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Spatial analysis of subjective well-being in Japan

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Abstract

This study investigates subjective well-being in Japan using a survey of 22,539 respondents in 46 prefectures in December 2019. We applied a Bayesian hierarchical model to the self-reported well-being respondents, supposing that well-being is decomposed into regional and individual factors. As a result, regional heteroscedasticity and individual factors are identified jointly, which clarifies the interesting features of Japanese subjective well-being. From the identified regional factors in prefectural levels, we find that coastal areas damaged by the 2011 tsunami and nuclear plant accidents have the lowest subjective well-being. This finding suggests that residents in the regions have not recovered and require additional mental and physical public support.

Keywords: Bayesian hierarchical model, Great East Japan Earthquake and Tsunami, Happiness survey, Regional heteroscedasticity, Spatial error model, Subjective well-being

1 Introduction

For the last century, subjective well-being (or happiness) has been extensively investigated across social sciences. Various studies in economics have identified factors associated with happiness. Existing happiness studies are summarised in the following paragraphs.

Several happiness studies have focused on the effects of socio-demographics on individual happiness, such as (i) age (Oswald, 1997), (ii) marital status (Helliwell, 2003; Blanchflower and Oswald, 2004), (iii) health (Graham et al., 2009). When viewed as a function of age, ageing and well-being for men and women have a U-shaped relationship, with a minimum in late middle age (Clark and Oswald, 1996).

Figure 2 shows a typical shape. Several countries have shown similar patterns (Oswald, 1997; Gerdtham and Johannesson, 2001). Helliwell (2003) noted that marriage is positively related to subjective well-being,

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whereas being single is evaluated as a more serious negative factor than being divorced or widowed. The potential influence of physical functioning on mental factors and the positive effects of physical health on well-being are widely acknowledged (Rasciute and Downward, 2010).

Numerous studies (Clark and Oswald (1994); Gerlach and Stephan (1996); Gerdtham and Johannesson (2001)) describe the relationship between economic factors and happiness. The discussion about income and happiness has become a controversial topic ever since Richard Easterlin published his work titled *Does Economic Growth Improve the Human Lot?* (Easterlin, 1974)). He found that income has a diminishing effect on happiness, namely, income does not improve happiness when it exceeds a threshold. In related studies on unemployment effects on happiness, unemployment is believed to be a serious negative factor of happiness (Ohtake, 2004; Winkelmann, 2014).

Happiness has a systematic relationship with regional and individual characteristics. Tella et al. (2003) revealed that macroeconomic factors, such as GDP per capita and unemployment rate, impact Europeans' well-being. Deaton (2008) used the Gallup World Poll to demonstrate a positive relationship between per capita income and happiness, showing that rich countries have high average scores of happiness.

A geographical analysis of happiness has been attracting attention recently. The first law of geography states that, 'everything is related to everything else, but near things are more related than distant things' (Tobler, 1970). Residents in a region are expected to have similar socio-economic, political and cultural environments that contribute to their well-being. Moreover, the social comparison mechanism shows that people are likely to compare themselves with other people in neighbouring areas, especially those who are close to them. Furthermore, a region's happiness determinants are likely to be similar to those of neighbouring regions. Therefore, evidence supports the claim that happiness is spatially dependent.

Okulicz-Kozaryn (2011) argued that people across European regions exhibit substantial regional similarity in happiness and that happiness and its determinants are spatially correlated. Stanca (2010) applied a two-step method to the World Values Survey (WVS) and found that ignorance of geographical factors may result in bias in understanding happiness. Pierewan and Tampubolon (2014) applied a hierarchical model that regards happiness as a spatially dependent latent variable. Using this model, they checked how happiness in an area in Europe is affected by its surrounding areas. They concluded that happiness is spatially dependent through unobserved factors, implying that clusters of happiness are often observed.

This study conducts a geographical and individual analysis of happiness in Japan through a survey conducted in December 2019 with 22,539 respondents. We extend Pierewan and Tampubolon (2014)'s hierarchical model to describe spatial behaviours accurately. Happiness is the sum of regional and individual factors. Regional factors are given by a spatial regression with prefectural-level independent variables, such as social welfare expenditure (SWEs) and prefectural income, whereas individual factors are given by a regression with several individual characteristics, such as age, sex and income. Regarding the model as a Bayesian hierarchical model, we employ the so-called empirical Bayesian approach to examine happiness features in Japan.

The contributions of this paper are summarised in two points. First, we develop a spatial model that can examine individual and regional components of happiness jointly by extending Pierewan and Tampubolon (2014)'s model. We express spatial factors by a regression model with errors following spatial autoregression, whereas Pierewan and Tampubolon (2014) constructed a spatial autoregression only without regressors. SWE per capita and ratio of forest area (RFA) in each prefecture will be used as the regressors, significantly improving our study's spatial factor evaluation. Second, the identified regional happiness detects severely low scores in the coastal areas hit by the 2011 Great East Japan Earthquake and Tsunami. We will discuss how the natural disaster and subsequent nuclear plant accidents have been affecting life in the areas in terms of subjective well-being by referring to several existing studies and our identified geographical distributions of happiness.

The remainder of this paper is organised as follows. Section 2 introduces in details Macromill Co., LTD's survey and the obtained individual-level dataset, including prefectural-level dataset obtained from e-Stat database. Section 3 provides details of the hierarchical model for the individual and prefectural-level datasets. Section 4 examines the identified results, and Section 5 discusses the results in comparison with those of existing studies. Finally, Section 6 presents a concluding remark.

2 Data and Methods

This section introduces the dataset together with an analytic strategy to conduct a spatial analysis of happiness in Japan. We mainly aim to detect regional characteristics by applying a spatial econometric model to survey data on happiness for 22,539 respondents from all over Japan, except Okinawa.

2.1 Data

We confided the happiness survey in this paper to Macromill Co., LTD [1], a market research company in Japan, by which happiness for 22,539 respondents from all over Japan, except for Okinawa, was surveyed, including several demographic information of gender, age, marital status, education level, number of children, personal and family incomes, occupation status and health conditions. The happiness survey was conducted in December 2019 for respondents in Japan. They were recruited online for an approximate correspondence of the distribution of gender, age, residential place of prefecture and income to those of the national population census.

Happiness was recorded in the survey as a response to the question, *'Currently, how happy do you feel? Score the degree of your happiness between 10 (very happy) and 1 (very unhappy).'* Figure 1 shows the histogram of the happiness survey measured in the 1–10 scale. The distribution is left-skewed, with the mean and standard deviation evaluated as 6.290 and 1.951, respectively.

Table 1 summarises the respondents' demographic information. In addition, Table 2 lists the size of respondents in each prefecture with the three prefectural-level variables of SWE per capita, gross prefectural domestic product per capita (GPP) and RFA. These variables were collected from e-Stat database in Japan [2]. Prefectural-level information will be used to identify regional heteroscedasticity.

Then, let us introduce the details on how the demographic information is summarised as category variables

[1] https://www.macromill.com/
[2] https://www.e-stat.go.jp/

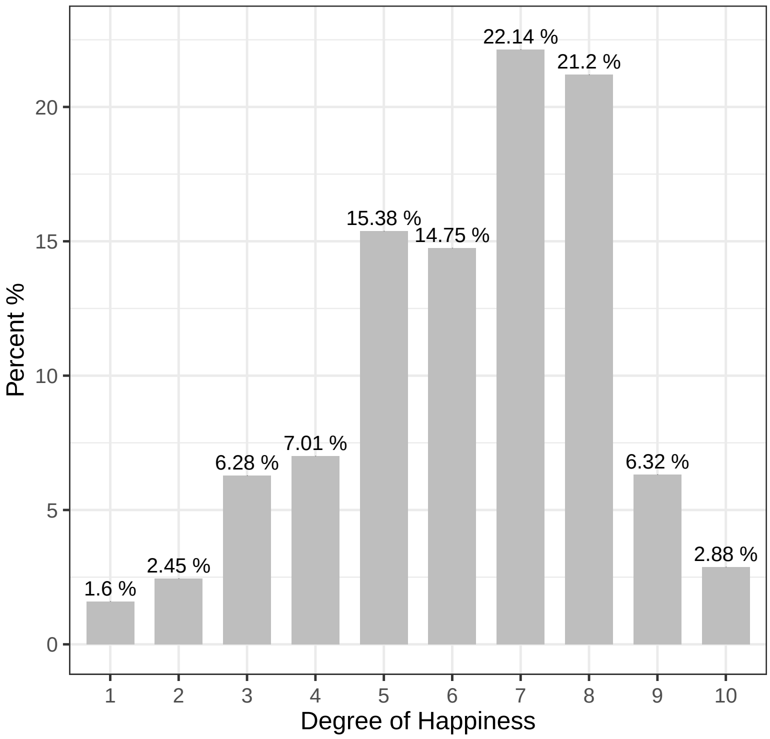

Figure 1: Histogram of responses of 22,539 samples to the question: *'Currently, how happy do you feel? Score the degree of your happiness between 10 (very happy) and 1 (very unhappy).'*

that will be incorporated as independent variables. We use age and gender to construct the categories of 22 groups, namely we divide all the respondents into two groups of female and male, each of which is categorised as 11 mutually disjoint subgroups corresponding to (1) age<20, (2)<25, (3)<30, . . . ,(10)<65 and (11)≥65.

As a result, we obtain 22 disjoint groups and define the group of female with age younger than 20 as the base group. Personal income is categorised into seven mutually disjoint groups of income, *i.e.* (1)<2 million yen, (2)<4 million, (3)<6 million, (4)<8 million, (5)<10 million, (6)<12 million and (7)≥12 million yen. The group less than 2 million yen is set as the base. Family income is categorised into 10 groups of income, *i.e.* (1)<2 million yen, (2)<4 million, (3)<6 million, (4)<8 million, (5)<10 million, (6)<12 million, (7)<15 million, (8)<20 million, (9)≥20 million yen and (10) as the group of no response. The group less than 2 million yen is set as the base. As a result, personal and family incomes are the categorical variables with 7 and 10 subgroups, respectively. Number of child is summarised as the dummy variable that is 1 for positive number of children and 0 otherwise. Marital status is recorded as the category variable with five groups of (1) single, (2) married male, (3) married female (full-time), (4) married female (part-time) and (5) married female (housewife). The single group is set as the base. Occupation status is categorised into 11 disjoint groups, *i.e.* (1) civil servant, (2) manager, (3) employed(office), (4) employed(engineer), (5) employed(others), (6) self-employed, (7) freelancer, (8) part-timer, (9) student, (10) others and (11) unemployed. The unemployed group is set as the base. Health condition is summarised into five dummy variables corresponding with a response to the binary questions on drinking, smoking, diabetes, hypertension and hyperlipidaemia. Education level categorised into five groups of

(1) junior school, (2) high school, (3) junior college, (4) university and (5) graduate school. The junior school is set as the base category.

2.2 Analytic strategy

For the demographics of $\boldsymbol{x}_i$ as the independent variables *i.e.* age, gender, income etc., as stated above, the usual model for happiness y_i of 1–10 scale for ith respondent is a regression given by

$$y_i = d + \boldsymbol{x}_i'\beta + \varepsilon_i, i = 1, \ldots, N,$$

where d is the intercept and ε_i is an error sequence of independently and normally distributed random variables with mean 0 and variance σ_ε^2. Let us extend the regression to a spatial model detecting regional variations which are not accounted for by the demographics. Denoting happiness for ith respondent residing in jth prefecture, we extend the regression to a hierarchical one by

$$y_{ij} = d_j + \boldsymbol{x}_i'\beta + \varepsilon_i, i = 1, \ldots, n_j, j = 1, \ldots, p = 46, \tag{1}$$

where d_j is a latent variable in jth prefecture that follows a prefectural-level regression

$$d_j = z_j'\delta + u_j, j = 1, \ldots, p = 46, \tag{2}$$

and z_j is the prefectural-level variables of SWE, GPP and RFA. To express a spatial similarity of the regional variations in d_j, we fit a spatial autoregression (SAR) to u_j, given by

$$\begin{aligned} u_j &= \rho \sum_{j=1}^{p} w_{jk} u_k + f_j, j = 1, \ldots, p = 46, \\ f_j &\sim N(0, \sigma_f^2), \end{aligned} \tag{3}$$

where w_{ij} is the first contiguity weight matrix playing a key role in spatial analysis, which is defined by

$$w_{jk} = \begin{cases} 1, & \text{if prefectures } j \text{ and } k \text{ are neighbors sharing a boarder} \\ 0, & \text{otherwise} \end{cases},$$

where $j, k = 1, \ldots, p = 46$. The diagonal elements of w_{jj} are designed to be 0. ρ in Equation (3), which needs to be in $(-1, 1)$ by the stationary condition, is the parameter that controls a strength of spatial correlation of u_j. The spatial correlation is higher when ρ is close to 1.

To account for happiness relative to the demographics and regional variables, our model in Equations (1)-(3) can be regarded as a Bayesian hierarchical model. Parameter d_j for the regional variation in Equation (1) has priors described in Equation (2), whereas β is supposed to have no priors, for which we assume a Gaussian distribution with mean 0 and precision matrix 0. Fixing the hyperparameters ρ, δ and σ_f^2 to describe the priors of

d_j, we will evaluate the posteriors d_j and β through Bayes' formula. We will specify the hyperparameters ρ, δ and σ_f^2 by the so-called empirical Bayesian approach, where they are specified to maximise the marginal likelihood given by marginalising out d_j in Equation (1).

We introduce the empirical Bayesian approach in two steps. First, the hyperparameters ρ, δ and σ_f^2 in Equation (2) are specified to maximise the marginal likelihood. Second, the posteriors of d_j and β in Equation (1) are evaluate through Bayes' formula. Our model in Equations (1)-(3) can be expressed conveniently in a matrix form. Let n and m be the sizes of respondents and prefectures, respectively. Let J be the n by m matrix to express the categorical variable of prefectures. For the ith row in J, jth column is 1 if i resides in jth prefecture and 0 otherwise. Arranging y_{ij}, x_i, z_j, d_j. ε_i, u_j and f_j into the suitable vectors or matrices, we obtain the matrix expression for our model by

$$\begin{aligned} \boldsymbol{Y} &= \boldsymbol{X\beta} + \boldsymbol{Jd} + \boldsymbol{\varepsilon}, \\ \boldsymbol{d} &= \boldsymbol{Z\delta} + \boldsymbol{u}, \\ \boldsymbol{u} &= \rho \boldsymbol{W u} + \boldsymbol{f}. \end{aligned} \tag{4}$$

Let us start from the selection of the hyperparameters to maximise the marginal likelihood of $\boldsymbol{Y}$ that margins out d_j in Equation (1 through Equation (2). The marginal distribution substituting d_j in Equation (1) with that in Equation (2) is

$$N\left(X\beta + JZ\delta, \sigma_\varepsilon^2 I_n + \sigma_f^2 JR(\rho)J'\right),$$

where

$$R^{-1}(\rho) = (I_m - \rho W)'(I_m - \rho W).$$

Reexpressing the variance matrix, for $\tau = \sigma_\varepsilon^2/\sigma_f^2$, as

$$\sigma_\varepsilon^2 \left\{\boldsymbol{I}_n + \tau \boldsymbol{J} R(\rho) \boldsymbol{J}'\right\} = \sigma_\varepsilon^2 \Omega(\rho, \tau), say,$$

we have the marginal log-likelihood function given by

$$\log L(\tilde{\beta}, \sigma_\varepsilon^2, \rho, \tau) = -\frac{n}{2}\log(2\pi\sigma_\varepsilon^2) - \frac{1}{2}\log|\Omega(\rho,\tau)| - \frac{(\boldsymbol{Y} - \tilde{X}\tilde{\beta})'\Omega^{-1}(\rho,\tau)(\boldsymbol{Y} - \tilde{X}\tilde{\beta})}{2\sigma_\varepsilon^2}, \tag{5}$$

where $\tilde{X} = (X, \boldsymbol{JZ})$, $\tilde{\beta} = (\boldsymbol{\beta}', \boldsymbol{\delta}')'$. Solving the first-order conditions with respect to β and σ_ε^2, we obtain

$$\begin{aligned} \tilde{\beta}(\rho,\tau) &= \left\{\tilde{X}'\Omega^{-1}(\rho,\tau)\tilde{X}\right\}^{-1} \tilde{X}'\Omega^{-1}(\rho,\tau)\boldsymbol{Y}, \\ \sigma_\varepsilon^2(\rho,\tau) &= \frac{1}{n}\left\{\boldsymbol{Y} - \tilde{X}\tilde{\beta}(\rho,\tau)\right\}'\Omega^{-1}(\rho,\tau)\left\{\boldsymbol{Y} - \tilde{X}\tilde{\beta}(\rho,\tau)\right\}. \end{aligned} \tag{6}$$

Substituting $\tilde{\beta}(\rho,\tau)$ and $\sigma_\varepsilon^2(\rho,\tau)$ into the corresponding ones in Equation (5), we obtain the concentrated marginal log-likelihood function,

$$\log L(\rho,\tau) = -\frac{n}{2}(\log(2\pi)+1) - \frac{n}{2}\log(\sigma_\varepsilon^2(\rho,\tau)) - \frac{1}{2}\log|\Omega(\rho,\tau)|.$$

We estimate ρ, τ to maximise the concentrated marginal log-likelihood function and then evaluates the estimators for $\tilde{\beta} = (\beta', \delta')'$ and σ_ε^2 through Equation (6). Then, we evaluate the posteriors of d_j and β in Equation (4) from the priors specified with the hyperparameters $\rho, \tau, \delta, and\sigma_\varepsilon^2$, which were estimated in the first step to maximise the marginal likelihood. The prior for d_j is specified as

$$N\left(Z\delta, \sigma_f^2 R^{-1}(\rho)\right),$$

whereas that of β is the non-informative prior specified by the normal distribution with mean 0 and precision 0 independent of d_j. Thus, the prior precision of $\theta = (d_1, \ldots, d_m, \beta')'$ is

$$diag(\sigma_f^{-2}R(\rho), 0_q) = \sigma_\varepsilon^{-2} diag(\tau^{-1}R(\rho), 0_q) = \sigma_\varepsilon^{-2} S_0(\rho,\tau), say,$$

where 0_q is the q by q 0 matrix with q given by the dimension of β. Applying the Bayes' formula to Equation (4), we obtain the posterior of $\theta = (d_1, \ldots, d_m, \beta')'$ given by the normal distribution with the variance and mean evaluated for $K = (J, X)$,

$$\sigma_\varepsilon^2 \bigg(K'K + S_0(\rho,\tau)\bigg)^{-1} = \sigma_\varepsilon^2 \boldsymbol{S}_1, say, \tag{7}$$

and

$$\boldsymbol{S}_1 \bigg(K'\boldsymbol{Y} + \tau^{-1}R(\rho)Z\delta\bigg), \tag{8}$$

respectively.

The estimators of the hyperparameters ρ, δ, σ_f^2 and σ_ε^2 are consistent and asymptotically normal under certain mild conditions to maximise the marginal likelihood in Equation (5). See Sato and Matsuda (2021) for details of the conditions and proof. The condition justifies asymptotically our choice of the hyperparameters and hence the t tests for β, δ through Equations(7) and (8), which shall be employed in the empirical analysis in the next section.

3 Empirical Results

Table 3 presents the estimation results by fitting the model in Equations (1) and (2) to the happiness survey data described in Section 2.1. The results are introduced in two parts. the effects of individual characteristics on happiness for β in Equation (1) and the regional variations of happiness for d_j together with ρ in Equations (2) and (3). See Section 2.1 for the details of the individual characteristics summarised as category variables.

3.1 Individual characteristics

Figure 2 below shows the estimated partial effects of gender and age. The figure shows a typical U-shaped curve;

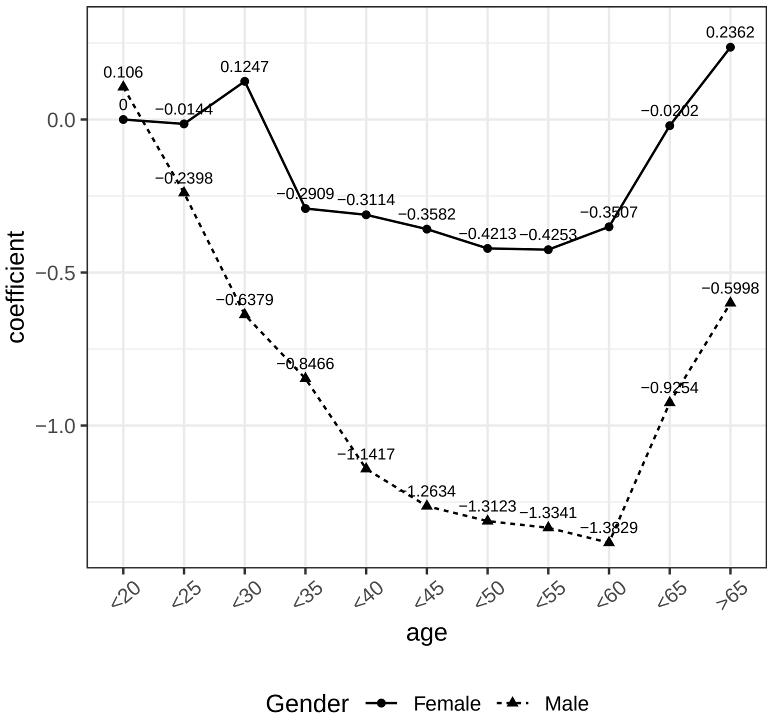

Figure 2: Partial effects of age on happiness identified by the categorical variable of gender and age in Equation (1)

the effect of age on happiness observed in several countries. See e.g. Blanchflower and Oswald (2008). The curve is relatively high in early adulthood, then falls, reaching its minimum in middle age and then rises after old age. Age has its minimum effect at the 50s for male and female. It reaches the minimum at 50-55 and 55-60 years for females and males, respectively. Men have smaller coefficients than women in all age groups, indicating that men are unhappier than women in all the age groups, *ceteris paribus*.

Figure 3 shows the partial effects of personal and family incomes identified in our analysis. The identified positive and diminishing effect of income has been observed in several happiness studies in other countries. See e.g. Easterlin (1974). The positive effect of personal income goes up gradually to the maximum at the group of 12 million Japanese yen, followed by a decrease beyond it. Family income has more significant positive effects on happiness than personal income. The positive effects maximise at the group of 20 million Japanese yen. Beyond the tipping point, the effects diminish.

Figure 4 summarises the partial effects of occupation status when the group of unemployment is the base. The employed groups have negative partial effects, whereas the groups of manager, self-employed, freelancer and student have positive partial effects. The student group is statistically significant at the significance level of 1%.

Next, we consider the partial effects of health conditions on happiness using the five dummies of the three major adult diseases and habits of smoking and drinking. Smoking has negative effects of -0.2793, which is worse

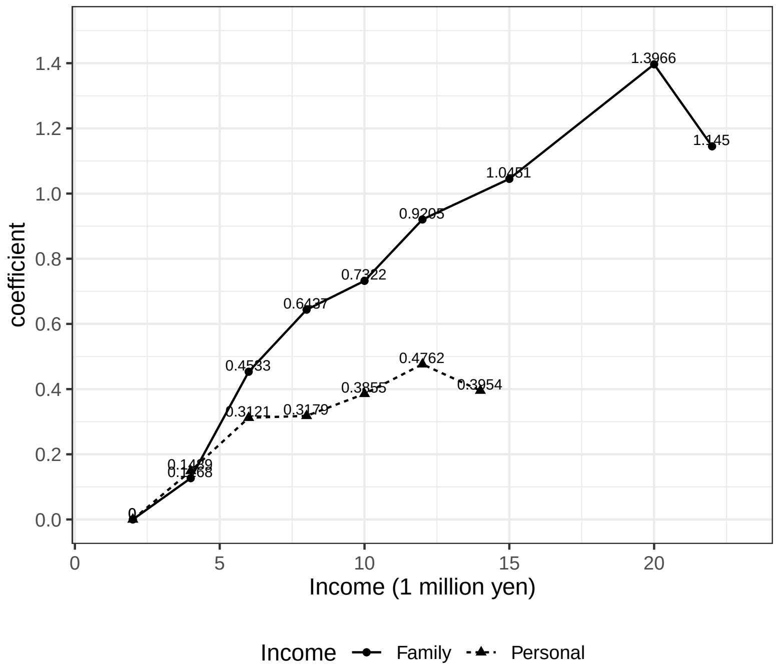

Figure 3: Partial effects of income on happiness identified by the categorical variables of personal income and family income in Equation (1)

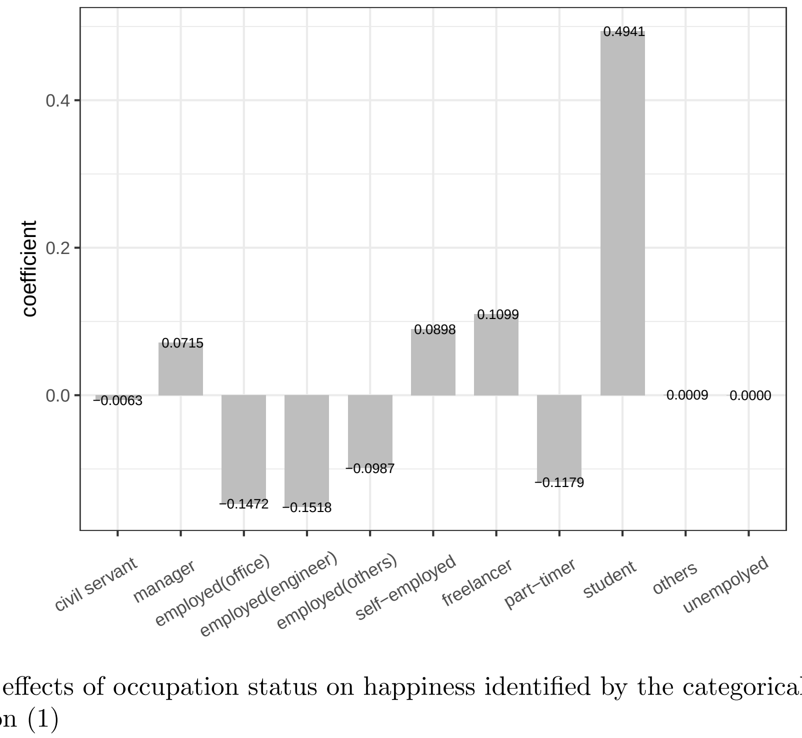

Figure 4: Partial effects of occupation status on happiness identified by the categorical variable of occupation in Equation (1)

than those of the three diseases evaluated as −0.1596, −0.1478 and −0.0997, whereas only drinking has positive significant effect at the 1% level in the health variables.

Table 3 shows contribution to happiness increases as education level raises. The partial effects of high school, junior college, university and graduate school are monotonically increasing as 0.2388, 0.3112, 0.4623 and 0.5261, respectively, when junior school is the base.

Finally, we consider the partial effects of marital status and number of children. People with children are happier than those without, by 0.1829 on average, *ceteris paribus*. Compared with single status, married status increases the partial effect on happiness for women and men. Married men are happier than the single person by 0.8662 on average, whereas 0.6484, 0.8433 and 0.9046 for full-time working wife, part-time working wife and housewife than the single group, respectively. The housewife has the greatest partial effect among the marital statuses.

3.2 Spatial effects

Let us move on to the estimation results for d_j and ρ in Equations (2) and (3). At first, the ρ parameter that controls spatial correlations is estimated at 0.8579, which is positively significant at the 1% significance level. Thus, d_j, happiness in jth prefecture after controlling individual characteristics, is geographically dependent with smooth behaviours. Table 3 shows that the prefectural-level variables of logged SWE and RFA in Equation (2) are significant, whereas log GPP is non-significant at the 10% level. Therefore, SWE and RFA have clear effects on regional variations of happiness unlike GPP.

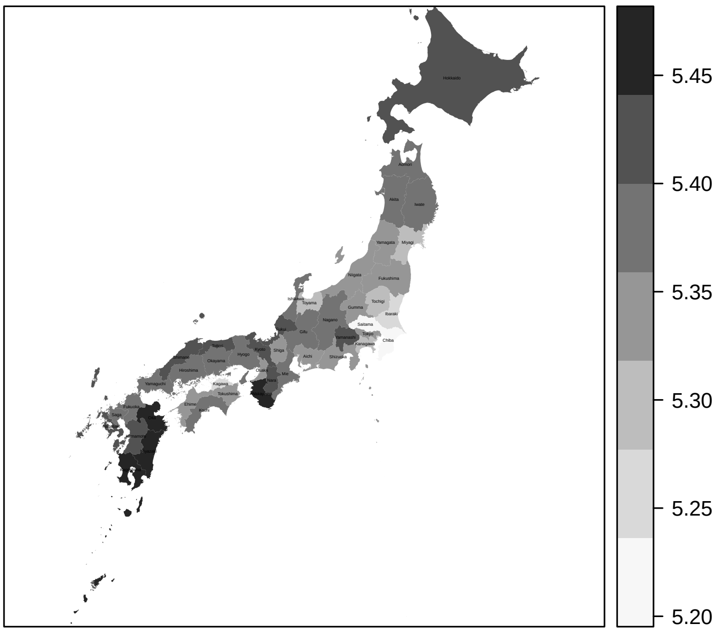

Figure 5: Regional variations of happiness identified by the prefectural dummies in Equation (2), which was evaluated after controlling for the individual characteristics.

Figure 5 illustrates is the map of regional variations in Japan evaluated by the posterior mean of d_j. Table 4 shows the prefecture ranked in terms of the identified happiness of d_j.

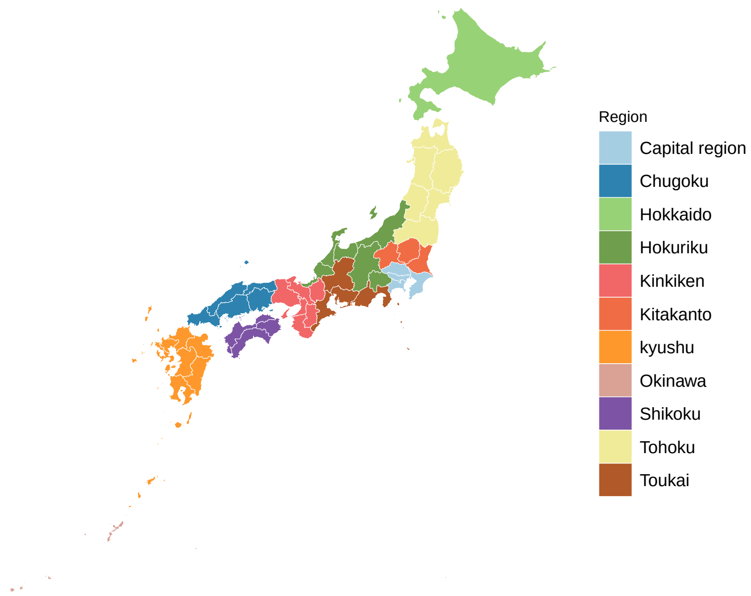

Figure 6: Name list of regions in Japan

We find non-trivial regional variations of happiness in each prefecture. Let us briefly summarise the regional features detected by the analysis in Figure 5 together with Table 4. Figure 6 presents the name list of the regions in Japan necessary to describe the results. Happiness in the south-western area tends to be higher than that in the northeastern area, except for Hokkaido. Happiness in Kyushu, Kinki and Hokuriku regions is higher, followed by Chubu and Kanto regions, whereas happiness in Tohoku region is lower. Kyushu region, located in the southwestern part of Japan, is overwhelmingly the happiest region. Most prefectures in Kyushu are ranked within the 10th place in the happiness ranking, such as Miyazaki, Kagoshima and Oita.

In addition, the islands of Shikoku and Hokkaido are noteworthy. Shikoku Island has less happy prefectures, though surrounded by happier neighbours. In contrast, Hokkaido, the second largest isolated island in the northernmost part of Japan, displays a spatial similarity of happiness with its neighbouring prefectures of Aomori and Iwate.

4 Discussion

This section discusses the comparisons of the findings described in the previous section with references to other happiness studies all over the world.

4.1 Individual components of happiness

The U-shaped effects of age on happiness identified in Figure 2 are not completely consistent between male and female. After controlling for personal socio-economic characteristics, happiness for females rises before 30 years old, which is considered unmarried in current Japanese society. Arguably, this result is because for the majority of Asian women, the period between the age of 20 and 30 is a period between leaving their parents' family though not having their family. This period is the time for females to study, work, invest and enjoy independence and autonomy. From a biological perspective, oestrogen (and fertility) in women hits the highest level from the mid- to late-20s before a decline (Easton et al., 2010). During this period, women are highly confident physically.

Furthermore, the identified U-shape for females is later than that for male. Thus, women are happier than men, which is consistent with the findings in several happiness studies, such as in Graham (2012). One possible explanation is that men tend to have a higher aspiration and be more stressed than women in society (Frey and Stutzer, 2010). As age increases, pressure from all social aspects increases, hence negatively exacerbating their unhappiness level. Therefore, this condition also indicates that men's happiness is more sensitive to age than that of women.

Zimmermann and Easterlin (2006) revealed that marriage is one of the most important factors of happiness, which is well-demonstrated in this study. In addition, we detect that housewives are the happiest in the category of married women, with slight differences between them. The question of whether women are happier as housewives than as working wives is a long-standing debate. Benin and Nienstedt (1985) found no statistically significant difference in the happiness between a housewife and working wife. However, Treas et al. (2011) found a small but statistically significant happiness advantage for housewives on cross-national data in 28 countries. They claimed that housewives are slightly happier than full-time working wives, although they have no advantage over part-time workers. Beja (2014) examined the happiness of housewives relative to national economic levels and claimed that working wives and housewives in upper-income countries do not significantly differ and that the happiness gap in low-income countries can reduce through social welfare programmes. These claims are consistent with our detected result on housewives in Japan as an upper-income country with intermediate social welfare programmes.

The existing findings in the relationship between parenthood with children and well-being are mixed and differ across countries on social policy contexts. Haller and Hadler (2006) used WVS data and emphasised that children have a non-significant effect on happiness after controlling for income. Glass et al. (2016) examined cross-national variations in the association between parenthood and happiness and revealed lower happiness levels among parents than non-parents in most advanced industrial societies. They found that the US shows the largest disadvantage of parenthood, followed by Ireland, Greece and the UK. Having children in these advanced societies may be a financial burden. Nevertheless, in other countries, most notably Norway and Hungary, parents are happier than singles. This finding is consistent with this research detecting that, in Japan, having children has a positive partial effect on happiness. The variations of the effects of children on happiness across countries may be due to the public support for parenting, including differences in paid parenting leave, legally mandated vacation and sick days and workplace flexibility.

This present study examines the relationships between diseases, including drinking and smoking habits and happiness and is in accordance with existing studies (see e.g.Argyle (2013)). The significant negative partial effects of diabetes, hypertension and hyperlipemia come from their damaging impacts on health. Detecting a significant negative effect of smoking habit on happiness, which is a major cause of lung cancer, is reasonable (Das, 2003). Unexpectedly, drinking habit has significant positive partial effects, considering that drinking is harmful to health, i.e. alcohol is the fifth biggest risk factor for premature death and disability globally (Lim et al., 2012). Geiger and MacKerron (2016) showed a strong and consistent moment-to-moment relationship between happiness and drinking events. Alcohol drinking is associated with considerably high happiness levels at that moment, i.e. 10.79 points on a 0–100 scale. Therefore, pouring oneself a drink increases one's happiness by 11%, which is in line with our results.

One of the most robust findings on happiness in the area of economics is that unemployment is destructive to well-being (Clark and Oswald, 1994; Tella et al., 2003). The identified partial effects in our study support this finding, except for the employed group. One possible reason of the negative effect of the employed group is that the base group of unemployed includes retired individuals and housewives with good family income and that certain employed individuals are under increased time pressures of commuting (Hilbrecht et al., 2014; Chatterjee et al., 2020). Existing studies have shown that self-employment has a multifaceted relationship with well-being. Alesina et al. (2004) argued on a survey in the US and Europe that self-employed individuals have lower happiness levels than full-time employees and that self-employment positively impacts high-income individuals only. This result is consistent with our findings that self- employment has a non-significant positive partial effect. Bardasi and Francesconi (2004) demonstrated that part-time jobs in the UK are detrimental to subjective well-being. This finding is in accordance with our result showing the negative but statistically non-significant partial effect part-time jobs.

The relationship between education level and happiness has not reached a consensus. An increasing number of studies suggest that the relationship between higher education and subjective well-being is either non-significant or negative (Powdthavee, 2010; Powdthavee et al., 2015). However, other researchers examining surveys on several countries showed that education level is positively related to happiness after controlling for income (Gerdtham and Johannesson, 2001; Inoguchi and Shin, 2009), which is consistent with our results. Nikolaev and Rusakov (2016) tested the hypothesis that the extent to which education makes individuals happy depends on their current age. Evidence shows that people with higher education are more likely to be happier on average than their less educated counterparts. In addition, Nikolaev (2018) used longitudinal data from the Household, Income and Labour Dynamics in Australia Survey to examine the link between higher education and three different measures of subjective well-being. He found that individuals with higher education are more likely to report higher levels of well-being and more satisfied with most life domains (financial, employment opportunities, neighbourhood, local community, children at home) compared with less educated persons.

4.2 Spatial components of happiness

We jointly evaluated the spatial and individual components of happiness. Spatial components are regional factors of happiness after controlling for individual characteristics. Table 4 presents these spatial components, indicating that the coastal areas of Chiba, Ibaraki, Ibaraki and Fukushima constitute the group with the lowest happiness in Japan. Let us consider certain backgrounds for the results.

The Great East Japan Earthquake on 11 March, 2011, was an exceptionally severe disaster, the worst in the memory of contemporary Japan (Yokoyama et al., 2014). The damage resulting from these related disasters—the earthquake, tsunami and nuclear plant accident— has been shared throughout Japan. The losses from the disaster include not only economic costs but also strong mental impacts on human beings, including the afflicted and non-afflicted areas of Japan (Ohtake and Yamada, 2013).

Comparison with the economic losses, many studies have found that people's subjective well-being after the disaster has not changed as much as expected. Using panel data following victims for 6 months after the earthquake, Sugano (2016) showed that a significant impact on expenditure and employment but less significant impact on subjective well-being and health of the elderly survivors. Uchida et al. (2014) tracked the well-being of young people in Japan outside of the afflicted areas before (December 2010) and after (March 2011) the earthquake. Results suggested that the young people had slightly increased their general well-being after the earthquake compared with before the earthquake. Furthermore, Ishino et al. (2012) used large panel data consisting of responses from over 4000 households in all over Japan and found that more Japanese people replied their happiness improved and that they have become more altruistic after the earthquake. One possible interpretation is that reflecting on the Great East Japan Earthquake had prompted people to re-evaluate their lives. This mindset promoted prosocial behaviours, such as making donations, volunteering and donating improved happiness. The studies reviewed here recognised that happiness has not changed as much as expected in negative aspects after the earthquake.

By contrast, according to Tanji et al. (2018) and Hikichi et al. (2019), evidence shows that although most economic losses have been recovered after the earthquake through reconstruction, the psychological distress of the affected people requires careful attention. Tanji et al. (2018) conducted a longitudinal observation on 284 adults who had lived in prefabricated temporary housing in Miyagi in northeastern Japan. This study investigated the association between the period of residence in prefabricated temporary housing and psychological distress in the time of baseline survey (September 2011) and the follow-up survey (January 2016). They found that the proportion of individuals with more severe psychological distress was higher among participants who had lived in prefabricated temporary housing for a long period. Among the participants with lower psychological distress at the baseline, cases of significant deterioration of psychological distress were reported in the group pf people who lived in prefabricated temporary housing over 4 years.

Hikichi et al. (2019) conducted a follow-up study of older survivors for six additional years with three waves of surveys. They found that the experience of housing loss was persistently associated with cognitive disability (4.9% and 13.0% in the second and third waves, respectively) and that the proportions of stroke and diabetes increased over time (1.9%–4.4% for stroke, 12.3%–14.3% for diabetes). Thus far, one may suppose that releasing the psychological pain of the affected people is difficult in the long run and that the depressed impact on survivors will last for a long time. This condition confirms our results to a certain extent that the coastal regions in Japan have the lowest subjective well-being, though 10 years have passed since the Great East Japan Earthquake.

5 Conclusion

In this study, we consider a method for applying a spatial hierarchical model for multilevel datasets composed of individual- and prefectural-level samples. The model can simultaneously detect the partial effects of personal and regional characteristics on personal happiness. Happiness depends not only on individual characteristics but also on their living conditions, neighbours and natural environment. Happiness across prefectures in Japan is spatially dependent: prefectures with a certain degree of happiness are also surrounded by a similar degree of happiness at their neighbouring prefectures. After controlling for individual- and prefectural-specific characteristics, spatial dependence remains strongly.

Further studies are required to detect subjective well-being in Japan in more details. Finding other possible essential factors on happiness is necessary by exploring unobservable variables. What are the characteristics that make human objectively feel happier or unhappier? Bright sunshine in Kyushu and beautiful snow scenes in Hokkaido are possible candidates for objective happiness, whereas high land prices and traffic congestion in Tokyo and harsh climate and frequent earthquakes in Tohoku are possible characteristics of objective unhappiness. Most of these characteristics are available in the age of big data. Using big data on subjective well-being can help widely investigate the essential factors of happiness in future studies.

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Appendices

Tables

Table 1: Summary of demographic information of the whole respondents

	Age<20	<25	<30	<35	<40	<45	<50	<55	<60	<65	>=65
Female	551	469	843	904	1087	1356	1362	1213	1171	1242	1082
Male	478	540	870	947	1100	1437	1378	1211	1167	1169	962
Personal income	<2 million yen	<4m	<6m	<8m	<10m	<12m	>12m				
	10058	5736	3859	1747	679	260	200				
Family income	<2 million yen	<4m	<6m	<8m	<10m	<12m	<15m	<20m	>20m	unknown	
	1483	4134	5201	3872	2289	1058	564	292	130	3516	
Health status	drinking		smoking		diabetes		hypertension		hyperlipidemia		
	yes	no	yes	no	yes	no	yes	no	yes	no	
	10183	12356	2887	19652	870	21669	3272	19267	2022	20517	
Education level	junior school	high school	junior college	university	graduate school						
education level	573	6782	5315	8860	1009						
Married status			married female								
	single person	married male	full-time	housewife	part-time						
	6803	7423	2663	2822	2605						
Children	0	>=1									
	9713	12826									
Occupation	civil servant	manager	employed(office)	employed(engineer)	employed(others)	self-employed					
	1003	386	4012	2887	2792	1028					
	freelancer	part-timer	student	others	unemployed						
	578	3670	1456	512	4185						

Table 2: Sample size with regional variables in each prefecture

Prefecture	Sample size	SWE	GPP	RFA(%)	Prefecture	Sample size	SWE	GPP	RFA(%)
Aichi	1476	54.3	3633	42.2	Miyagi	450	52.6	2926	55.9
Akita	203	74.1	2553	70.5	Miyazaki	148	72.7	2407	75.8
Aomori	248	73.1	2558	63.8	Nagano	367	61.4	2882	75.5
Chiba	1063	46.7	3020	30.4	Nagasaki	198	75.2	2519	58.4
Ehime	258	71.7	2656	70.3	Nara	281	62.2	2522	76.8
Fukui	125	64.3	3157	73.9	Niigata	382	53.8	2826	63.5
Fukuoka	1110	62.1	2800	44.5	Oita	196	68.6	2605	70.7
Fukushima	241	54	3005	67.9	Okayama	382	57.2	2732	68
Gifu	354	57.9	2803	79	Osaka	1582	68	3056	30.1
Gumma	337	55.7	3098	63.8	Saga	130	69.9	2509	45.2
Hiroshima	495	59	3068	71.8	Saitama	1353	48	2958	31.9
Hokkaido	973	79.3	2617	67.9	Shiga	237	60.1	3181	50.5
Hyogo	1048	59.9	2896	66.7	Shimane	89	74.4	2619	77.5
Ibaraki	536	57.5	3116	31	Shizuoka	594	46.3	3300	63.1
Ishikawa	200	56.4	2908	66	Tochigi	338	53.5	3318	53.2
Iwate	228	64.9	2737	74.9	Tokushima	123	66.4	2973	75.2
Kagawa	194	60.1	2945	46.4	Tokyo	2517	64	5348	34.8
Kagoshima	211	77.3	2414	63.4	Tottori	118	75	2407	73.3
Kanagawa	1709	52.2	3180	38.8	Toyama	215	49.5	3295	56.6
Kochi	91	79.9	2567	83.3	Wakayama	116	74.7	2949	76.4
Kumamoto	263	72	2517	60.4	Yamagata	213	55.1	2758	68.7
Kyoto	486	68	2926	74.2	Yamaguchi	214	62.2	3048	71.6
Mie	305	58.5	3155	64.3	Yamanashi	142	63.4	2873	77.8

Note: SWE: Social welfare expenditure per capita(thousand yen) ; GPP: Prefectural income per person (thousand yen); RFA(%): Ratio of forest area

Table 3: Estimated Results

Variables	Coefficients	S.E.	Variables	Coefficients	S.E.	Variables	Coefficients	S.E.
Prefectual level:								
Spatial effect ρ	0.8579***	(0.1623)	Constant	3.527 ***	(0.7578)			
Log SWE	0.1922*	(0.1076)	Log GPP	0.066	(0.0805)	Log RFA	0.1264 ***	(0.0477)
Individual level:								
20<Female<25	-0.0144	(0.1083)	Female<30	0.1247	(0.1030)	Female<35	-0.2909 ***	(0.1040)
Female<40	-0.3114***	(0.1025)	Female<45	-0.3582 ***	(0.1004)	Female<50	-0.4213 ***	(0.1001)
Female<55	-0.4253 ***	(0.1023)	Female<60	-0.3507***	(0.1035)	Female<65	-0.0202	(0.1025)
Female>65	0.2362**	(0.1043)	Male<20	0.1060	(0.1060)	Male<25	-0.2398 ***	(0.1036)
Male<30	-0.6379 ***	(0.1028)	Male<35	-0.8466***	(0.1032)	Male<40	-1.1417 ***	(0.1016)
Male<45	-1.2634***	(0.0987)	Male<50	-1.3123***	(0.0996)	Male<55	-1.3341***	(0.1025)
Male<60	-1.3829***	(0.1041)	Male<65	-0.9254***	(0.1040)	Male>65	-0.5998***	(0.1072)
Personal Income (P) :								
200<P<400	0.1489***	(0.0448)	P<600	0.3121***	(0.0562)	P<800	0.3179***	(0.0711)
P<1000	0.3855***	(0.0945)	P<1200	0.4762***	(0.1338)	P>1200	0.3954***	(0.1626)
Family income (F):								
200<F<400	0.1268**	(0.0575)	F<600	0.4533***	(0.0581)	F<800	0.6437***	(0.0616)
F<1000	0.7322***	(0.0674)	F<1200	0.9205***	(0.0800)	F<1500	1.0451***	(0.0975)
F<2000	1.3966***	(0.1265)	F>2000	1.1450***	(0.1838)	F=unknown	0.2712 ***	(0.0563)
Health Conditions:								
Drinking	0.1007 ***	(0.0257)	Smoking	-0.2793***	(0.0375)	Diabetes	-0.1596 ***	(0.0653)
Hypertension	-0.1478***	(0.0377)	Hyperlipidemia	-0.0997**	(0.0445)			
Occupation Status:								
Civil servant	-0.0063	(0.0886)	Manager	0.0715	(0.1116)	Employed(office)	-0.1472***	(0.0691)
Employed(engineer)	-0.1518***	(0.0724)	Employed(others)	-0.0987	(0.0703)	Self-employed	0.0898	(0.0787)
Freelancer	0.1099	(0.0936)	Part-timer	-0.1179	(0.0738)	Student	0.4941***	(0.0823)
Others	0.0009	(0.0974)						
Education level:								
High school	0.2388 ***	(0.0746)	Junior college	0.3112***	(0.0781)	University	0.4623 ***	(0.0769)
Graduate school	0.5261***	(0.0962)						
Marital Condition:								
Married male	0.8662 ***	(0.0532)	Married female: full-time	0.6484***	(0.0613)	Married female: part-time	0.8433 ***	(0.0798)
Married female: housewife	0.9046***	(0.0748)						
Children	0.1829 ***	(0.0365)						

Note: $^{*}\ p < 0.1$; $^{**}\ p < 0.05$; $^{***}\ p < 0.01$

Table 4: Rankings of Estimated Happiness across Japan

Prefecture	Happiness	S.E.	Region	Rank	Prefecture	Happiness	S.E.	Region	Rank
Miyazaki	5.4643	0.0406	Kyushu	1	Hiroshima	5.3688	0.038	Chugoku	24
Kagoshima	5.4539	0.0404	Kyushu	2	Iwate	5.3656	0.0355	Tohoku	25
Wakayama	5.4529	0.0324	Kinkiken	3	Ishikawa	5.3605	0.0322	Hokuriku	26
Oita	5.4517	0.0384	Kyushu	4	Okayama	5.3602	0.0345	Chugoku	27
Kumamoto	5.4387	0.0394	Kyushu	5	Shiga	5.3532	0.0317	Kinkiken	28
Kyoto	5.4258	0.0309	Kinkiken	6	Tokushima	5.3495	0.0501	Shikoku	29
Nagasaki	5.4258	0.0431	Kyushu	7	Ehime	5.3483	0.0498	Shikoku	30
Yamanashi	5.4137	0.0303	Hokuriku	8	Shizuoka	5.3467	0.0299	Toukai	31
Fukui	5.4131	0.0322	Hokuriku	9	Tokyo	5.3436	0.0287	Capital region	32
Shimane	5.41	0.0392	Chugoku	10	Gumma	5.336	0.0303	Kitakanto	33
Nara	5.4079	0.0322	Kinkiken	11	Aichi	5.324	0.0287	Toukai	34
Hokkaido	5.4059	0.0363	Hokkaido	12	Fukushima	5.3239	0.0314	Tohoku	35
Tottori	5.4059	0.0361	Chugoku	13	Yamagata	5.3222	0.0323	Tohoku	36
Nagano	5.3924	0.0299	Hokuriku	14	Niigata	5.3218	0.0303	Hokuriku	37
Gifu	5.3914	0.0314	Toukai	15	Osaka	5.3211	0.0302	Kinkiken	38
Kochi	5.3903	0.0494	Shikoku	16	Toyama	5.3147	0.0308	Hokuriku	39
Mie	5.3849	0.0313	Toukai	17	Tochigi	5.3092	0.0309	Kitakanto	40
Saga	5.3841	0.041	Kyushu	18	Kanagawa	5.3011	0.0295	Capital region	41
Hyogo	5.3794	0.0304	Kinkiken	19	Miyagi	5.2858	0.0334	Tohoku	42
Fukuoka	5.378	0.0358	Kyushu	20	Kagawa	5.2702	0.049	Shikoku	43
Akita	5.3751	0.035	Tohoku	21	Ibaraki	5.2469	0.0305	Kitakanto	44
Yamaguchi	5.3731	0.0394	Chugoku	22	Saitama	5.2245	0.0294	Capital region	45
Aomori	5.3724	0.0364	Tohoku	23	Chiba	5.2128	0.0296	Capital region	46