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Graphical analyses of occupation-wise suicide risk in Japan

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Abstract

I construct data on the numbers of workers and suicide victims in their working ages in Japan from 1980 to 2010 for each of 10 occupation classes and for males and females separately. I document a complex transition of the job profiles of occupation classes, and establish a correspondence between Japanese and international job classifications. Four general characteristics of occupation-wise suicide risk in Japan emerge from graphical analyses of constructed data. First, heterogeneous aging patterns of suicide deaths and numbers of workers create complex aging patterns of suicide rates. Second, the age-adjustment and stabilizations of suicide rates are crucial for an accurate measurement and a fair comparison of suicide risk for workers in each occupation or over the entire economy. Third, the surge of overall suicide risk in Japan since 1998 might be driven by that in few occupations for each gender. Particularly, (a) a high suicide-risk profiles for male workers in agricultural, forestry and fishery and jobless categories has been stable over time, hence not a main culprit of such surge, and (b) less informative patterns of female suicide rates may be a consequence of the cancellations of higher suicide risk in some occupations and lower suicide risk in any other occupations during such surge. Fourth, gender- and occupation-wise pattern of suicide risk is further confounded with heterogeneity across regions.

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1 Introduction

Figure 1 displays the average suicide rates (i.e., the numbers of suicide deaths per 100,000 individuals) of Japanese males and females within each year, plotted against 16 five-year age-cohorts. These are borrowed from Ikeda and Zhang (2016, Figure 1) in order to indicate three general characteristics of suicide risk in Japan: (a) a gender difference in aging profiles of suicide rates, (b) a surge of male suicide rates since 1998, and (c) a flatter pattern of female suicide rates than the male counterparts, especially in their working ages (15-64). (b) has been quoted as a signal of higher suicide risk of males during the period of deep recession and financial crises, beacuse this period coincides with the surge of unemployment rates of males in working ages, and the unemployed status is an intuitive and empirically well-grounded socio-economic risk factor for suicide (e.g., Hamermesh and Soss 1974; Koo and Cox, 2008; Chen, Choi, Sawada and Sugano 2012; and Milner, Spittal, Pirkis and LaMontagne 2013). However, the suicide risk of workers has been rarely discussed in the context of economic research.

This study attempts to document several features of occupation- and gender-wise suicide risk of Japanese workers. There are at least three benefits of fostering our understanding of this issue. First, the suicide of active workers may bring a huge economic cost to their families, workplaces, and even macroeconomy: (a) the previous studies in the western countries including Japan report the estimated cost of 0.74 to 21 billion USD from 2001 to 2005 (SIEC Alert, 2010; Kaneko and Sato 2009); (b) suicide of active workers incurs a greater tangible cost in terms of the productivity or earnings losses; and (c) the victims in the workplaces have more extensive social networks, hence incurring higher intangible/human costs of pain, grief, suffering, etc. Second, suicide of active workers is an important signal about inefficient operations in workplace. In Japan, a part of suicide-at-jobs incidences are linked to a low social support, high psychological demand, low decision latitude, and long working hours, potentially driven by the fear of unemployment during the deep recession and a rigid Japanese labor market (Amagasa, Nakayama and Takahashi 2005; Kamesaka and Tamura, 2016). Indeed, these issues are considered as main culprits of the stagnated productivity in Japan since early 1990s (Jorgenson, 2016). Third, it may give some clues about the suicide risk of females behind relatively flat, and therefore less informative, patterns of their suicide rates. Ikeda and Zhang (2016) provide some evidence on the anti-risk nature of female unemployment rate for female suicide rates, and suggest that it may stem from the stressful convention or enforced roles in their workplaces.

I confirm three general characteristics of occupation-wise suicide risk in Japan. First, heterogeneous aging patterns of suicide deaths and numbers of workers create complex aging patterns of suicide rates. Second, the age-adjustment and stabilizations of suicide rates are crucial for an accurate measurement and a fair comparison of suicide risk for workers in each occupation or over the entire economy. Third, the patterns of aggregate suicide risk may reflect heterogeneous suicide risk across different occupations. All of these facts point toward

the importance of preliminary data analysis in a dis-aggregated level, prior to any inference on the basis of aggregated measures.

2 Literature on occupation-wise suicide risk

Agerbo et al. (2007) suggest the importance of controlling for socio-economic, demographic and psychiatric confounders using Danish individual level data. They imply that once mentally disordered, workers in different occupations sugger from relatively uniform suicide risk. Thus, occupations relying on workers' long, hard and coorporative works may induce their greater suicide risk. Milner et al. (2013) is a recent systematic review and meta-analyis of suicide by occupation, on the basis of 34 high-quality papers of retrospective population-level studies, case-control studies, meta-analyses and systematic reviews in the U.S. (13), Canada (4), Europe (13), Japan (1), Korea (1), New Zealand (1), and Australia (1). They suggest that the occupations in ISCO 8 and 9 (mainly "elementary" and "manual workers") are the riskiest, followed by ISCO 5 ("sales and services", including police officers) and ISCO 6 ("skilled farmers"). In contrast, ISCO 1 ("managers") and ISCO 4 ("clerical workers") are safe. They argue that (i) wider social and economic disadvantages, including lower education, income and access to health services, may explain the results, (ii) the effect of accessibility to lethal means is mixed, and (iii) psychosocial working conditions, e.g., low job control, low social support, and high job demands, together with occupational skill levels, may lead to greater risk of depression. (i) is shared with Agerbo et al. (2007). (i) and (ii) are consistent with the finding of Roberts, Jaremin and Lloyd (2013), in which the suicide risk of health care occupations (veterinarians, pharmacists, dentists, and doctors) and farmers in England and Wales has reduced substantially from 1979-1980 to 2001-2005, whereas manual workers have faced greater suicide risk due to their sensitivity to business cycle and structural shift of the economy. (iii) is parallel to Amagasa, Nakayama, and Takahashi's (2005) case study on the possibility of suicide in Japan due to over-working.

Marrital status is linked to the suicide risk in general (Smith, Mercy and Conn 1988). Moreover, workers in different occupations may face different likelihoods of being divorced, single and widowed (Stack 2001 and the references therein). A common belief is that shift works, supervisory problems, fluctuating activeness in the workplace, instantaneous decision making, etc., may induce higher divorce and suicide risk. However, McCoy and Aamondt (2010) indicate that the the divorce rates for the U.S. law-enforcing occupations, especially police officers, are lower than those of the general population, even after controlling for demographic and other job-related variables. Jalovaara (2002) suggests that the divorce risk in Finland may have several characteristics, such as (i) a hump-shaped pattern against the marrital duration, peaked at 5- to 9-year durations; (ii) spouses' (especially husbands') unemployment and wifes' income or employment are positive correlates of divorce risk whereas home ownership and spouses' employment in farming are negative correlates, all of which are observed relatively uniformly over the marrital durations; and (iii) occupational variations of

divorce risk exist mostly for short-duration marriages. (ii) indicates that occupations with unstable employment status may show relatively higher divorce rates and may lead to higher suicide risk. Lower divorce risk of farming suggests that the divorce may not be a strong risk factor of suicide for farmers; but a higher chance of being widowed, especially for rapidly aging workers in Agri occupation, may excerbate the suicide risk. (iii) suggests that the variations in ages of first marriage across occupations may have something to do with higher suicide risk, especially for male workers, in their middle ages.

Earlier empirical results, e.g., Breuer (2015) or Ikeda and Zhang (2016), indicate a suicide-risky feature of unemployment, especially for males. However, their data do not sort the suicide rate by occupations. The suicide risk of workers in different occupations may respond to the region-wide unemployment rate in different ways. Classen and Dunn (2012) suggest that it is not the job loss itself but a long duration of unemployment spells that comoves with the suicide risk of jobless people in the United States using state-level data. For males, the riskiest duration of unemployment is from 15 to 26 weeks, beyond which the unemployment insurance is terminated. For females, the suicide risk monotonically increases with the duration of unemployment. This result suggests an important research hypothesis: it may be harder for a person losing a job in some occupation to find the next job than the other in other occupations. This may be possible if a worker's skill accumulated in a certain occupation may not be commensurable to others. Besides, some occupations may experience inflows or outflows of people with different risk profiles than the majority of incumbents, thereby creating a time variation of the suicide risk in the entire population. For instance, the increase of female workers in a particular occupation may lower the suicide risk of the entire group because females are less suicide-risky tha nmales. Combined with the creation and destruction of occupations over time, liquidity and frictions of job serching process may have heterogeneous impacts on the time-varying suicide-risk of different occupations.

3 Data and Variables

The data in this study are sourced from Table 11 in the Regional Statistics for Suicide Prevention (RSSP, henceforth). It is a re-aggregated version of the mortality records. An alternative and official assembly of these individual records is given by the "Report of Vital Statistics: Occupational and Industrial Aspects", with unpublished stratifications of suicide deaths according to the prefectures, 5-year age-cohorts, and occupations. These stratifications are useful later because RSSP data have already been age-adjusted, so it is not clear how the reported suicide rates are affected by a clustering of suicide deaths in a certain small-population subclass. The latter data are based on the suicide deaths from April 1st to the next March 31 in a fiscal year of survey for the Population Census, during which the reporters of motrality records have to specify the deceased's occupation. The standardization procedure for RSSP data needs a separate account: see Section 4.2.

3.1 Detailed compositions of occupational classes

There are ten categories of occupations in our data.

1. Specialist and technical workers ("Spec/Tech")

These include researchers in natural science/humanities/social science, engineers and technicians, health care workers (e.g., doctors and nurses), social welfare specialist professionals, legal workers, management specialists (e.g., accountants), teachers, workers in religion, writers, journalists and editors, art professionals (e.g., artists, photographers and designers, musicians and stage designers), and other specialists and technical workers (e.g., private tutors).

2. Administrative and managereial workers ("Adm/Mng")

These include public servants, officers of companies, organization, and others. The composition in this class has been stable in our sample period from 1980 to 2010.

3. Clerical workers ("Clerical")

These include the general clerical workers, outdoor servie workers, transport and communication clerical workers, and office appliance operators (e.g., computer operators). The composition in this class has been stable in our sample period from 1980 to 2010.

4. Sales workers ("Sales")

These include the merchandise sales workers and quasi-sales workers (e.g., real estate agents and dealers, insrance brokers and salespersons, etc.). The composition in this class has been stable in our sample period from 1980 to 2010.

5. Service workers ("Service")

These include domestic support service workers and domestic hygiene service workers (e.g., housekeepers, hairdressers, launderers), food and drink preparatory workers (e.g., cooks and bartenders), customer service workers (e.g., food and drink service, and customer entertainment workers), residential facilities, office buildings and other management personnel (e.g., houses, condominiums, office building or car park management personnels), and other service workers (e.g., advertisers, care workers for treatment and welfare institutions).

6. Security workers ("Security")

These include the members of the self defence forces in Japan, police officers, firefighters, and public security workers.

7. Agriculture, forestry and fishery workers ("Agri")

The composition of occupations in this class are obvious.

8. Transport and communication workers ("Trans/Comm")

These include railway drivers, motor vehicle drivers, ship and aircraft operators, and communication workers (e.g., telephone exchange operators, mail collection and delivery workers).

9. Production process and related workers ("Prod")

These consist of "mannual occupations", classified as eighter I-1: manufacturing and production workers, I-2: stationary engine and construction machinery operators and electricity workers, or I-3: mine workers, construction workers and labourers.

10. Jobless

There is no such category as "jobless" in the occupational classification, but I synthesize it because there are records of the occupation-specific suicide deaths for such people.

3.2 Transitions of classifications

The Japan Standard Occupation Classification (JSOC) changed substantially in 1986 and 2009. In the 1986 change, the "mining workers" and "skilled production workers" are combined as "production process and related workers". We will always implement this aggregation retrospectively for data in 1980 and 1985 waves. The 2009 change is more complex. The "Trans/Comm" workers split into (a) professional and engineering workers, (b) clerical workers, (c) transport and machine operation workers, and (d) carrying, cleaning, packaging, and related workers. The "Prod" workers split into (a) manufacturing process workers, (b) transport and machine operation workers, (c) construction and mining workers, and (d) carrying, cleaning, packaging, and related workers. Finally, the "Sales" workers split into (a) sales workers, and (b) service workers. See Figure 2 for these changes in 2009. Table 1 summarizes the transition of occupational categories in our suicide data.[1] It does not fully track the complex split and recombination of occupations in the 2009 change, as seen in Figure 2. One way to track a similar profile of occupations is to limit our attention to the period until 2005, in order to avoid the disturbance of occupational classifications in 2009. Alternatively, we can use the entire sample from 1980 to 2010, but focus on limited classes of occupations, such as 2. Adm/Mng, 6. Security, 7. Agri, and 10. Jobless. If we retrospectively combine 4. Sales and 5. Service for for pre-2009 waves, then we can track this synthetic class of "Sales and Service" workers over the whole sample.

[1]Special thanks to Mr. Yoshitake Takebayashi of Institute of Statistical Mathematics for kindly providing me this summary.

Table 1: Transition of occupational categories in RSSP.

	1980, 1985		**1990, ..., 2005**		2010
i.	Spec/Tech	**1.**	**Spec/Tech**	B.	Spec/Tech
ii.	Adm/Mng	**2.**	**Adm/Mng**	A.	Adm/Mng
iii.	Clerical	**3.**	**Clerical**	C.	Clerical
iv.	Sales	**4.**	**Sales**	D.	Sales
x.	Service	**5.**	**Service**	E.	Service
ix.	Security	**6.**	**Security**	F.	Security
v.	Agri	**7.**	**Agri**	G.	Agri
vii.	Trans/Comm	**8.**	**Trans/Comm**	I.	Trans
vi.	Mining	**9.**	**Prod**	H.	Manufacturing
viii.	Skilled Prod			J.	Construction
				K.	Carrying

Notes. The transition of occupational classification in RSSP, grossly corresponding to the transition in JSOC. My suicide data follow the bold-font classifications in the middle of this table, which had been effectively officially from 1990 to 2005. The classifications in 1985 and 1980 are aligned with these reference classifications by combining vi. mining workers and viii. skilled production workers. The classifications for raw data in 2010 have undergone a substantial change in 2009, so their correspondence with the reference classifications is not precise. vi. Mining and viii. Skilled Prod in 1980 and 1985 waves stand for the mining workers and skilled production workers, whereas H. Manufacturing, J. Construction, and K. Carrying in 2010 wave mean manufacturing process workers, construction and mining workers, and carrying, cleaning, packaging and related workers, respectively.

3.3 Correspondence between JSOC 2009 and ISCO 2008

The latest International Standard Classification of Occupations (ISCO) is based on the 2008 version. Recall that the statistical department in the government of Japan has attempted to align the Japanese standard to ISOC, especially in the 2009 change. Combined with Table 1, we can link the suicide risk suggested for some occupational classes in our data to those in other studies using the ISCO (e.g., Milner et al., 2013). For instance, it is relatively safe to compare the result for 2. Adm/Mng and 3. Cleric in our data with those for "1. Managers" and "3. Clerical support" in ISCO 2008 data. 1. Spec/Tech in our data can be compared with the combination of "2. Professionals" and "3. Technicians/associate professionals" in ISCO 2008 data.. The comparison between JSOC 2009 and ISCO 2008 for the other categories is not straightforward. For instance, 54. Protective services such as police officers are included in 5. Service and sales in ISCO 2008, whereas they are counted as a part of 6. Security in our data. ISCO data distinguish occupations in agricultural, forestry and fishery occupations according to the required skill levels, while JSOC 2009 data do not.

3.4 Expected Risk Profiles of Occupations in our data

The jobs in 6. Security and 7. Agri in our classicifaction have been thought of as suicide risky. This empirical results have been interpreted as their easier access to lethal means, such as guns, firearms, fatal chemical substances. 8Trans/Comm and 9. Prof are

Table 2: Correspondence between JSOC since 2009 and ISCO since 2008.

JSOC 2009		ISCO 2008	
A(2)	Administrative and managerial	1.	Managers
B(1)	Professional and engineering	2.	Professionals
		3.	Technicians/associate professionals
C(3)	Clerical	4.	Clerical support
D(4)	Sales	5.	Service and sales, excluding 54
E(5)	Service	9.	Elementary, excluding 92, 93
K(9)	Carrying, cleaning, packaging		
F(6)	Security	54.	Protective services
		0.	Armed forces occupations
G(7)	Agriculture, forestry and fishery	6.	Skilled agricultural, forestry, fishery
		92.	Agricultural, forestry, fishery
H(9)	Manugacturing process	7.	Craft and related trades
I(8)	Transport and machine operation	8.	Plant/machine operators, assemblers
J(9)	Construction and mining	93.	Mining, const., manufact., transport

Notes. For JSOC 2009, "A(2)" means that the administrative and managerial workers are labelled A in the official classification since 2009, whereas the corresponding code in RSSP data is 2 as seen in Table 1. It is useful for linking the ISCO classes and those in my data.

relatively low-skilled jobs, and several studies report their suicide-risky nature, whereas jobs in 1. Spec/Tech and 2. Adm/Mng are considered to be high-skilled and low-risk of suicide. Note that our classification of jobs in 1. Spec/Tech includes both health-care workers and art professionals, which have been thought of as suicied-risky in the previous literature, and management specialists, teachers, and workers in religion who are believed to be less suicide-risky occupations.

4 Descriptive/Graphical Analyses of Suicide Risk at Jobs

4.1 Patterns of Age- and Occupation-wise Suicide Rates

One way to summarize the suicide risk is to aggregate suicide rates over regions and waves to focus on patterns of aging and occupational patterns. Figure 3 plots means, medians and their simple averages (all of which use variations over 47 prefectures) of the 7-wave averages of age- and occupation-specific suicide rates for male workers in their 10 classes of working ages (15-19, 20-24, ..., 60-64). Figure 4 shows the numbers of male workers in blue thick lines and male suicide deaths in red dotted lines. I use the unpublished records of suidice deaths in RVSO because there are no records of age-stratified suicide deaths in RSSP, and a raw number x plus one is transformed by natural logarithm, i.e., $\ln(1+x)$, to align the scale for all vertical axes and to make the empirical distribution of the resulting numbers more symmetric (cf., Ikeda and Zhang 2016, Figure 3). There are three general characteristics in these figures. First, for the majority (≥ 24) of 47 prefectures, there are no suicide deaths of

the youngest male workers (15-19), as shown by the median-based suicide rates in Figure 3 and suicide deaths in Figure 4. Second, a slight variation of the number of suicide deaths in a small-sized stratum can lead to a huge swing of the outlier-sensitive mean-based suicide rates. For instance, one suicide death is reported for male Adm/Mng class with two official workers of age 15-19 in Kyoto prefecture as of 2005, so that the crude suicide rate for this stratum is 50,000. Thus, a simple aggregation by either mean or median of the age-specific suicide rates can be quite unstable due to huge outliers or many zeros. Third, the spread between mean-based and median-based numbers roughly measures the imprecision of the calculated suicide rates. For instance, the suicide rates for Pro/Tech, Adm/Mng and Clerical workers over the age of 30, and Sales, Service, and Prod workers of most ages may be more reliable than those for the others. We can alleviate the excess sensitivity of the mean- and median-based numbers (after $\ln(1+x)$ transformation) by taking their arithmetic averages, as the blue thick lines in Figure 3 suggest. Note that approximately symmetric nature of the distribution of $\ln(1+x)$-transformed suicide rates allows me to use this method, as justified by Damilano and Puig (2004). A similar intuition underlies the stability of Bayesian filtered numbers in Section 4.2. Third, the numbers of suicide deaths of male workers show a clear aging effect: they increase uniformly from youngest to middle ages, reach the peak in the late 50s, then decline toward retirement. The comparison of Figures 3 and 4 suggests that a complex pattern of male suicide rates is generated by the different aging profiles of suicide deaths and numbers of workers.

Male workers in Adm/Mng and Security deserve for separate treatments. First, the suicide rates of male Adm/Mng workers are high in young ages, but decline toward their 30s. There are two interpretations of this fact. First, it may be just because a suicide rate is inversely related to the number of workers in its denominator. In fact, Figure 4 suggests that the numbers of male workers in these strata are small yet gradually increase toward late 30s, as is opposite to the pattern just observed in Figure 3. Second, young entrepreneurs may really suffer from a high suicide risk due to the failure of their business, because Japanese civil law adopts the "unlimited liability" principle. Chen, Choi, Mori, Sawada and Sugano (2012) investigate the implications of limited vs. unlimited liabilities across different countries as a potential source of cross-country variations in suicide risk. Their story may be more suitable for an analysis of occupation-wise suicide risk rather than that of a population-wide aggregates, because the latter reflects the suicide risk of jobless persons. Therefore, we should be careful of these two different stories whenever the suicide rates for male Adm/Mng workers are concerned. Second, Figure 4 suggests that both numbers and rates of suicide deaths of male Security workers are low, and the numbers of such workers are stable over the age classes. This is a sharp contrast to the experiences in previous studies surveyed by Milner et al. (2013), in which security-related occupations are highly suicide-risky due to their easier access to lethal means.

Figure 5 shows age- and occupation-specific suicide rates for female workers, whereas Figure 6 plots the numbers and suicide deaths of female workers. There are four distinct

features in these figures relative to those for males. First, for the majority of prefectures, there are no suicide deaths of female workers in most of the age classes. Accordingly, the gap between the median-based and mean-based suicide rates is huge. In particular, high suicide rates of female Admin workers under 25 and female Security workers of age 35-44 may not be reliable. Second, the female suicide rates reach the first peak in their 20s, especially for those in Adm/Mng, Service, Agri and Trans. They indicate that the Japanese labor market may not be comfortable for fresh female workers. Third, we need a caution in interpreting the wild trajectory of suicide rates for female Security workers, because there are few suicide deaths. Fourth, the suicide risk of female workers in Service, Agri and Prod in their 40s and 50s may be accurately measured, as suggested by tight spreads between mean-based and median-based measures for these age classes.

These observations indicate the importance of investigating the age profiles of row suicide deaths and population sizes, in conjunction with that of suicide rates. For male workers, the suicide risk increases from their late 30s, reaches the peak in their 50s, then declins toward retirement. This is clear in the age profile of the numbers of suicide deaths in Figure 4, but it carries over to that of suicide rates to some extent. It is harder to interpret the age profile of female workers' suicide risk.

4.2 Age-Adjustment and Stabilization of Prefecture-Level Suicide Rates

Another way to summarize the suicide risk is to aggregate suicide rates over ages, in order to see variations of resulting numbers over time, prefectures and occupations. We need a great caution in doing so because the aging effect is a strong confounder for mortality data. There are three ways to summarize prefecture-wise suicide rates over ages: (i) a crude rate, given by the total number of suicide deaths over all ages divided by the total number of persons; (ii) a direct age-adjusted rate, given by the weighted average of age-specific crude suicide rates, using weights on the basis of age-matched fractions of persons in a reference group; and (iii) an indirect age-adjusted rate, also known as the standardized mortality ratio (SMR). To obtain SMR, I compute the expected suicide death by multiplying an age-specific suicide rate in a reference group by the number of persons in an age-matched group of our interest. SMR is then given by the total number of actual suicide deaths over ages relative to the total expected suicide deaths over ages. This SMR times the crude suicide rate in the reference group is conventionally called the indirectly age-adjusted suicide rate.

If we only wish to understand a suicidal tendency in a certain region, the method-(i) gives a statistically valid measure of suicide risk implied by data. If we wish to compare the resulting numbers from different regions, then the crude rates may disturb the ordering of suicide risk of different regions due to their different aging structures. The method-(ii) has the advantage of a fine comparability across different regions as long as the same reference group is used, whereas the disadvantage of a potential instability if some strata have small population, because a random fluctuation of suicide deaths can cause a large swing in the

resulting number. Method-(iii) has the disadvantage of less comparability, as it may employ different wave-wise reference groups, but it tends to be more stable than the direct method. To further improve this stability property of the indirect method, I follow Tango et al. (2007, Chapter A.1) to reinterpret SMR as the posterior mean of a Gamma prior to SMR as a random effect, and apply a Bayesian updating formula. Because I estimate the hyper-parameters for that prior by the method of moment, let me refer to this method as: (iv) ind_{MM}, i.e., the indirect suicide rate using Bayesian-filtered SMR and a method of moment. Finally, we can alternatively use a Bayesian method and numerically maximizing he log likelihood function. This is how RSSP data are computed. I refer to this as: (v) ind_{LL}, i.e., the indirect suicide rate using Bayesian-filtered SMR and a log-likelihood maximization.

Table 3 summarizes the sample mean and standard deviations of prefecture-wise suicide rates, calculated by exploiting variations over 47 prefectures and 7 waves, using method-(i) to (iv), and the corresponding numbers reported in RSSP data using the method-(v). We can see that age-adjusted rates without Bayesian filtering sometime suffer from huge fluctuations. These extreme values appear for male workers in Adm/Mng, and female workers in Adm/Mng, Security, and Trans/Comm. In contrast, ind_{MM} using the method-(iv) and the data in RSSP using the method-(v) are successfully stabilized, as seen in means without huge outliers, and small standard deviations. Recall that calculating the crude rate may be the most precise way to assess the average suicide risk within a fixed region, hence their mean value may be a relatively correct description of the average suicide risk in Japan. Because the rates in RSSP have only slightly lower values than these crude rates and successfully controlled standard deviations, RSSP data may be qualified well for a reasonable comparison of suicide rates over prefectures and occupations. In contrast, The results in ind_{MM} rows for the method-(iv) may suffer from a bias due to over-smoothing, because of much smaller standard errors given the bias-variance tradeoff. However, the indirectly age-adjusted suicide rates are based on wave-specific model populations. In case of RSSP, the model population seems the wave-specific country-wide population of working ages, but it includes the jobless people. Therefore, RSSP data may be less reliable for comparison across waves. This means that whenever using that data in a regression framework, we should carefully control the potential confounding effect of demographic changes over time.

4.3 Occupation-Wise Suicide Rates

Figure 7 shows the occupation-specific average suicide rates, their 95% confidence intervals on the basis of heteroskedasticity-autocorrelation-consistent (HAC) standard errors (Newey and West, 1987), and the corresponding crude suicide rate over all ages and all occupations (vertical bars), from 1980 to 1995 (blue dotted) and from 2000 to 2010 (red real). I exclude workers under the age of 20 in order to avoid their counfounding effects as suggested in Section 4.1. Three important features emerge from Figure 7: (a) Male workers in Spec/Tech, Adm/Mng and Service have experienced a sharp increase in their suicide rates from pre- to

post-1998 subperiods, driving the upward shift of the crude rate. In particular, male Service workers become significantly riskier than Agri workers in the post-1998 period. (b) Female workers in Adm/Mng, Security and Trans/Comm become riskier, whereas the suicide rates of any other occupations (including jobless) have been slightly lower in the post-1998 period. Their combined effects result in a slight increase in female suicide rates over all occupations. (c) There are clear gender differences among workers in the same occupation. For instance, male Service workers and female Adm/Mng, Security and Trans/Comm workers always face higher suicide rates than their opposite-gender conterparts in both pre- or post-1998 periods.

These results suggest several implications for any potential research. First, it is important to recognize the riskiest class of occupation as a main driver of the occupation-wide suicide risk of each gender. Agri has been the riskiest occupation for males, but Service has overtaken it since 1998, as indicated by the feature-(a) above. Second, less-informative patterns of female suicide rates in their working ages in Figure 1 may be a consequence of mutual cancellations of higher and lower suicide risk in different occupations, as suggested by the feature-(b). Third, it is important to sort the occupational suicide risk according to genders, as obviously motivated by the feature-(c). One possible explanation for the last issue is given by the theory of status integration (Gibbs and Martin 1964; Stack 2001). It suggests that persons in statistically infrequent role sets (e.g., female solders in a male-dominant workplace) may be subject to a greater stress and therefore higher suicide rates than their counterparts (e.g., female teachers in a female-dominant workplace). Fourth, Adm/Mng workers become riskier in the post-1998 period, regardless of genders. It suggests that the suicide risk of Adm/Mng workers may be partly driven by a gender-free source, e.g., the business cycle effect. Therefore, the economic variables such as bunkruptcy or unemployment may be more informative about the suicide risk for Adm/Mng than for the other occupations or for the entire sample.

4.4 Pre- and post-1998 regional patterns of occupational suicide risk

Figures 8 to 13 report the age-adjusted suicide rates for male workers in Spec/Tech, Adm/Mng, Service, Agri and Trans, and Jobless persons, from 1995 to 2010. The regional patterns of suicide rates in the first three waves (1980, 1985, 1990) are not so much different from those in 1995, hence their maps are omitted. These maps suggest several interesting features. First, the 1998 surge of suicide rates over the whole country may be driven by Spec/Tech, Admin/Mng and Service classes of occupations. The suicide risk of male Agri workers and Jobless persons has been high but relatively stable over time. Second, the timing of surging suicide rates after 1997 is heterogeneous over prefectures and occupations. For instance, the southwestern panels for wave-2005 indicate that the suicide risk for Adm/Mng and Pro/Tech workers increase in wave-2005. Third, different occupations have different regional patterns of suicide rates. For instance, the patterns of suicide risk for male Adm/Mng and Service workers are similar over regions and over time, so that these occupations may share the same source of suicide risk, e.g., the effect of business cycle. The male workers'

suicide risk in Agri is concentrated in Tohoku area (Aomori, Iwate, Akita), Niigata, and Miyazaki, in which Agri is an important industry. These prefectures have been counted repeatedly as the most suicide-risky prefectures in Japan. Therefore, the suicide risk of males in Agri may have a common facor, associated with the occupational characteristics, industrial or labor market structures, vulnerability to economic and/or natural disasters, poor agricultural policies, etc.

Figures 14 to 19 map the suicied rates for female workers in Adm/Mng, Service, Security, Agri, Trans and Jobless. They indicate several features of female suicide risk over time and over regions. First, the surge of suicide rates are visible for Adm/Mng, Security, and Trans. Moreover, these occupations become suicide-risky at different timings: Admin/Mng in some prefectures become risky in 2000-wave; others in 2010-wave. Moreover, population densities in those risky prefectures, i.e., Hokkaido, Tottori, Shimane, Saga, Kagoshima, and Kochi, are relatively low. It suggests that female workers running Adm/Mng business in less-populated area may face greater suicide risk. Second, higher suicide risk of female Security workers are relatively concentrated in a limited number of prefectures, i.e., these around Tokyo, Kagoshima, Hiroshima, Yamaguchi, and Oita. Third, higher risk for female workers in Trans is common over the whole country, and its peak comes in the 2010-wave, more than ten years after the country-wide surge of suicide risk. Fourth, the comparison of Trans/Comm and Service maps suggests that the high sucide risk for females Trans/Comm workers is driven by the risk for those in Transport occupations, not in communication occupations, because the latter are removed from the Trans/Comm class to the Service class in 2010-wave data. Given these heterogeneity of suicide risk surge over the prefectures, waves, and occupations, we need to introduce a time effect carefully in any inference based on panel data.

5 Conclusion

I construct a prefecture-level dataset of suicide victims and workforces in 10 occupation classes including jobless. The detailed analysis about the job component of each occupation class is necessary for having a solid understanding of how my dataset, covering 30 years of 7 waves with six 5-year intervals, because the job classification in Japan has changed frequently, particularly in 1986 and 2009. I provide a correspondence between the latest job classifications in Japan and international counterpart for a better comparison of any results using my dataset with any previous studies. Based on the constructed data, I decompose the age structure of the gross suicide rates for each occupation into those of the number of suicide deaths and of the number of workers. It reveals that the complex age pattern of gross suicide rates stem from the non-aligned age patterns of two components. It suggests that the importance of a great caution in interpreting the age-pattern of suicide rates and aggregating gross suicide rates as a single measure of suicide risk for each occupation. Several discriptive and comparative studies suggest that the indirectly age-adjusted suicide rates with a Bayesian filter seem appropriate for comparison in suicide risk across different occupations, genders, and regions; less so for

inter-wave comparison, but may not be so harmful, as long as a macro time effect is carefully controlled for. Turning to the surge of suicide risk since 1998, my occupation-wise data reveals that it might be driven by few occupations with similar characteristics, such as administrative and managerial workers, specialists and technical workers, and service workers for males, and administrative and managerial workers, security and transportation and communication workers for females. Moreover, these occupation- and gender-specific patterns are further confounded with the regional characteristics, thereby making the importance of introducing interacted fixed effects carefully in any statistical analysis.

Acknowledgement

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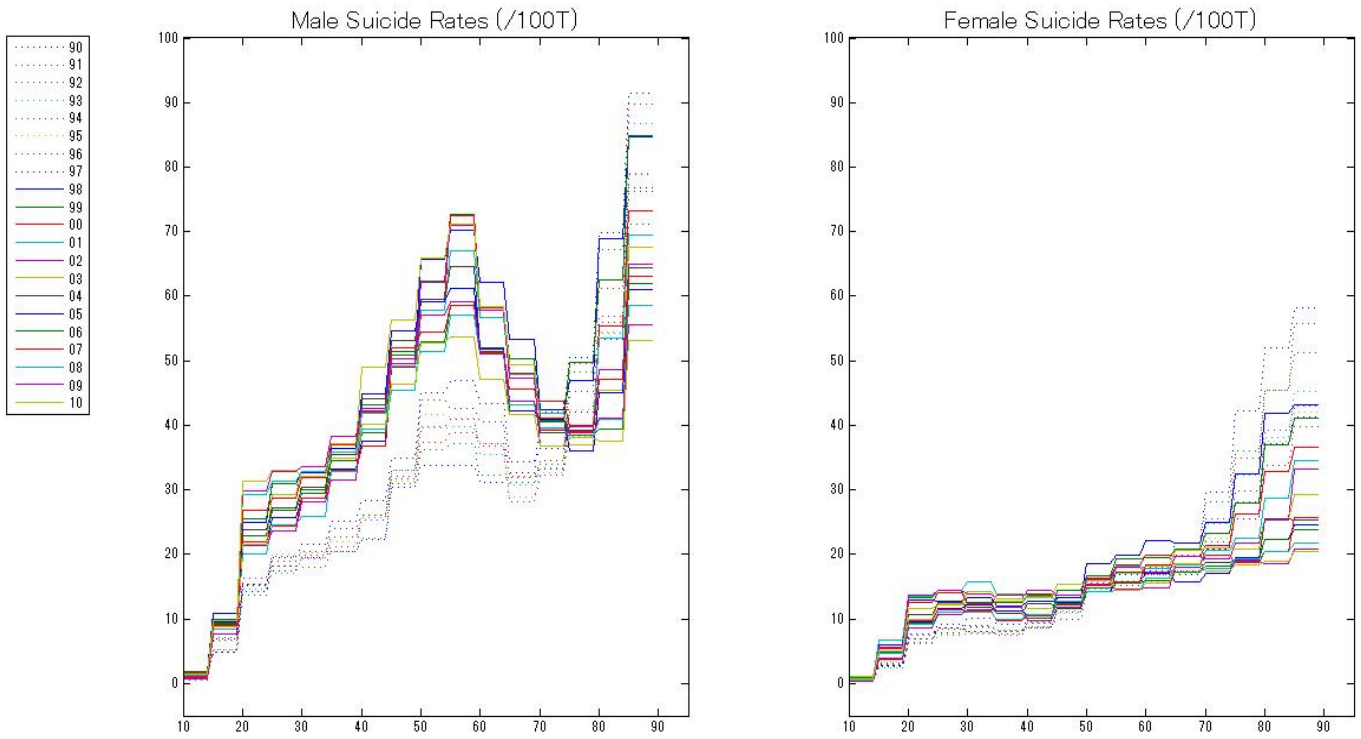
Figure 1: The age pattern of suicide rates of Japanese males (left) and females (right).



Notes. These are the average age-adjusted suicide rates (i.e., the numbers of suicide deaths per 100,000 population) of males and females within each fiscal year for each path, plotted against the 16 five-year age cohorts. The dotted curves represent the rates before 1998, and the real curves are in and after 1998. Male suicide rates show a clear N-shaped pattern and the surge after 1997, whereas the females' patterns show little regularities except for some aging effect.

(3)職業・産業分類の新旧対照表
The comparison list of classification of occupation and industry (FY2010-FY2005)

職業
occupation

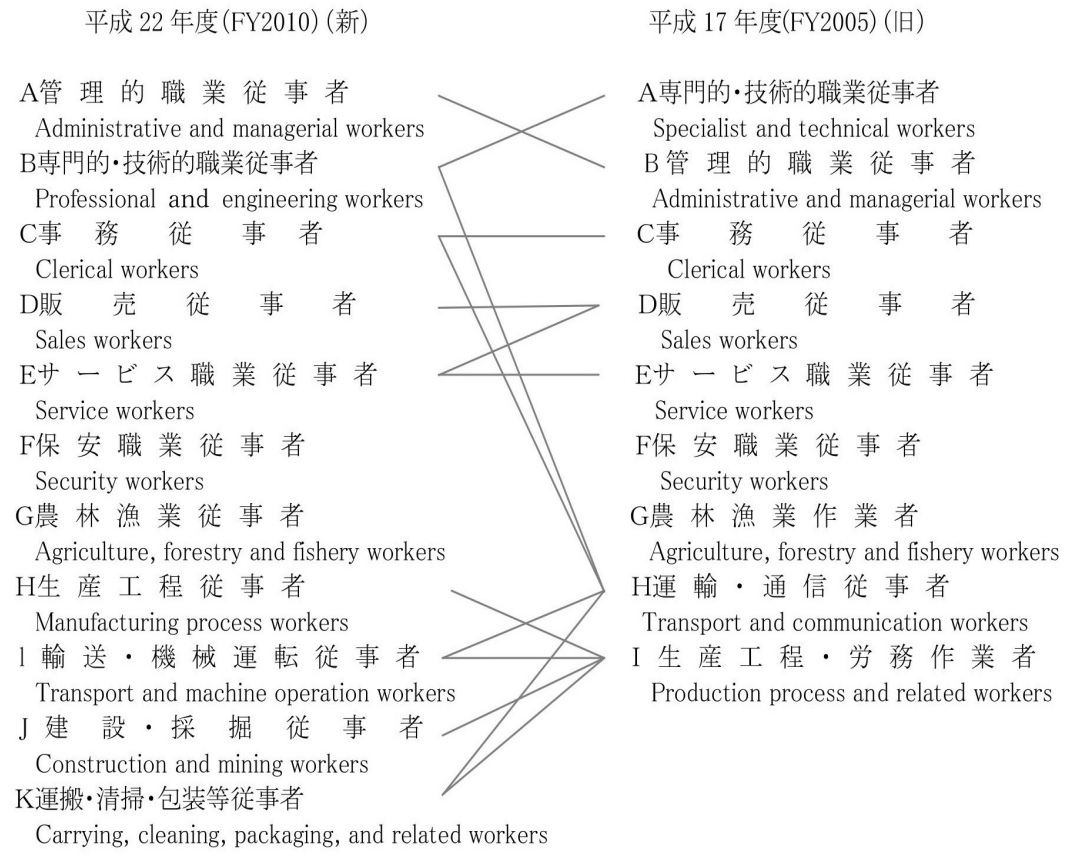


Figure 2: The actual transition of occupational categories from wave-2005 to wave-2010.

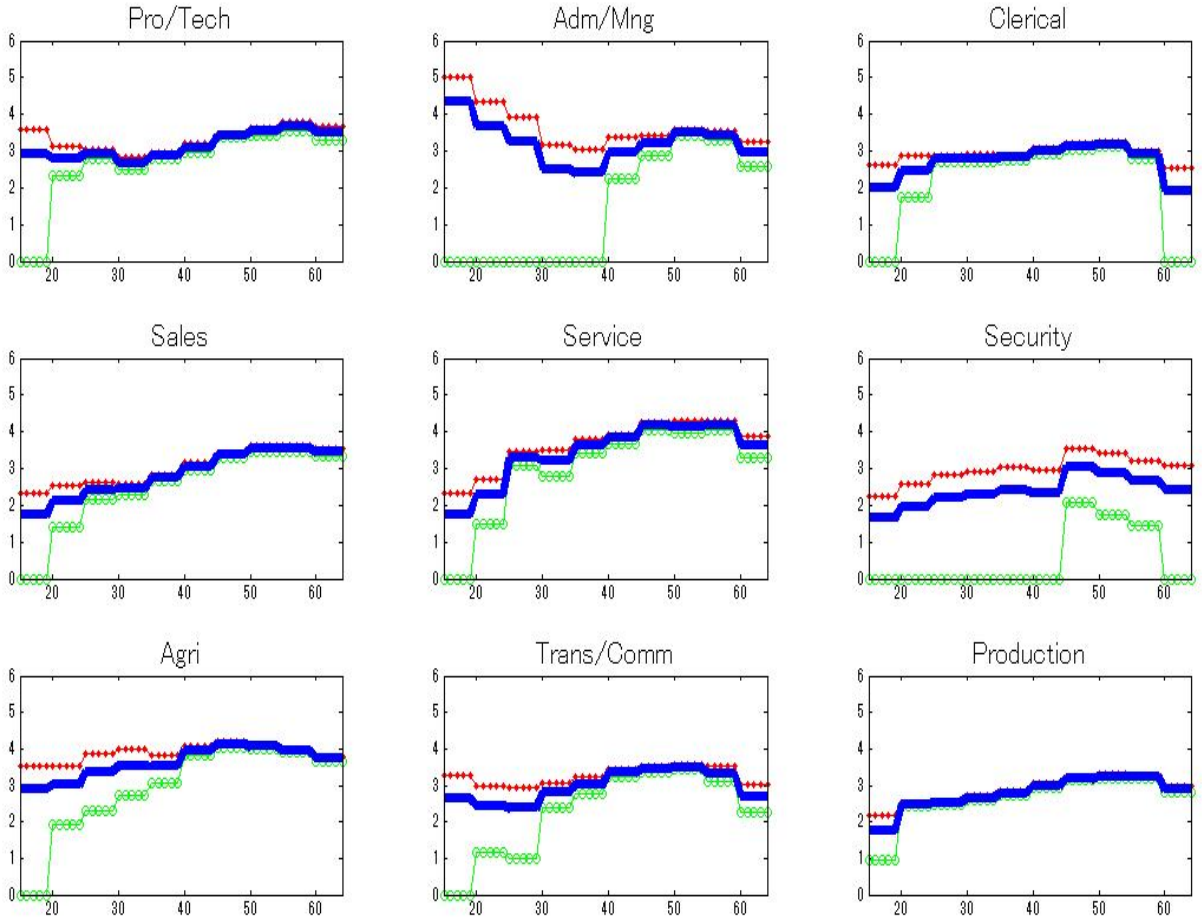


Figure 3: The wave-averages of occupation-specific prefecture-averaged suicide rates (red dotted), prefecture-medianed suicide rates (blue circled), and their $1/2, 1/2$ averages (green starred) for males and for 9 occupations. All numbers are subject to $\ln(1+x)$ transformation. Note that the blue circled lines for several occupations stick to the horizontal axis, indicating that for some 5-year age intervals, there are very few positive suicide rates are recorded over 47 prefectures. The red dotted lines for prefecture-averages are always above the blue-circled prefecture-medians, indicating very strong left-skewed distributions. The green starred lines are the arithmetic averages of these mean-based and median-based suicide rates, to alleviate the sensitivity of averages to big positive outliers and of medians to many zeros.

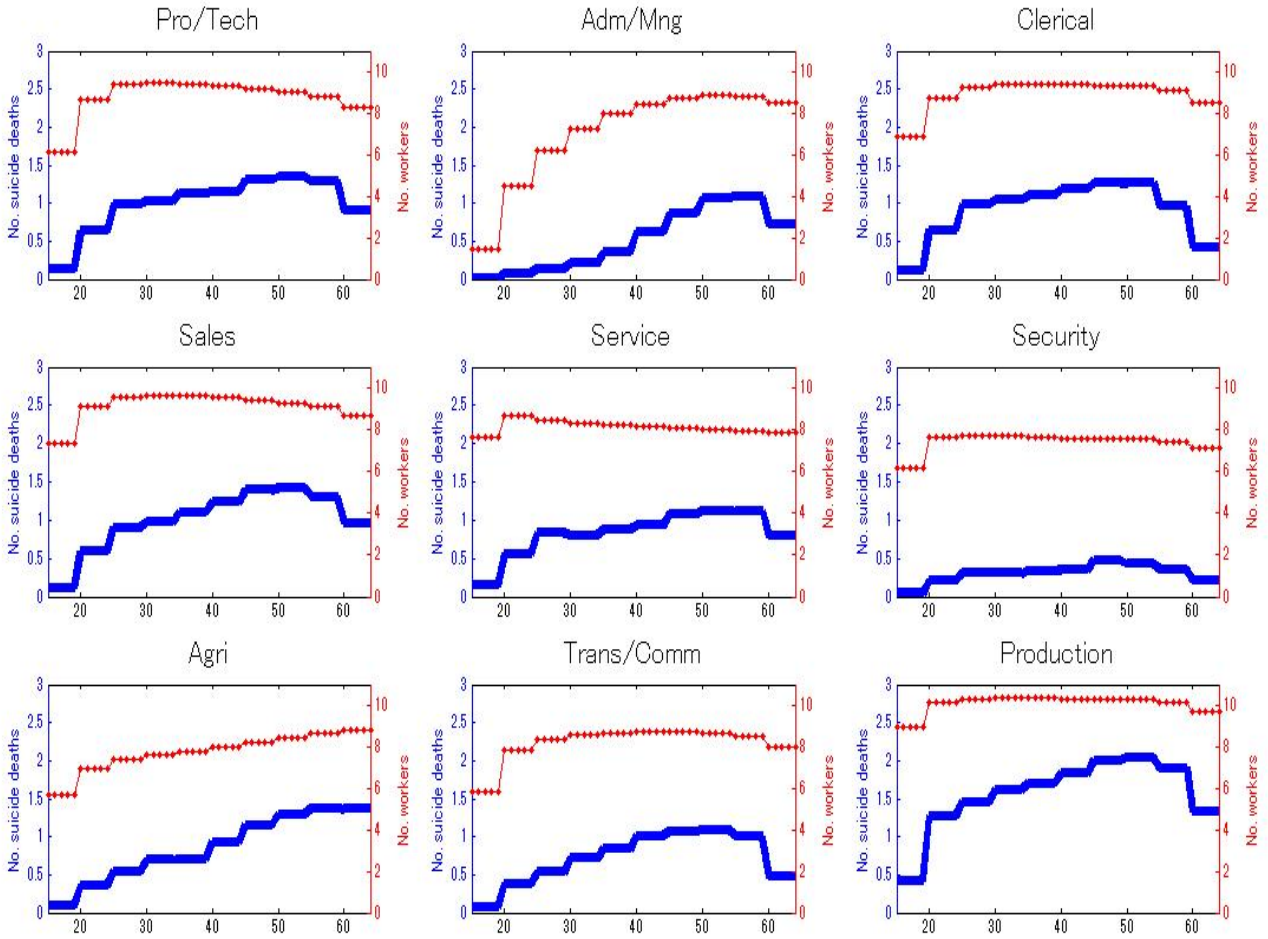


Figure 4: The wave-averages of occupation-specific size of population of male workers in each stratum (blue thick) in the left axis and the number of suicide deaths (red dotted) in the right axis. Both numbers are transformed by $\ln(1+x)$.

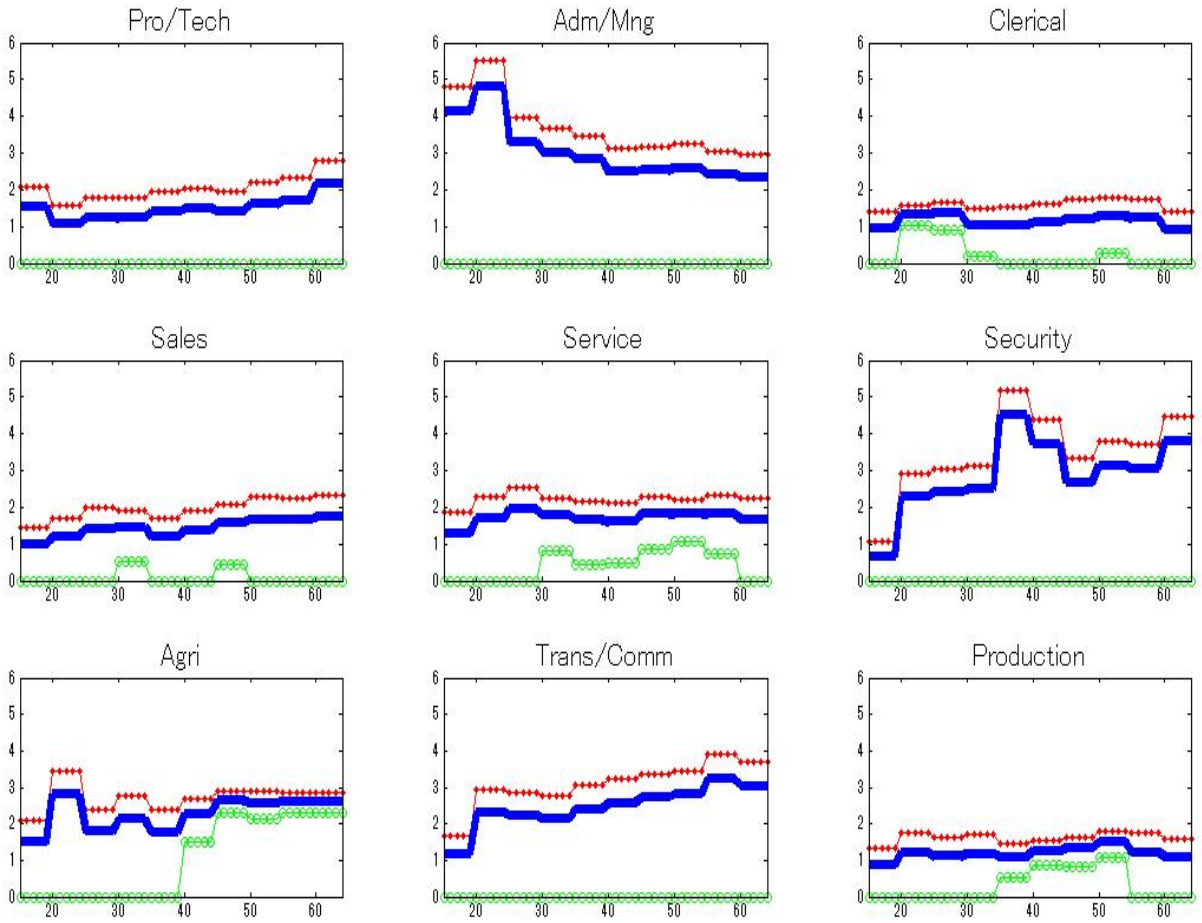


Figure 5: The wave-averages of occupation-specific prefecture-averaged suicide rates (red dotted), prefecture-medianed suicide rates (blue circled), and their $1/2, 1/2$ averages (green starred) for females and for 9 occupations. All numbers are subject to $\ln(1+x)$ transformation. Note that the blue circled lines for several occupations stick to the horizontal axis, indicating that for some 5-year age intervals, there are very few positive suicide rates are recorded over 47 prefectures. The red dotted lines for prefecture-averages are always above the blue-circled prefecture-medians, indicating very strong left-skewed distributions. The green starred lines are the arithmetic averages of these mean-based and median-based suicide rates, to alleviate the sensitivity of averages to big positive outliers and of medians to many zeros.

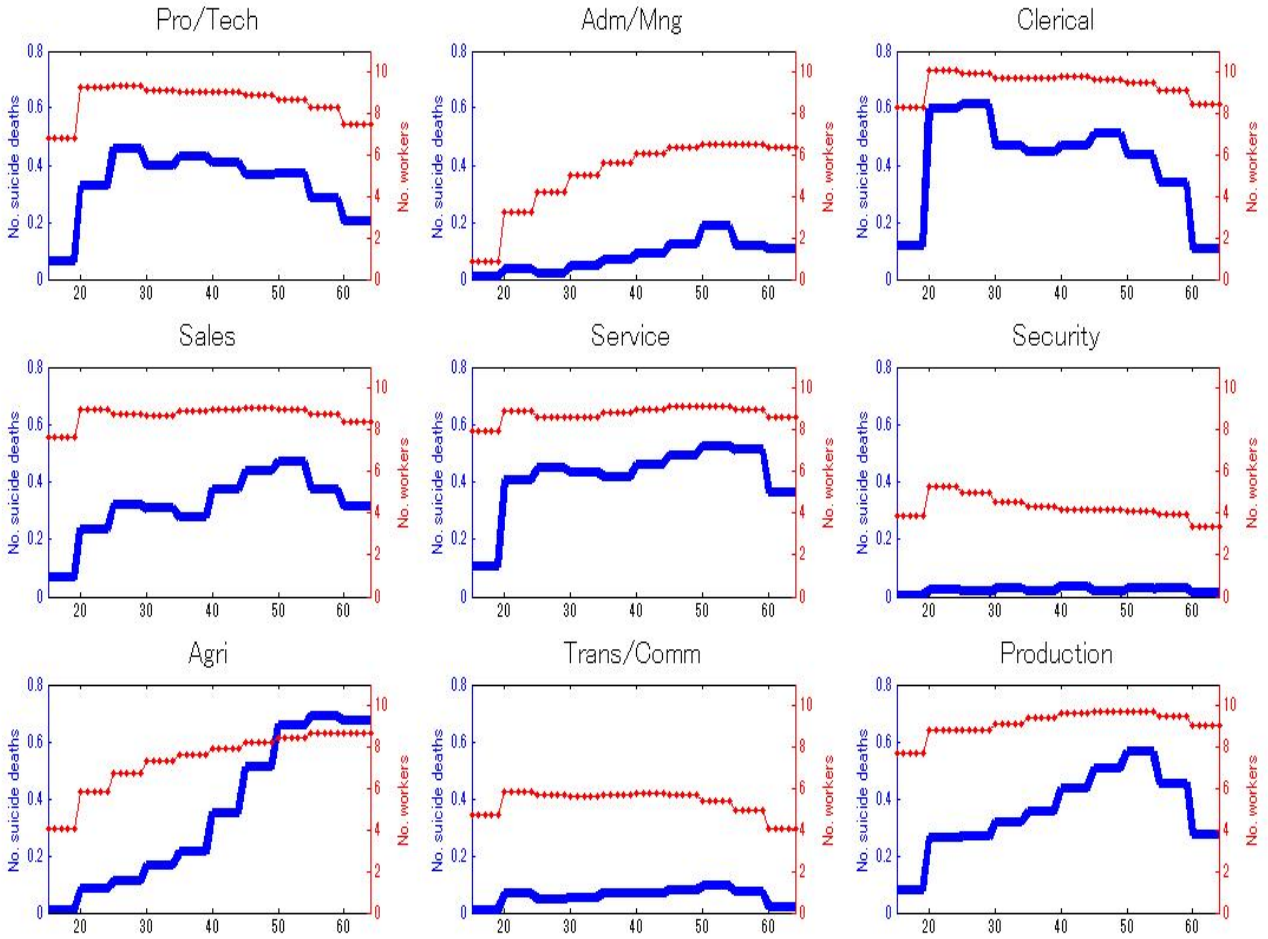


Figure 6: The wave-averages of occupation-specific size of population of female workers in each stratum (blue thick) in the left axis and the number of suicide deaths (red dotted) in the right axis. Both numbers are transformed by $\ln(1+x)$.

Table 3: Comparisons of various age-adjusted suicide rates

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
						Mean (males)				
crude	26.21	28.50	18.58	21.70	42.26	19.86	46.33	26.98	18.36	59.15
direct	28.30	44.91	16.97	21.31	42.33	18.48	48.16	25.30	17.22	130.15
indirect	25.96	23.10	18.29	21.53	44.16	19.92	37.63	25.46	18.34	62.38
ind_{MM}	25.48	22.81	18.05	20.96	43.56	19.90	37.93	25.32	18.00	62.38
ind_{LL}	24.63	27.32	18.07	20.17	39.94	19.14	46.90	26.55	17.93	58.80
						Stdev (males)				
crude	10.07	13.69	7.53	9.34	17.27	13.75	15.65	11.03	5.73	10.31
direct	15.58	132.45	9.07	9.34	17.72	14.27	23.74	17.80	5.84	25.78
indirect	9.81	11.10	7.41	9.21	17.84	13.85	12.78	10.33	5.74	9.88
ind_{MM}	5.64	3.10	2.39	5.33	5.39	6.56	6.37	4.99	3.71	5.65
ind_{LL}	6.19	7.01	3.95	6.03	8.84	4.86	9.98	4.91	4.28	5.99
						Mean (females)				
crude	6.22	23.33	4.06	6.96	8.80	33.74	17.73	26.54	4.33	22.42
direct	9.29	57.08	5.38	6.94	9.04	121.86	16.40	161.57	4.63	21.90
indirect	8.09	20.28	5.39	7.54	10.00	48.29	14.28	33.19	4.87	19.31
ind_{MM}	8.09	20.50	5.36	7.47	9.92	48.28	14.35	33.94	4.86	19.28
ind_{LL}	6.29	22.43	4.03	6.63	8.49	23.11	17.82	25.05	4.30	21.84
						Stdev (females)				
crude	4.02	30.04	2.45	4.46	4.81	93.11	9.02	43.56	2.42	5.53
direct	9.66	182.84	6.10	4.51	5.61	473.94	18.80	800.25	3.19	4.92
indirect	5.24	26.14	3.26	4.72	5.46	134.57	7.33	54.37	2.73	4.11
ind_{MM}	2.29	6.42	1.17	1.54	2.01	5.42	2.81	7.89	1.82	2.93
ind_{LL}	1.75	9.18	0.98	1.62	2.05	19.19	4.42	13.68	1.02	3.80

Notes:

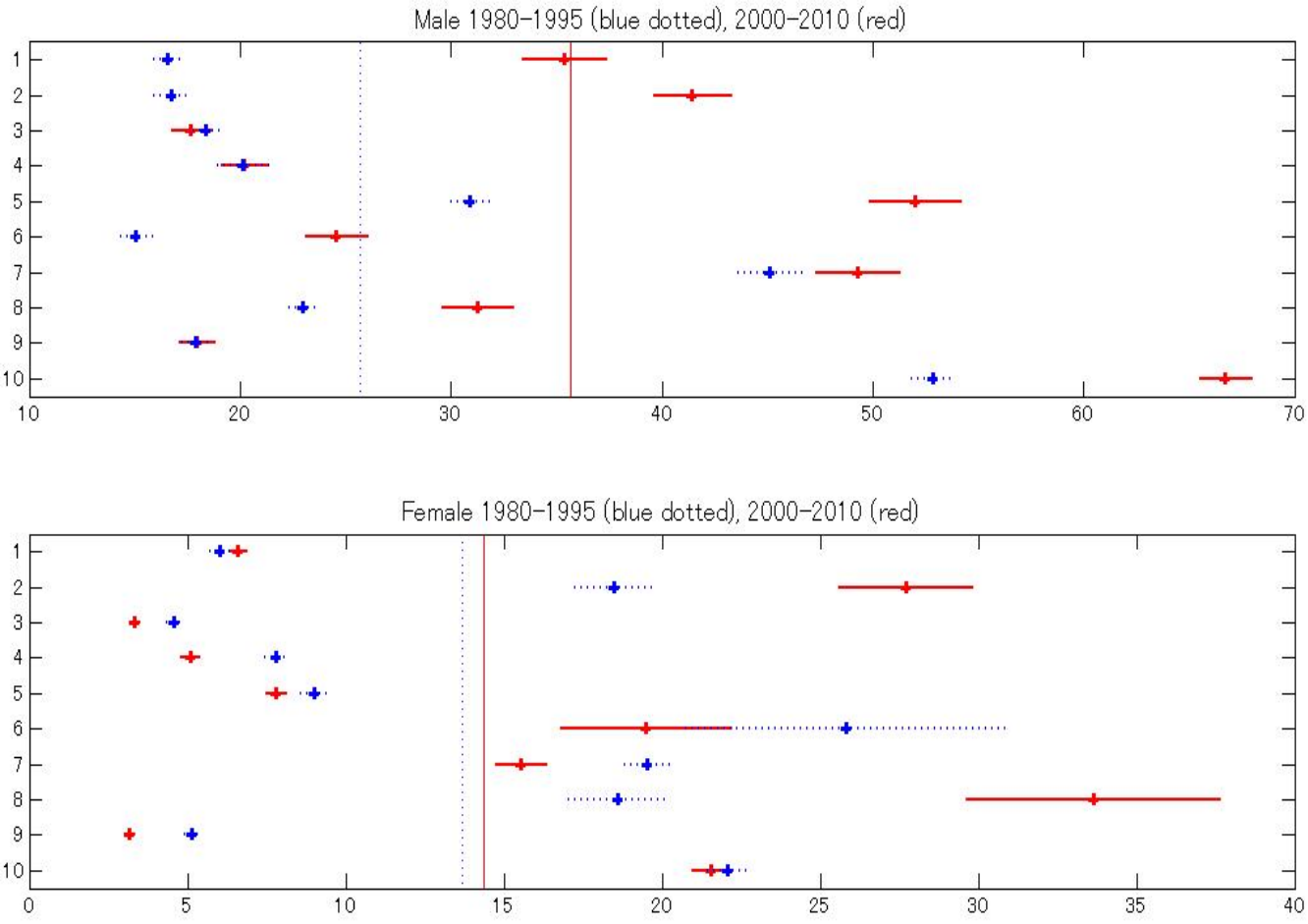


Figure 7: The occupation-wise means, the 95% confidence intervals of occupation-specific age-adjusted Bayesian filtered suicide rates, and their means over occupations (vertical partitions): males (top), females (bottom), pre-1998 (blue dotted), and post-1998 (red real).

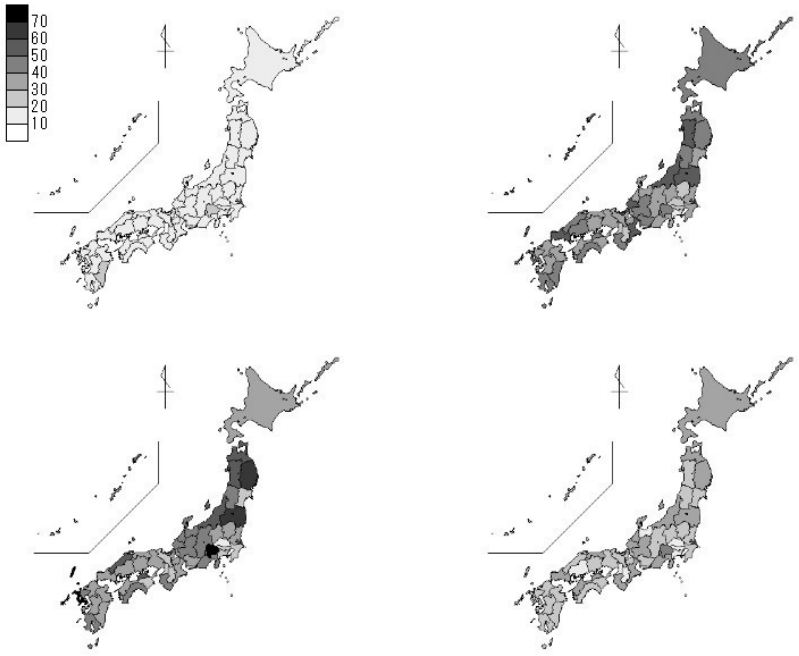


Figure 8: The prefecture-level age-adjusted suicide rates of male Specialist and technical (Spec/Tech) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

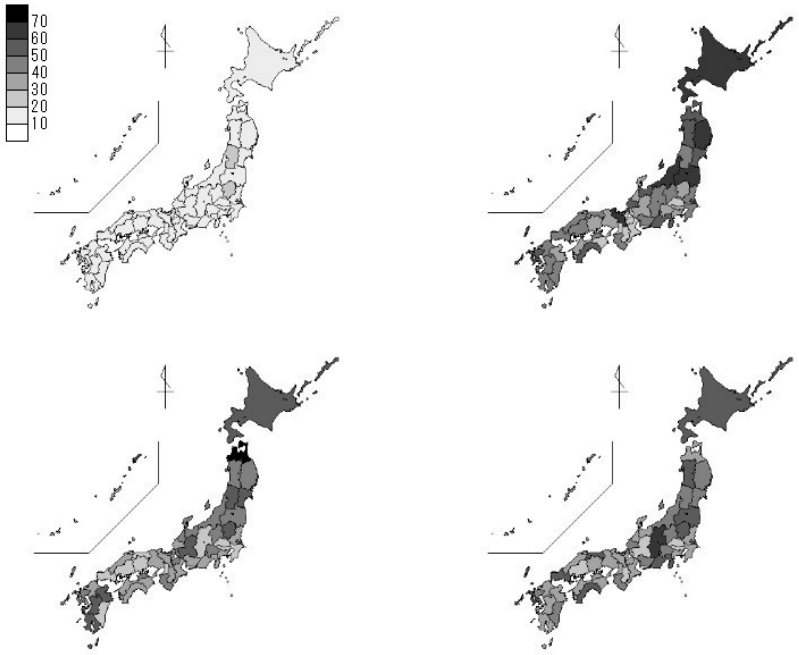


Figure 9: The prefecture-level age-adjusted suicide rates of male administrative and Managerial (Adm/Mng) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

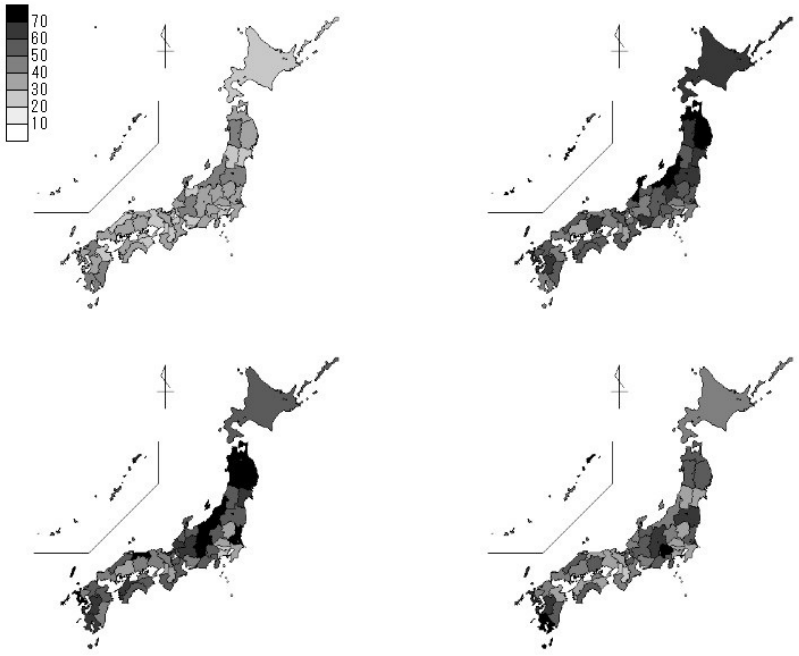


Figure 10: The prefecture-level age-adjusted suicide rates of male Service workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

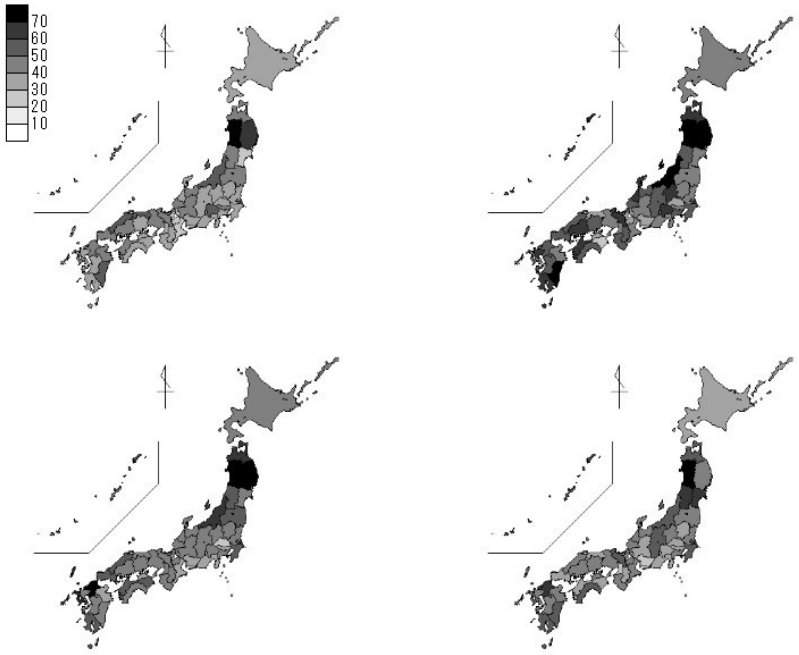


Figure 11: The prefecture-level age-adjusted suicide rates of male agriculture, forestry and fishery (Agri) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

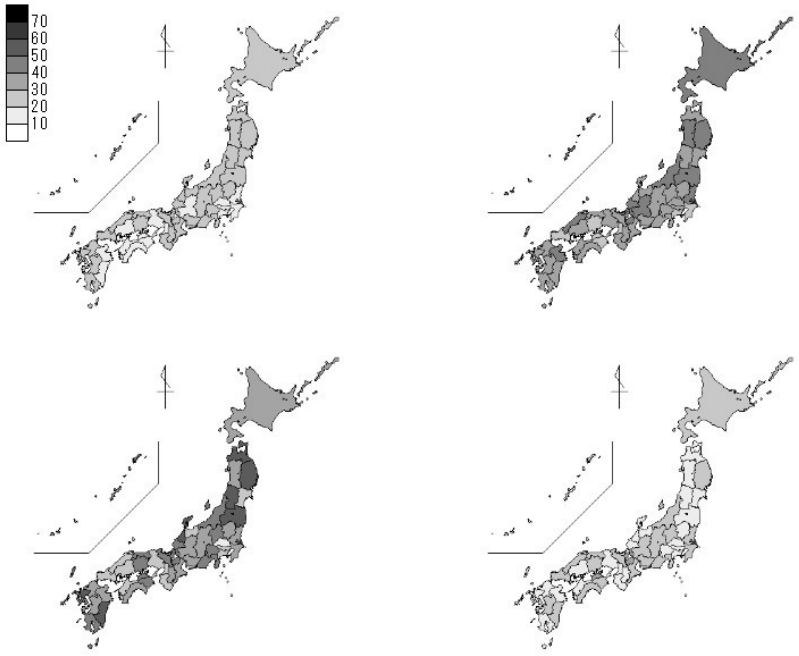


Figure 12: The prefecture-level age-adjusted suicide rates of male transport and communication (Transport) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

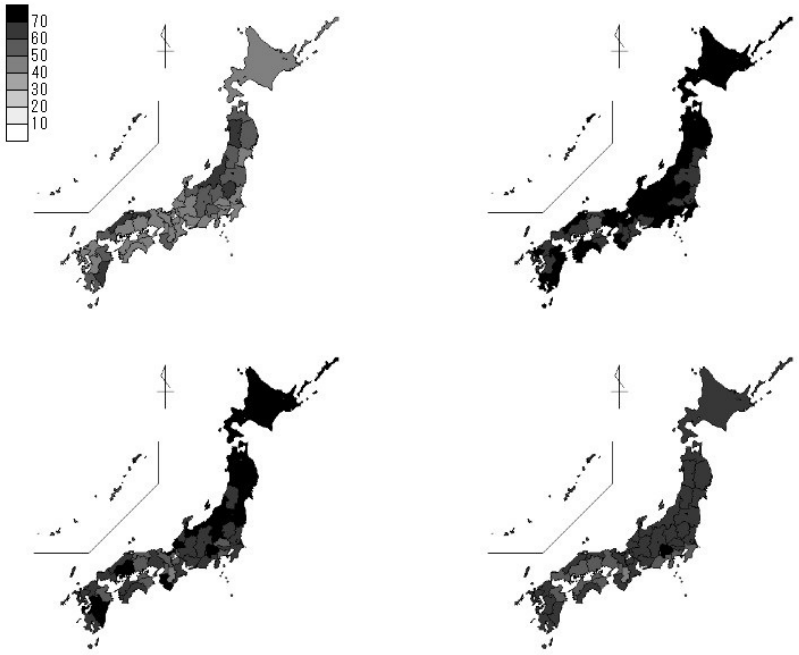


Figure 13: The prefecture-level age-adjusted suicide rates of male jobless persons, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

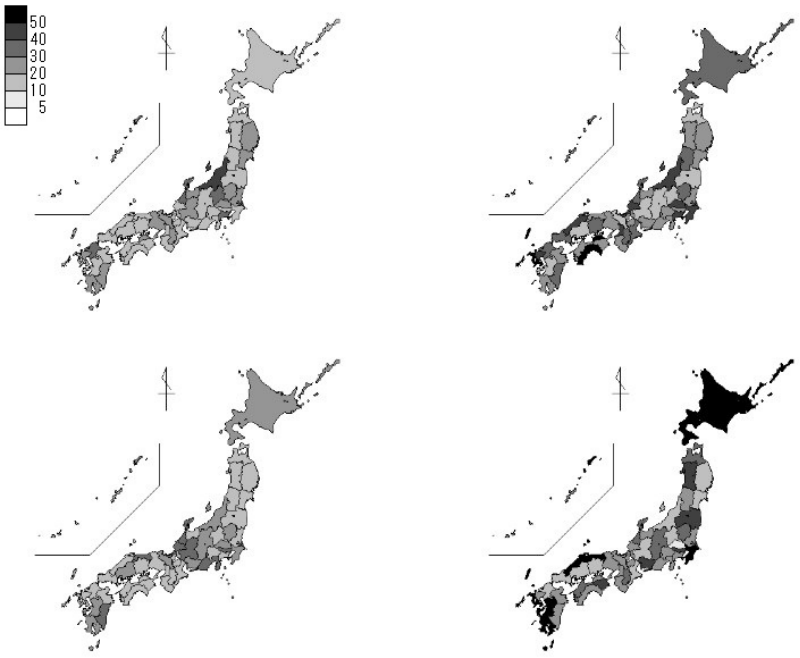


Figure 14: The prefecture-level age-adjusted suicide rates of female administrative and managerial (Adm/Mng) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

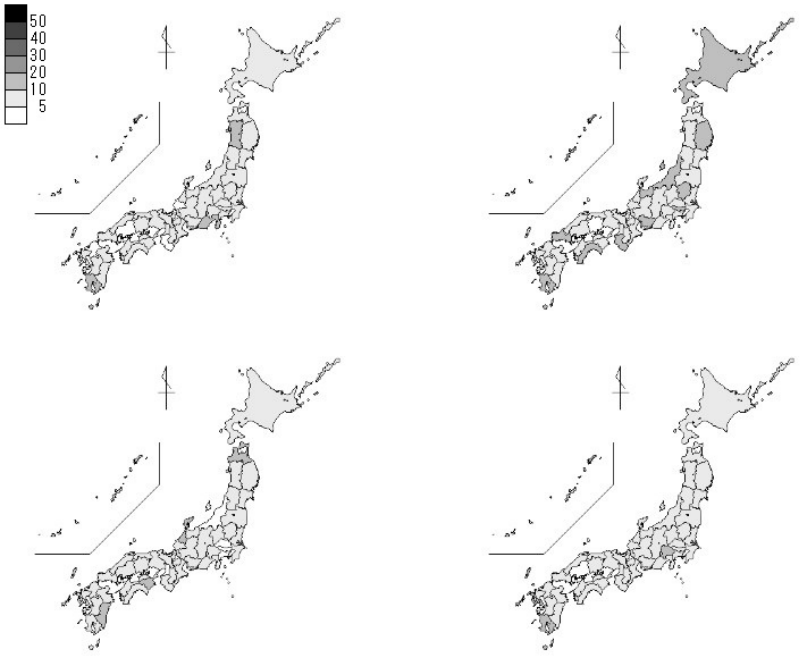


Figure 15: The prefecture-level age-adjusted suicide rates of female Service workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

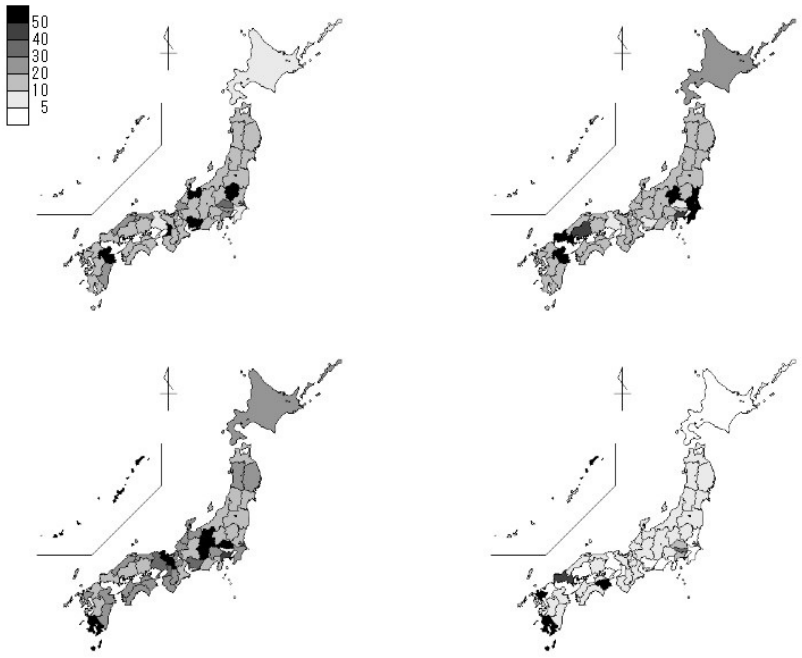


Figure 16: The prefecture-level age-adjusted suicide rates of female Security workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

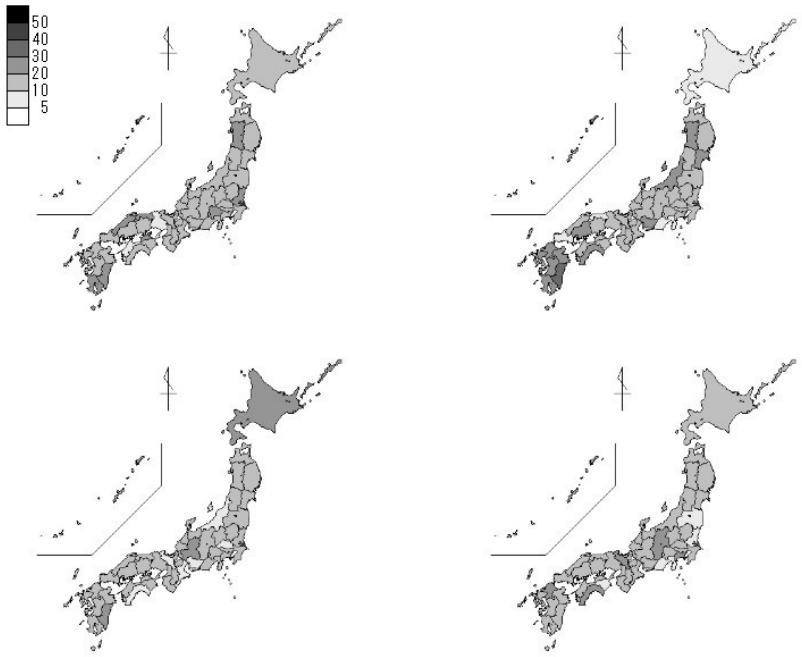


Figure 17: The prefecture-level age-adjusted suicide rates of females for agriculture, forestry and fishery (Agri) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

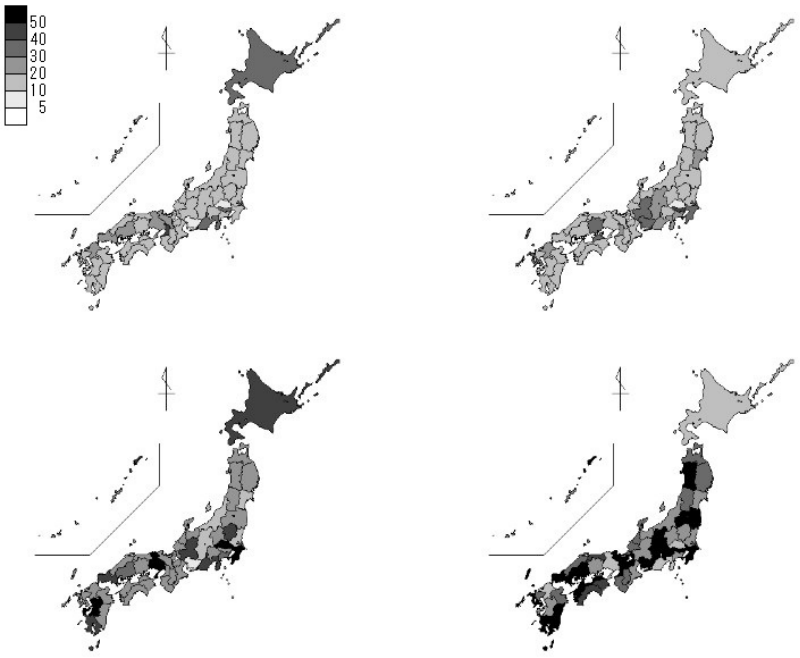


Figure 18: The prefecture-level age-adjusted suicide rates of females for transport and communication (Trans) workers, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).

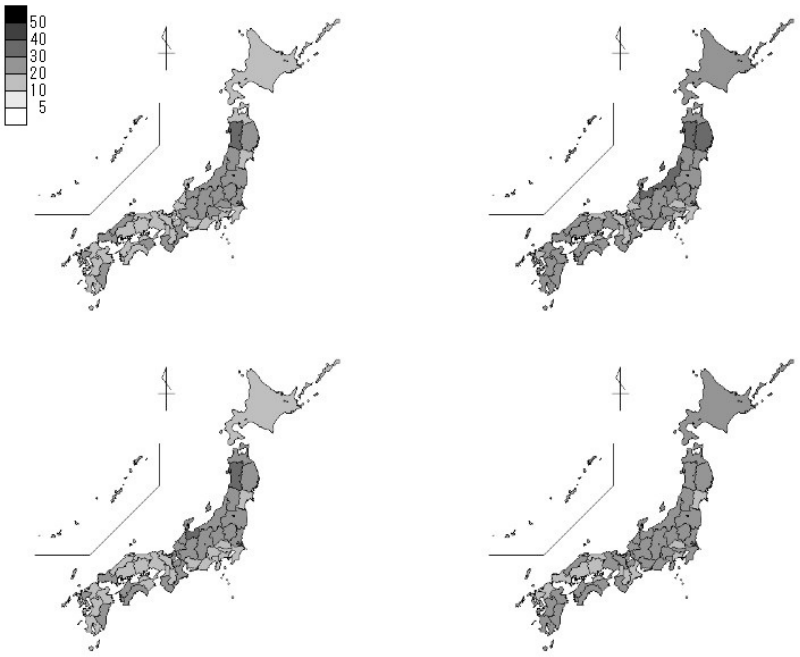


Figure 19: The prefecture-level age-adjusted suicide rates of female jobless persons, 1995 (NW), 2000 (NE), 2005 (SW), 2010 (SE).