean for this 17-year sample is 23 per 100,000, with an average of 34 per 100,000 for men, compared to a much lower 13.1 for women. In other words, about 70 % of

6 人口動態推計都道府県別にみた死因簡単分類別死亡率（人口１０万対）各年度. http://www.e-stat.go.jp/SG1/estat/NewList.do?tid=000001028897 (for 2012; accessed 30 March 2013). The numbering of tabs in these websites changes frequently; suicides are contained in the "causes of death by prefecture" tab.

suicides in Japan are committed by men (not unusual in international comparison). Therefore, in the analyses that follow the results for "all suicides" and "male suicides" are very similar, and to improve readability I will skip the results for "all suicides" and report those for males and females only. The highest suicide rates were reported in Northern and Southern Japan (the prefectures of Akita, Aomori, Niigata, and Miyazaki), and the lowest in the middle (Shiga, Nara and Mie for men; Saga, Hiroshima, Okayama, and Ishikawa for women). Akita prefecture recorded by far the highest suicide rates in the sample, with the maximum overall of 44.6 (in 1993), and 66.1 for men (in 2003), and a maximum of 25.2 for women (also in 2003). The lowest suicide rate was in Shiga for men (15, in 1993), and in Okinawa for women (6, in 1995).

The second category in Table 1 consists of variables related to health and society. Sunshine is expressed in hours per year by prefecture, and varies widely. "Low sunshine prefectures" include Akita, Fukui, Niigata, and Toyama, with Tottori reporting the record-low of 1,324 in 1993. "High sunshine prefectures" are Yamanashi (west of Tokyo), Tokushima and Kochi, and Miyazaki, with a record 2,423 hours reported by Aichi in 1994.[7] Figure 1, which graphs sunshine hours for Tokyo from 1993 to 2009, shows that there is substantial year-to-year variance in this variable. It is interesting to note that the year 1998 – which marked the full-blown banking crisis and the jump in suicides – also happened to be a year of abnormally low sunshine in Tokyo, with about 25 % fewer sunny hours than average.

The divorce rate is expressed per 1,000 people, by prefecture; it was lowest in Niigata (1993) and highest in Okinawa (2001).[8] The variable "ageing" refers to the ratio of a prefecture's population that is older than 65 years, and it ranges from less than 9.7 % (Saitama in 1993, a family-friendly quasi-suburb to Tokyo) to 29.6 % (Akita in 2010). "Density" is measured in persons per square kilometer, and not surprisingly, is highest in Tokyo and lowest in Hokkaido (both in 2010).[9]

The third group of variables contains the economic ones. In contrast to previous studies, I measure unemployment by using the job-openings-to-jobseekers ratio (*kyūjin bairitsu*) for April each year, the month most relevant to university graduates.[10] The "*kyujin* ratio" is collected by the local offices of the government employment agency, Hallo Work. The ratio expresses the availabil-

7 Sunshine data are available from http://www.stat.go.jp/english/data/nenkan/1431-01.htm and http://www.stat.go.jp/english/data/chouki/01.htm (accessed 30 March 2013).

8 Drawn from Vital Statistics of Japan, 人口動態調査各年度 都道府県別にみた年次別離婚率, http://www.stat.go.jp (accessed 30 March 2013); see footnote 6.

9 Prefecture-based data can be found at http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h21.html (accessed 30 March 2013).

10 This ratio can be downloaded from the Ministry of Health, Labour and Welfare at http://www.mhlw.go.jp/toukei/list/114-1.html (Tab 9 as of 2012), accessed on 30 March 2013.

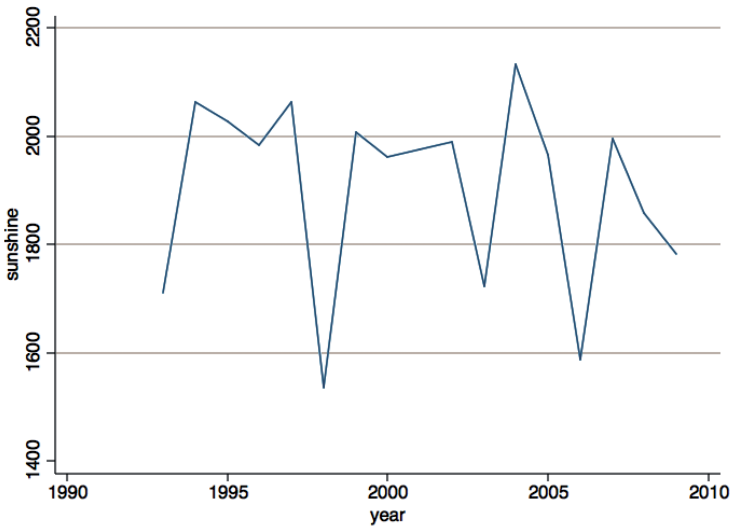

Figure 1: Annual sunshine hours in Tokyo, 1993–2009.

ity of jobs (the higher, the more jobs), and even though it does not capture people who find jobs through different routes (e.g., the Internet, a local ad), it is highly correlated with the unemployment rate and has the advantage of being generally more sensitive to seasonal fluctuations. That said, like the unemployment rate, the *kyujin* ratio suffers from the limitation that people who give up looking for a job simply drop out of the statistics. The distribution of this variable ranges from just 0.18 (Okinawa in 1995) to 1.95 (Aichi in 2007, meaning there were almost two jobs per applicant in the prefecture).

While unemployment marks an extreme case of personal hardship, a somewhat lesser but potentially similarly detrimental effect might come through a decline in wages. Data suggest that wages have fallen in Japan since the late 1990s, and this has been flagged as a major cause of reduced consumption and slow economic growth (e.g., Horioka 2006). To see whether personal income has an effect on the suicide rate, I include the annual growth rate in per capita wages, for the years 1997–2009.[11] The deepest fall in wages, with −9.5 %, was recorded in Shizuoka in 2009, and the highest rise with 4.2 % in Tochigi prefecture in 2004.

11 Consistent time series data for prefecture-based wages begin in 1996, and using the growth rate restricts observations for this variable to the period 1997–2009, downloaded from http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h21.html (accessed 30 March 2013).

Table 2: Correlation table.

	Suicide rate	Sunshine	Divorce rate	Ageing	Density	*Kyujin*	Wage growth	GPP growth	Bankruptcy rate
Suicide	1								
Sunshine	−0.46	1							
Divorce	−0.03	0.25	1						
Ageing	0.49	−0.13	−0.24	1					
Density	−0.26	0.14	0.32	−0.43	1				
Kyujin	−0.30	0.17	−0.34	0.11	0.06	1			
Wage growth	−0.02	0.02	0.02	−0.09	−0.00	0.32	1		
GPP growth	−0.17	0.06	−0.09	−0.21	0.03	0.25	0.34	1	
Bankruptcy	−0.09	−0.03	0.22	−0.22	0.52	−0.13	−0.17	0.06	1

$n = 611$

The overall state of the prefectural economy is measured by the growth rate of the real gross prefectural product (GPP), in 2000 prices.[12] This, too, ranges widely, from –10.9 % (Ibaraki in 2009) to 9.8 % in Aomori (2006). Another measure that can be assumed to express the overall economic situation is the corporate bankruptcy rate. This variable is constructed here by using the number of bankruptcies in a prefecture, normalized by prefecture population (in 1,000).[13] The extreme points in the dataset were recorded for Okinawa in 2010 (with 0.035) and Tokyo in 2002 (0.312).

Table 2 presents the correlations among these nine variables. Suicide and sunshine are highly correlated, but they behave completely independently in regards to all other variables. Most associations are as expected. For example, "ageing" (the percentage of people over 65 in a prefecture) is associated with places that have fewer people, fewer job openings, and slower wage and economic growth. The divorce rate is higher in places that have fewer older people, in urban areas, or where wages are increasing (perhaps empowering the spouses to go it alone), but also where there were fewer jobs and more bankruptcies.

Like all other studies of this design, this paper faces the challenge that the data are prefecture-based, meaning that they measure only the overall incidence in each prefecture. This means that those who get divorced or become

12 Same as footnote 9.

13 Corporate bankruptcy data were drawn from Tokyo Shoko Research, at http://www.tsr-net.co.jp/news/status/yearly/ (accessed 30 March 2013).

unemployed and those who commit suicide may be different people. It is important to keep this caveat in mind as we interpret the data.

4 Analysis and results

I employ OLS regressions, with the male and female suicide rates as dependent variables. In a first step, I look at the effects of the dependent variables by category (results in Table 3), and in a second step I consider all variables with three separate period dummies (Table 4). The first of the period dummies is the years 1993–1997, to see whether the 1998 jump changed the socioeconomic setting in important ways (it does not). The second is the 1993–2000 period, to capture the "lost decade" of the 1990s, and the third is the period 2000–2009, to capture the 2000s as compared to the "lost decade." Due to a mixture of nominal and continuous coefficients, all results report unstandardized regression coefficients, and an interpretation of coefficients is limited to the male–female comparison.

Table 3: Regression results (1) – base models.

	1	2	3	4	5	6	7	8
VARIABLES	male suicide rate				female suicide rate			
sunshine	-0.0156***	-0.0123***	-0.0138***	-0.0158***	-0.00384***	-0.00327***	-0.00362***	-0.00374***
	(0.0012)	(0.0008)	(0.0013)	(0.0011)	(0.0004)	(0.0004)	-0.000467	(0.0004)
divorce	11.24***	9.840***	1.998*	12.07***	-0.348	-0.877***	-2.309***	-0.541*
	(0.7470)	(0.5710)	(1.0230)	(0.7820)	(0.2600)	(0.2610)	-0.364	(0.2780)
ageing		128.5***				26.75***		
		(5.4150)				(2.4700)		
density		-0.000647***				0.000146		
		(0.0002)				(0.0001)		
kyujin			-5.913***				-1.491***	
			(1.0650)				-0.379	
wagegrowth			-0.405***				-0.0416	
			(0.1420)				-0.0505	
gppgrowth				-0.436***				-0.115***
				(0.1090)				(0.0389)
bankruptcy				-38.16***				0.56
				(6.5980)				(2.3440)
Constant	42.73***	21.22***	63.12***	45.89***	21.04***	15.57***	25.89***	21.18***
	(2.3690)	(1.5980)	(2.7930)	(2.3590)	(0.8240)	(0.9040)	-0.994	(0.8380)
Observations	799	799	611	799	799	799	611	799
R-squared	0.302	0.591	0.264	0.338	0.114	0.238	0.213	0.124
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

Table 3 contains the four base models for the entire period. The first base model includes only the core sociological variables of sunshine and divorce. We see that sunshine is highly significant and negative for both males and females: the less exposure to sun, the higher the suicide rate. This result does not change, regardless of specification.[14] Further exploration of the sunshine variable will follow below.

In contrast to previous research, the divorce rate is strongly significant, and the coefficients are much larger for men than for women. What is more, the variable takes different signs for men (higher divorce rate correlates with more suicides) than for women (higher divorce, fewer suicides). This result, too, persists through all models. It appears as if many Japanese women may feel less anxiety, insecurity, or depression about divorce, whereas men may feel more desperate and helpless. There is surprisingly little research on divorce in Japan, especially regarding recent years. We know that historically Japan has been comparatively pragmatic about marriage and also divorce, and until 1966 the number of arranged marriages exceeded that of so-called "love" marriages. Yet, whereas the divorce rate was comparatively very high at the end of the nineteenth century, with about 3 per 1,000 people, this ratio dropped to 0.5 in post-WWII Japan, perhaps as part of the social setup of the developmental state (Fuess 2004; Ono 2006).

Since then, however, the marriage rate has fallen and the divorce rate has risen steadily. According to Japan's Vital Statistics, as of 2010, the marriage rate in Japan was 5.5 (compared to 6.8 in the United States and 4.7 in Germany), and the divorce rate had quadrupled to reach 2 in Japan (3.4 in the United States, 2.3 in Germany). Various interpretations for this rise have been proffered, including: a changing pattern with economic development and demographic change; a change in social norms; or a change in the relative costs and benefits of marriage that has resulted from either a rejection, by women, of life as a stay-home mother and the work patterns of male "lifetime employees," or from a growing equalization of status. For example, Ogawa and Ermisch (1994) show a direct relation between rising full-time workforce participation and the divorce rate. Regardless of the reason or interpretation, the current analysis suggests that the increase in divorces is a negative development for many men, yet a positive one for women. It seems as if, at least at the prefectural level, many Japanese women find divorce liberating.

The second base model in Table 3 adds "ageing" and "density" to the base specification. Ageing enters positively and significantly as predicted by the

14 I also conducted the analysis by looking only at the association between sunshine and suicide, and this yielded very similar results (not reported here).

international literature, though perhaps in challenge to the various studies for Japan by Chen et al. that call attention to working-age males. The percentage of people older than 65 is a powerful explanatory factor for a prefecture's suicide rate, and the coefficient is much larger for men than for women. In contrast, density is significantly negative for men (more suicides in less populated places) but not significantly different from zero for women. As we will see in Table 4, these results flip in the overall model, and further thoughts will be offered there.

Model 3 zooms in at the two measures of personal economic hardship (unemployment and wages). For men, the fewer the job openings and the lower the wage growth, the higher is the suicide rate. For women, job openings are also significant, though wages are not. Finally, Model 4 looks at the more macro-economic indicators. Lower economic growth – i.e., recession – is also associated with a higher suicide rate for both, men and women. However, this variable, too, flips signs in the full model. The bankruptcy rate, while not significant for women, has the opposite sign for men from what one might expect: it is significant and negative. That is, the lower the corporate bankruptcy rate, the higher the suicide rate, and vice versa. One possible interpretation is that Japan's encompassing "too big to fail" policies are often said to have led to the creation of so-called zombie companies that have no future and no hope but are artificially kept alive with subsidies (Caballero et al. 2008). Working at such companies can be very demotivating for employees who are unable to move to more exciting tasks due to severely limited mid-career job opportunities. In this interpretation, ironically, more bankruptcies could be a sign of a chance for change. Still, the result for the bankruptcy rate remains a puzzle, and I leave a full exploration of this matter for future research. In what follows, I drop the bankruptcy rate to get a clearer picture of the other economic variables.

In terms of fit, Model 2 (the sociological and personal markers) has the highest explanatory power. The R-squared is generally higher for men than for women, in particular for the economic variables, implying that the reasons for suicides might be more multifaceted for women, where factors not considered here (such as children) may also come into play in important ways.

Table 4 presents the results for the overall analysis. Models 1 (for men) and 5 (for women) comprise the entire period from 1993 to 2009, whereas the following three models each contain a period dummy. For both men and women the sunshine variable remains consistently significant and negative. Moreover, in each specification the divorce rate continues to be significantly positive for men, and negative for women. Ageing is highly significant, as before, and the coefficient is much higher for men than for women. Perhaps part of the suicide story in Japan is simply related to the fact that the country has one of the

Table 4: Regression results (2): full models with period dummies.

	1	2	3	4	5	6	7	8
	male suicide rate				female suicide rate			
sunshine	-0.0117***	-0.0110***	-0.0120***	-0.0118***	-0.00332***	-0.00315***	-0.00350***	-0.00337***
	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
divorce	4.654***	3.502***	6.113***	5.558***	-2.265***	-2.562***	-1.329***	-1.602***
	(0.8480)	(0.9120)	(1.0380)	(1.0210)	(0.3820)	(0.4130)	(0.4650)	(0.4590)
ageing	125.3***	118.3***	136.6***	132.3***	21.12***	19.32***	28.38***	26.28***
	(6.9270)	(7.1970)	(8.3380)	(8.2190)	(3.1210)	(3.2620)	(3.7380)	(3.6910)
density	-0.000266	-0.000283	-0.000241	-0.000252	0.000272***	0.000268***	0.000288***	0.000282***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
kyujin	-8.823***	-9.069***	-7.741***	-8.314***	-2.101***	-2.164***	-1.407***	-1.727***
	(0.8900)	(0.8860)	(0.9930)	(0.9450)	(0.4010)	(0.4010)	(0.4450)	(0.4240)
wagegrowth	-0.000324	0.12	-0.0822	-0.0162	0.0377	0.0687	-0.0148	0.0261
	(0.1170)	(0.1210)	(0.1210)	(0.1170)	(0.0526)	(0.0550)	(0.0542)	(0.0525)
gppgrowth	0.478***	0.449***	0.456***	0.473***	0.0418	0.0342	0.0276	0.0381
	(0.0940)	(0.0937)	(0.0941)	(0.0940)	(0.0424)	(0.0425)	(0.0422)	(0.0422)
1993-1997		-3.036***				-0.782*		
		(0.9260)				(0.4200)		
1993-2000			1.626**				1.043***	
			(0.6720)				(0.3010)	
2000-2009				-1.081				-0.793***
				(0.6830)				(0.3060)
Constant	30.45***	33.42***	24.38***	27.78***	21.17***	21.94***	17.28***	19.22***
	(2.7190)	(2.8450)	(3.6910)	(3.1950)	(1.2250)	(1.2900)	(1.6550)	(1.4350)
Observations	611	611	611	611	611	611	611	611
R-squared	0.574	0.581	0.578	0.576	0.269	0.273	0.283	0.277
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

fastest-ageing populations in the world, and a third of suicides are committed by people older than 60.

Density and wage growth are no longer significant for men, and GPP growth takes on a positive sign, now implying more suicides during growth periods. This lends support to Ruhm's (2000) finding that morbidity is counter-cyclical in the United States, as well as to Neumayer (2004), who shows an increase in suicides in Germany during booms. For women, density now takes on positive significance, meaning that living in a larger city is associated with a higher suicide rate. Without a deeper exploration into matters of family size, etc., little more can be said than that alienation in the big city may be more adverse than loneliness in the countryside. Overall, the circumstances may be more location-specific than the overall number of people in relation to the size of the prefecture. Neither wage nor GPP growth matters for women.

The *kyujin* ("job openings") ratio is large, negative, and strongly significant for both men and women, and the coefficients are much higher for men. This confirms the findings of existing studies on Japan for men, but in this strength and consistency it is new for women. It will be interesting to explore this result

further in the future: perhaps women's job prospects are better captured with the "job-opening ratio" than the unemployment rate, or the result may simply reflect changes with higher labor participation by women in recent years.

The period dummies offer little additional information: nothing much changes, except that in the period of 1993–2000 (including the 1998 jump), the above findings are reinforced, whereas they are less so for men before 1998, and less so for women in the 2000s. One possible explanation is that economic factors have become more important for men, and even less important for women. The R-squared continues to be much higher for men, again suggesting that future research on this matter should broaden the lens to include more noneconomic variables, especially for women.

Taken together, the three variables that stand out from this analysis are sunshine, divorce, and *kyujin*. The negative values for sunshine lend credence to the assertion that the SAD affliction is also widespread in Japan. One final question we can now ask is: how much so? In order to evaluate the relevance of "sunshine" – a proxy for well-being largely independent of the economy – Table 5 looks at the interaction of the sunshine variable with the three economic variables, *kyujin*, wage growth, and GPP growth. Models 1 and 5 reinforce the previous findings: sunshine is negative and significant for both men and women. Now the economic variables are significant only for men; the previously strong result for *kyujin* for women disappears in this specification.

Table 5: Interaction effects: sunshine and the economic variables.

	1	2	3	4	5	6	7	8
	male suicide rate				female suicide rate			
sunshine	-0.0128***	-0.0235***	-0.0126***	-0.0128***	-0.00463***	-0.00597***	-0.00450***	-0.00463***
	(0.0012)	(0.0033)	(0.0013)	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0005)
kyujin	-7.718***	-35.83***	-7.709***	-7.713***	-0.476	-3.983	-0.466	-0.473
	(1.0070)	(8.0980)	(1.0080)	(1.0070)	(0.3730)	(3.0250)	(0.3730)	(0.3730)
wagegrowth	-0.562***	-0.547***	-0.868	-0.564***	-0.027	-0.0251	-0.345	-0.0283
	(0.1470)	(0.1460)	(1.2990)	(0.1470)	(0.0543)	(0.0544)	(0.4810)	(0.0544)
gppgrowth	0.443***	0.432***	0.442***	-0.0866	-0.0308	-0.0321	-0.0315	-0.414
	(0.1190)	(0.1180)	(0.1200)	(0.9660)	(0.0442)	(0.0442)	(0.0443)	(0.3570)
sun x kyujin		0.0147***				0.00183		
		(0.0042)				(0.0016)		
sun x wage			0.000159				0.000165	
			(0.0007)				(0.0002)	
sun x gpp				0.000276				0.0002
				(0.0005)				(0.0002)
Constant	66.30***	86.70***	66.04***	66.30***	22.53***	25.08***	22.27***	22.53***
	(2.3500)	(6.2800)	(2.5810)	(2.3520)	(0.8700)	(2.3460)	(0.9550)	(0.8700)
Observations	611	611	611	611	611	611	611	611
R-squared	0.276	0.29	0.276	0.276	0.162	0.163	0.162	0.163
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

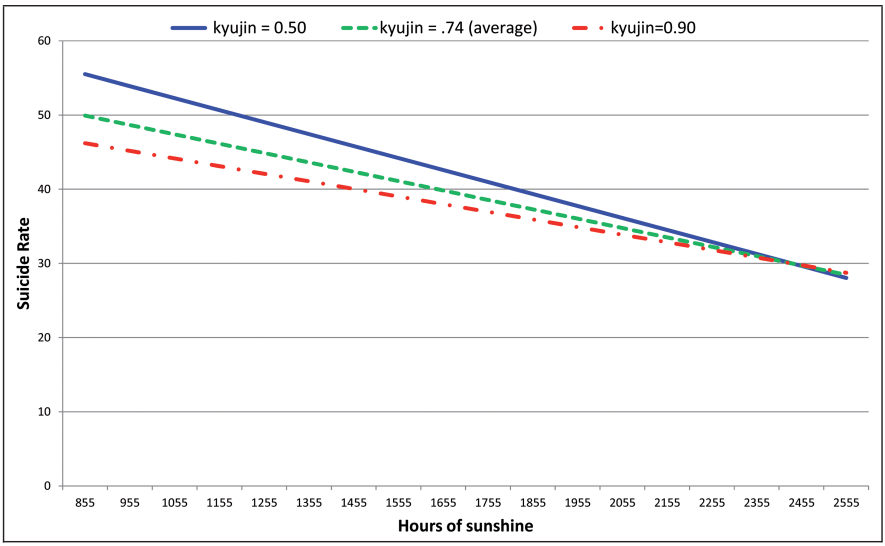

Figure 2: Suicide rate: the interaction of sunshine and the labor market.

Of the interaction terms, the interaction between sunshine and *kyujin* is significant for men, and it is positive. In general, this means that the impact of one variable on the suicide rate is reinforced by the other. To be able to tell a clearer story about this interaction, Figure 2 shows the form of this interaction by graphing the values of the interaction term on the axes of suicide and sunshine (see Aiken and West 1991). The slopes of all three lines are significantly different from zero. The middle (dotted) line is the average *kyujin* ratio of 0.74, the upper line shows the value of the interaction term if the *kyujin* ratio is 0.9, and the lower line if it is 0.5. Note that the three lines converge as the number of sunshine hours increases. This means that in high-sunshine settings, the unemployment rate has almost no effect on the suicide rate. In contrast, in low-sunshine settings, the effect of unemployment on the suicide rate is greatly enhanced by sunshine, by more than 10 %.

The main conclusion to be drawn from this analysis is that while economic factors matter in explaining the high suicide rate in Japan, they do not offer the complete story. Mental well-being, as proxied here by sunshine, is at least equally as, if not more, important: sunshine significantly enhances the effects of *kyujin*. The effect of sunshine holds equally for men and women.

5 Conclusions

So far the primary research focus in socioeconomic studies of suicide in Japan has been on economic variables. Many studies have shown strong associations between economic conditions, especially unemployment, and suicide rates. The findings for unemployment are confirmed here. However, economic variables do not tell the complete story. When the exogenous variable of sunshine hours is accounted for, the effects of some of the economic variables are attenuated, while one – unemployment – is enhanced. A detailed analysis of the interaction effect shows that it may be sunshine that is reinforcing the effect of unemployment, rather than the opposite. In prefectures with more sunshine hours, the effect of unemployment wanes, and vice versa.

A second new and strong finding concerns the divorce rate. So far, few studies have used Japanese data (as opposed to OECD or WHO data) to explore this variable, and this paper appears to be the first to document a strong, negative association between divorce and suicide for women, which is in marked difference to other countries. A detailed exploration of this association is left for future research.

This study should be considered only a first of what will hopefully be a series of endeavors to correct the current overemphasis on economic variables. One possible next step is to include more variables on the sociological aspect of suicides, such as number of family members per household, or variables that allow to instrument inclusion of people, in particular the elderly, in local events. Japan has gone to great effort to provide leisure and diversion for the elderly, including huge investments in local gyms, special classes for senior citizens, and also guided tourism and other social activities. The findings of this paper suggest that these measures could be more important than meets the eye. Future studies may want to consider interaction between such variables of social inclusion and economic ones.

Finally, one hopes that Japan further expands its efforts to help people in mental distress. The focus on economic variables, while justified, offers too easy an excuse for not addressing the issue of depression. We cannot change the hours of sunshine in each prefecture, but perhaps more help can be offered to those afflicted by a lack thereof, beyond loan programs and similar economic initiatives.

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