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Spatial and Multivariate Analysis of Japan's Prefectural Digital Divide

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ABSTRACT

This study of the digital divide within Japan utilizes data from Japan's 47 prefectures for spatial analysis of distributions of technology utilization variables. It analyzes the spatial outliers and clusters of prefectures for the country. The paper constructs a conceptual model based on 10 dependent factors and 17 independent ones. The relationship of the independent to dependent factors is moderated by exploratory analysis of spatial patterns of technology utilization and by confirmatory analysis of correlates of technology utilization, while screening for spatial randomness. Geographical findings indicate areas of outlier high and low technology use as well as distinctive cluster patterns for the four major islands of Japan. Regression findings show the significance to technology utilization of newspaper circulation, patents registered by Japanese citizens, students and pupils per capita, household expenditures on education, farm household population (inverse), and young dependency ratio (mixed positive and negative). Practical implications are considered.

Keywords

Japan, Digital Divide, Spatial Autocorrelation, Mapping, Cluster Analysis, Regression, Implications

INTRODUCTION

In this paper, we focus on Japan, one of the five leading industrialized nations (Group of Five or, G-5) worldwide. With approximately 55 million internet hosts (second only to the United States in 2010), almost 100 million internet users (third only to China and the US in 2010), Japan is also among the top eight nations worldwide in terms of total number of main telephone lines in use and total number of mobile cellular telephone subscribers (The Central Intelligence Agency, 2012). At the same time, growth and usage of ICT in Japan is possibly hindered by a significant aging population. The goals of this paper are to add insight into Japan's prefectural differences in technology levels and growth rates, to explore what are the leading correlates of prefectural technology differences among socio-economic variables, to analyze and control for spatial distributions of technology levels, and based on the findings to discuss implications for IS practitioners and researchers, as well as for Japan's government policy makers in increasing technology utilization, with particular attention to underserved states and regions.

The overall research question is how Japan's prefectural utilization of technologies is arranged geographically and what determines the correlates of technology utilization for prefectures. The remainder of this paper is arranged into sections on literature review, conceptual model, research questions, methodology, exploratory analysis of geographical patterns of technology levels, regression analysis, findings, discussion, government policy implications, and conclusion.

The research has unique features that are unprecedented in the literature on the digital divide in Japan. First, in the literature, no prior study of multivariate correlates of Japan's digital divide has utilized data at the prefecture level. Although a study examined three cases of broadband expansion in three remote, mountainous prefectures (Arai and Naganuma, 2010), there is a gap in understanding the geographical dimensions of technology utilization for the whole nation. Japan's 47 prefectures are the smallest geographic unit in Japan that has systematic government data on technology, social, and economic attributes. A second unique contribution is the use of spatial analysis methods to analyze quantitatively the geographic patterns and extent of spatial autocorrelation error in studying the nation's digital divide. The exploratory methods consist of mapping of cluster analysis regions; local Moran's I statistic is applied to examine the geographical similarities and outliers in technology levels for the entire nation at the prefecture level. In addition the regressions evaluated for spatial autocorrelation through Moran's I tests, in order to exclude regression findings that are geographically biased. The prefecture data on 27 variables, available from Japanese government sources, have not previously been applied for Japan, so the empirical findings are unique.

LITERATURE REVIEW

A handful of studies in the last decade have investigated ICT utilization and the digital divide in Japan. While some of these studies focus solely on Japan and sometimes on a specific type of ICT (Akiyoshi and Ono, 2008; Ida and Sakahira, 2008; Ishii, 2004; Kawaguchi, 2006; Nakayama, 2003; Yuguchi, 2008), others are multi-country comparative studies (Chen and Wellman, 2004; Ono, 2005; Ono and Zavodny, 2007; Quibria et al, 2003).

A recent case study (Arai and Naganuma, 2010) analyzed how broadband infrastructure and access is being implemented in three less economically developed prefectures of Japan. It highlighted the national commitment to provide modern internet even to remote mountainous areas. Although it lacks the present study's spatial multivariate analysis of all 47 prefectures, it is similar to the present study in the prefecture unit of analysis.

Japan has 47 prefectures, which are administrative areas with a governor and legislature, somewhat similar to U.S. states. The prefecture system originated in 1871. The current governmental role for 47 prefectures was set in 1947 by the Local Autonomy Law. Japan is about 70 percent mountainous, so many prefectures have dramatic topographic features that lend importance to including geography in study of the country's IS adoption and diffusion.

Nakayama (2003) has examined the social, cultural, and economic sources of the digital divide in Japan and has segregated Japanese digital users into three distinct generations based upon preferred mode of communication (by hand, personal computer, or mobile phone) and writing (by pen and brush, alphabet keyboard, or ten-key keypad), age, composition of generations by gender and employment, encouragement received in school, cost of digital technologies, etc. These factors reflect the adoption of mobile devices with non-alphabetic keyboards by young people. Yuguchi (2008) specifically discussed economic implications of subsidies provided by the national government in broadband and mobile telephone services.

Japan's high average rates of technology utilization stem from its early and rapid adoption of mobile technologies (Ishii, 2004; Ito et al., 2005). Mobile 3-G environment was present in Japan before almost any other nation, and had strong influence on personal lifestyles, especially of younger Japanese, and expressed in a concept known as "keitai," which implies ubiquitous use and social networking (Ito et al., 2005).

Economic implications of the possession of a personal computer at home are discussed by Kawaguchi (2006) who identified that a PC at home facilitates the possibility of full-time employment among women and is positively correlated with salaries of both men and women in Japan. Ida and Sakahira (2008) found that income levels, type of service usage such as movie-viewing, and type of residence are important determinants of broadband internet subscription.

Multi-national studies have often compared the digital divide in Japan with that in other developed or industrialized nations such as USA, U.K., European nations, and Nordic countries, and sometimes with far-eastern and other Asian neighbors. Such studies have often found that income, education, infrastructure (Quibria et al, 2003), and factors such as high costs, English language barrier, lack of relevant content, lack of technological support (Chen and Wellman, 2004) often shape the digital divide between nations.

CONCEPTUAL MODEL

The conceptual model was established by induction from prior literature studies of other nations and their states/provinces, as well as general studies of Japan's technology growth. The independent variables have mostly been extensively researched in the digital divide literature and are grouped below by Category. The conceptual model appears in Figure 1.

Demographic influences. Age structure has rarely been included in digital divide research at the country or state/provincial level. We include it in the present study because Japan has the world's oldest population, which give added importance to age differences. Secondly, Japanese young people are known to be among the most engaged and technologically savvy youth worldwide (Ito, Okabe, and Matsuda, 2005). We include the variables of *working age population* and *young dependency ratio* (i.e. the ratio of young population to working age population).

Economic influences on technology utilization from prior research have included income (Baliamoune-Lutz, 2003; Dasgupta et al., 2005), integration in the global economy (Onyeiwu, 2002; Quibria et al., 2003; Chinn and Fairlie, 2006); international trade openness (Baliamoune-Lutz, 2003); foreign direct investment (Pick and Azari, 2008); and R&D (Quibria et al., 2003; Pick and Azari, 2011). A study of comparative prevalence and growth rates for mobile phones in the 1990s showed that both 1990 income per capita and log of income change for the decade influenced mobile phone adoption (Dasgupta et al., 2005). Manufacturing productivity was included in a prior study of technology utilization in the Indian states (Pick et al., 2011). Although not in prior studies, we include employment because of the strong cultural emphasis in Japan of being employed, as reflected by Japanese workers often joining a corporation for a lifetime. We include two income variables in the model, *household income* and *prefecture income*; two employment variables, *unemployment* and *employees in corporations*; and *manufacturing productivity*.

Infrastructure. A study of ICT diffusion in 18 Asian nations found investment in infrastructure, which presumably includes electrical capacity, to be a key correlate for ICT growth (Quibria et al, 2003). In research on factors that promote IT for Bangalore, cheap electricity was identified as important for start up and continuing supply of electricity in IT development (Van Dijk, 2003).

Education. In most country-based studies of determinants of technology utilization, education has been significant (Robison and Crenshaw, 2002; Kiiski and Pohjola, 2002; Ono and Zavodny, 2007; Pick and Azari, 2008, 2011; Yates, 2011). In a microdata-based five comparative study of five nations, three of them Asian, higher education and income were the most important correlates of information technology usage (Ono and Zavodny, 2007), while in China, the nation's college- educated segment in the early 2000s had about eight times the internet use of the population as a whole (Zhu and Wang, 2005). Consequently, two determinants are included in the conceptual model to measure different dimensions of education, *household expenditures on education* and *students and pupils per capita.*

Cooperatives. The importance of cooperative society membership to IT use has been validated in several studies in India (Gupta et al., 2007; Pick et al., 2011). Gupta et al. have validated the uses of information and communication technologies in cooperative banks and micro finance institutions in India. In our study, two variables – agricultural cooperatives and agricultural federations, i.e. federated groups of cooperatives are included.

R&D. In a regression study of socioeconomic influences on technological sector receipts and payrolls for 164 U.S. counties, the most important correlate overall was professional/scientific/technical services workforce, followed by other services workforce (Azari and Pick, 2005). Scientists and engineers per capita were among two dominant determinants of technology capacity in 49 nations (James and Romijn, 1997). In the conceptual model, the R&D related variables of *technical workers*, and *patents registered by Japanese citizens* are included.

Openness. Societal openness has been emphasized in studies that have included democracy and freedom (Robison and Crenshaw, 2002; Baliamoune-Lutz, 2003), rule of law, property rights, and enforcement of contracts (Quibria et al., 2003). Authors have reasoned that a democratic, free, and lawful society fosters more communication of ideas and collaborative activity (Robison and Crenshaw, 2002; Yates et al., 2011). In the present study, a multiple dimension *index of prefectural openness* from the Japan Association of Citizen Ombudsman is included.

The dependent variables in the conceptual model are mostly ones used in prior studies of the digital divide (Robison and Crenshaw, 2002; Balaimoune-Lutz, 2003; Quibria et al., 2003; Chinn and Fairlie, 2007; Pick and Azari, 2011). The study is unique in the digital divide literature at the state/province/prefecture level in including as dependent variables the IP phone expenditures per family (Telecommunications Utilization Survey, 2012) and Facebook, Twitter subscribers per capita (User Local Inc., 2012). These more modern technology attributes have not previously been studied in the digital divide literature at the national or state/province/prefecture levels.

RESEARCH QUESTIONS

The research questions are as follows:

1. What is the appropriate conceptual model for understanding the spatial patterns of levels of technology utilization and what are the correlates of technology utilization levels for key types of technology?
2. What are the spatial outliers for spatial patterns of prefectures for the technology utilization factors, and how to the prefectures agglomerate together based on similarity in values?
3. What are the demographic, economic, educational and societal correlates of technology utilization factors by prefectures?
4. Are the estimates of these correlates free of spatial autocorrelation errors?

METHODOLOGY

Data collection

A variety of data sources for the study are seen in Table 1. Four of the sources are official publications of the Japanese government (Japan Patent Office, 2012; Japan Ministry of Internal Affairs and Communications, 2012; Japan National Consumer Survey, 2012; and Japan Statistical Yearbook, 2005, 2008, 2009, and 2010). In addition, information came from the Japan Association of Citizens' Ombudsman (2012) and from User Local Inc. (2012). The Japan Citizens' Ombudsman Association is a network of ombudsmen and other lawyers and government critics who have provided information about the openness and transparency of the national and prefectural governments in the country. Information on prefectural government openness was obtained from the website, which is in Japanese, and translated into English. The User Local Inc. (http://social.userlocal.jp) is a well known and reliable website in Japan that is published in Japanese. Information from it was translated into English. The latter two sources were used, because the Japanese government does not publish prefectural information on societal or governmental openness, or on social networking. Data at the prefecture level have not been utilized before in digital divide research on Japan and hence provide a unique study aspect.

In Table 1, all of the variables were for the years 2009-2011, except one variable for 2008 and two attributes for 2005. We were constrained to use a three-year window (2009-11) because data for many factors are not collected yearly. We feel the three year window for 24 out of 27 variables gives sufficient time simultaneity. Since the variables are per capita, we do not feel there is large error by treating these variables as a cross section.

Research Methodology

The steps in the research were to gather attributes for the factors in the conceptual model; test the factors for multi-collinearity and reject variables causing multi-collinearity; map the final set of variables to explore the rudimentary factors; apply local spatial autocorrelation and mapping of groupings from k-means cluster analysis to show outlier prefectures and clustering of prefectures similar on dependent factors, apply spatial autocorrelation methods (Longley et al., 2011) on the dependent variables to test whether or not spatial agglomeration is present for high value prefectures and low value prefectures; apply OLS stepwise regression analysis for the full set of 47 prefectures to test for correlates as posited in the model, and test the regressions for conformity to OLS regression assumptions and to test for spatial autocorrelation in the regression residuals. The local spatial autocorrelation analysis, mapping of k-means clusters, and spatial autocorrelation tests on regression residuals are rarely applied in IS research.

To test for spatial outliers dependent variables were mapping with Local Moran's I statistic (LISA) (ESRI, 2011). The LISA method reveals local distributions of spatial association. It shows presence of spatial outlier areas or clusters of area, which are significantly positive or negative in value, relative to values for contiguous areas. It can be viewed as showing positive "hot spots" or negative "low spots" of a factor's values relative to its neighboring areas (Anselin, 1995). The concept of "neighbor" employed for this study is that neighbors are those prefectures contiguous to a prefecture.

A further exploratory method to understand the groupings of states was to apply k-means cluster analysis, following the LISA analysis. K-means cluster algorithm divides the prefectures into 3 to 5 clusters, based on similarity of characteristics. In the limited space of this paper, the full cluster analysis that includes characterization of clusters is not presented, but the map of four clusters based on the ten dependent variables is calculated and discussed.

A key question in this study is whether the ten dependent variables show significant agglomeration of high values or low values; have a random spatial pattern; or are configured so high values are surrounded by low ones, and vice versa. This can be tested by the Moran's I statistic (Longley, Goodchild, Maguire, and Rhind, 2011; ESRI, 2011). The Moran's I test is inferential; the null hypothesis is that the values of a variable are randomly distributed spatially. Its interpretation is done by the p value for statistical significance (if p is not significant, the variable is randomly distributed spatially). Further, if the z score is positive, the values of a variable are more agglomerated (high values located near high ones and low values near low ones). If it is negative, the spatial pattern resembles a "checkerboard" pattern, in which high values are surrounded by low ones and vice versa (Longley et al., 2011; ESRI, 2011).

Ordinary Least Square (OLS) regression is applied for the 10 dependent variables, based on the 17 independent variables (Table 1). The independent variables are all based on the conceptual model. Variables were pre-tested for multi-collinearity, using the variance inflation factor (VIF) to assure that it is not present. As seen in Table 1, 22 out of 29 variables are converted to per capita or per family. The other seven are also converted to ratios, indices, or other forms that control for the varying population sizes of the provinces. Stepwise regression methods are useful for exploratory studies, where prior research only weakly points to factors of potential significance (Rosenshein et al., 2011). The regression findings are tested for conformance to regression assumptions by the Joint Wald Statistic, Koenker (BP) Statistic, and Jarque-Bera Statistic. Joint Wald Statistic is a test of the joint significance of several coefficients of individual independent variables (Wald, 1943). The Koenker (BP) Statistic Test for heteroscedasticity, i.e. that the variance of the residuals is not constant (Lyon and Tsai, 1996). The Jarque-Bera Statistic is a goodness-of-fit test of whether sample data, in this case regression residuals, have skewness and kurtosis that correspond to a normal distribution (Jarque and Bera, 1980).

EXPLORATORY STUDY OF SPATIAL PATTERNS OF TECHNOLOGY LEVELS

Findings on spatial autocorrelation for the dependent variables indicate that they mostly have high, positive spatial autocorrelations (Table 2). This is not surprising considering that the k-Means cluster analysis had shown significant spatial agglomerations, such as the six prefectures in the north of the largest island of Honshu, and on Honshu the three Tokyo metropolitan prefectures and the five prefectures that surround them. Three dependent variables, however, are not spatially autocorrelated, mobile phone expenditures/family, IP phone expenditures, and fixed phone subscribers. For the least agglomerated, fixed phone subscribers, it can be reasoned that the historical adoption/diffusion process has led to fairly random penetration across all the country; since this technology is becoming displaced today, the former "hot spots" have diminished leading to a random pattern. The lack of agglomeration for the former two variables is surprising, given that they are current technologies that are still being rapidly improved. The large extent overall of spatial clustering of the dependent variables highlights the need for the regression analysis to control for spatial patterns present, in order not to introduce a source of regression error.

LISA analysis was conducted on all the dependent variables; however LISA analysis discussions are excluded due to space constraints. The dependent variable, mobile telephone subscribers per capita, is shown as a map in Figure 2. The local spatial autocorrelation analysis of this variable is shown in Figure 3. The high valued outlier of two prefectures of Tokyo are shown in black as "HH" and the low outlier in the north of the main island of Honshu is shown in blue as "LL."

Maps of the individual dependent variables of mobile telephone subscribers and Facebook subscribers are seen in Figures 2 and 4. Results of the k-means cluster analysis for 4 clusters, based on all 10 dependent variables are shown in Figure 5. Findings indicate a cluster for the southern metropolitan area of Honshu that includes Tokyo, Kyoto and Nara; a large 17-prefecture cluster for most of the remainder of central Honshu, a small cluster of Kyoto, Hyago, to the south of the large central cluster, and a cluster that encompasses the north and south peripheral islands of Kyushu, Shikoku, and Hokkaido, plus a few far south and far north prefectures on Honshu.

RESULTS FROM REGRESSION ANALYSIS

The stepwise regression findings (see Table 3) indicate highly significant results for all the regressions. Across all ten variables, the most important correlates are newspaper circulation, education, patents, and farm population. Young dependency ratio is also highly significant for five dependent variables, but the direction of effect varies. The section will report on these key findings, and the comment particularly on fixed phone subscriber, Facebook and Twitter variables.

Discussion

The finding for newspaper circulation has been supported by a study for India (Pick et al., 2011). In India, the elevated technology usage level in Delhi state was highly related to registered newspapers and periodicals. These traditional forms of publishing are regenerators of content, which stimulate the internet, web, and 3-G and 4-G mobile telephones, all of which are used frequently based on the abundance of content. In the case of Japan, the variables that are significantly related to newspaper circulation comprise the internet, broadband, mobile phone and IP phone, all of which are content driven.

R&D as reflected in patents and technical workers has significance for half of the technology factors. It is not surprising that broadband, mobile phones, Facebook, and Twitter are in this group as those are very forward looking forms of technology that are driven by R&D.

Education is a well known attribute form numerous studies of countries, and state/provincial units (Robison and Crenshaw, 2002; Ono and Zabodny, 2007; Pick and Azari, 2008; Pick and Nishida 2011; Pick et al., 2011; Yates 2011). In Japan, the newer forms of technology are more related to education than older forms. For instance, personal computers are unrelated and fixed phone subscribers have an inverse relationship. By contrast, internet expenditures, IP phone expenditures, Facebook subscribers, and Twitter subscribers are positively correlated with education.

The strong inverse relationship of farm population to technology utilization points to rural Japan lagging behind urban areas. This has been noted in studies of India (Pick et al., 2011), for which the rural population has strikingly lower access to and use of technology. If fixed phones are ignored, the age-related correlates point largely to working age population as positive. Curiously, young dependency ratio is inversely related to broadband and Twitter. However, this might be due to the dependency ratio of young to working age population. A high ratio might be more likely to occur in less metropolitan areas, which might not have as much access to broadband, and for which Twitter may not have caught on as much.

CONCLUSIONS

Returning to the research questions, they may be answered as follows:

1. *What is the appropriate conceptual model for understanding the spatial patterns of levels of technology utilization and what are the correlates of technology utilization levels for key types of technology?*
   The appropriate conceptual model includes seven well known technology utilization variables, plus three variables representing newer technologies that have not been researched, namely IP telephones, Facebook subscribers, and Twitter subscribers. The appropriate independent factors include 17 indicators that represent demography, economics, infrastructure, education, cooperatives, R&D, and societal openness. The model includes an exploratory analysis of geographical distribution of technology utilization and a confirmatory analysis of technology utilization correlates that screens for spatial autocorrelation.

2. *What are the spatial outliers for spatial patterns of prefectures for the technology utilization factors, and how to the prefectures agglomerate together based on similarity in values?*
   The spatial outliers were tested for the key variable of mobile phone subscriptions and indicated a high local cluster for the metropolitan area of Tokyo, and a low spatial local cluster for the northern Honshu prefectures of Aomon and Akita. Cluster analysis of all ten dependent variables indicated a cluster for the southern metropolitan area of Honshu that includes Tokyo, Kyoto and Nara; a large 17-prefecture cluster for most of the remainder of central Honshu, a small cluster of Kyoto, Hyago, to the south of the large central cluster, and a cluster that encompasses the north and south peripheral islands of Kyushu, Shikoku, and Hokkaido, plus a few

far south and far north prefectures on Honshu. The latter cluster suggests that distinctive similar pattern of technology utilization is present for all three of Japan's more peripheral major islands.

3. *What are the demographic, economic, educational and societal correlates of technology utilization factors by prefectures?*
   The major significant correlates are newspaper circulation, patents registered by Japanese citizens, students and pupils per capita, household expenditures on education, farm household population (inverse), and young dependency ratio (mixed positive and negative). There are distinctive correlates for Facebook and Twitter, which emphasize innovation, students and pupils, and urban areas (i.e. inversely related to farm population). Fixed phone correlates point to utilization by older age persons, from inverse relationships with working age population, young dependency ratio, and household expenditures on education; the variable also is inversely related to farm population.

4. *Are the estimates of these correlates free of spatial autocorrelation errors?*
   The regression estimates are almost entirely free of spatial autocorrelation of the residuals. The only significant positive spatial autocorrelation is for internet users, which implies future need to include additional independent factors to control for it.

The results have practical implications for government policies in Japan. Results imply that additional advancement of technology utilization can be spurred by policies that emphasize content generation, as represented by the proxy of newspaper circulation; innovation and R&D, and education. The results indicate that technology by and large has lower utilization among the older aged and urban Japanese prefectures. To adjust for imbalances, national IT policies are recommended that provide extra support for the older population and rural areas. Since Japan has the largest proportion of old citizens worldwide, such policies favoring the elderly would have substantial impact on a large segment of the country's population.

For IS practitioners, findings give further justification to an extensive literature that technology utilization is associated with education and income, while adding the result that age structure of the user population is related to IT utilization, in particular that youth and working age user population is associated with IT use, while older users are negatively associated. The findings are useful to practitioners in understanding the expected utilization from business and government users located in different localities in Japan and other countries. For IS researchers on the digital divide, the study fills in a knowledge gap for a leading nation in population and economic size. It introduces the exploratory spatial methods of LISA and cluster mapping, and the confirmatory testing of spatial autocorrelation. The methods have rarely been used in IS research yet provide the potential for more accurate multivariate analysis for technology utilization and for other IT dependent variables, for which the data points are geo-referenced at the levels of individuals, businesses, states/provinces, and nations.

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Category	Variable	Source*	Year	Definition
DEPENDENT VARIABLES				
Technology Use	PC penetration rate for families	NCS	2009	Personal computer penetration rate i.e. ratio of families which have at least one PC
Technology Use	Internet users/ 100 pop.	MIC	2010	Internet users less than 6 years old per 100 population
Technology Use	Internet expeditures/ family	NCS	2009	Internet expeditures per family
Technology Use	Broadband subscribers/capita	MIC	2010	Broadband subscribers per capita
Technology Use	Mobile telephone subscribers/capita	TCA	2009	Mobile telephone subscribers per capita
Technology Use	Mobile phone expenditures/family	NCS	2009	mobile telephone expenditures per family
Technology Use	IP phone expenditures per family	NCS	2009	IP telephone expenditure per family
Technology Use	Fixed phone subscribers/capita	TCA	2009	Fixed phone subscribers per capita
Technology Use	LN Facebook subscribers/capita	Facebook	2011	Natural log of Facebook subscribers per capita
Technology Use	Twitter Subscribers/capita	ULI	2011	Twitter subscribers per capita
INDEPENDENT VARIABLES				
Demographic	Working Age Population (Pop. 20-64) / Total Population	SYB	2010	Ratio of population age 20-64 to total population
Demographic	Young Dependency Ratio (Pop. 0-19 / Pop. 20-64)	SYB	2010	Ratio of population age 0-19 to population age 20-64
Demographic	Farmers per 100 population	SYB	2010	Number of farmers per 100 population
Economic	Household income per family	NCS	2009	Household income per family
Economic	Prefecture income per capita	SYB	2008	Prefecture income per capita
Economic	Unemployment per capita	SYB	2010	Unemployed population per capita
Economic	Employees in corporations per capita	SYB	2009	Employees in corporations per capita
Economic	Manufacturing productivty	SYB	2010	Value of manufactured goods divided by total cash earnings
Infrastructure	Electrical power consumption per capita	SYB	2009	Electric power consumption (ini millions of kilowatt hours) per capita
Education	Household expenditures on education per family	NCS	2009	Household expediture on education per family
Education	Students and pupils per capita	SYB	2005	Students and pupils per capita
Cooperatives	Agricultural cooperatives per capita	SYB	2009	Agricultural cooperatives per capita
Cooperatives	Agricultural federations per capita	SYB	2009	Agricultural federations per capita (a federation is a group of cooperatives)
Technology	Technical workers per capita	SYB	2005	Technical workers per capita
Technology	Patents registered by Japanese citizens per capita	JPO	2009	Number of patents registered by Japanese citizens per capita
Openness	Openness score for prefectures	ACO	2009	Mulit-dimensional index of the openness of the prefectural government
Openness	Newspaper circulation (mornings) per capita	SYB	2010	

* ACO = Japan Association of Citizen Ombudsman
JPO = Japan Patent Office
MIC = Japan Ministry of Internal Affairs and Communications
NCS = Japan National Consumer Survey (in Japanese)
SYB = Japan Statistical Yearbook
ULI = User Local Inc.

Table 1 Dependent and Independent Variables, Japan, 2009

Personal penetration rate for families	Internet users per 100 pop.	Internet expeditures per family	Broadband subscribers per capita	Mobile telephone subscribers per capita	Mobile phone expenditures per family	IP phone expenditures per family	Fixed phone subscribers per capita	LN Facebook subscribers per capita	Twitter Subscribers per capita
0.519***	0.392***	0.553***	0.506***	0.220***	0.146	0.111	0.085	0.216*	0.266***

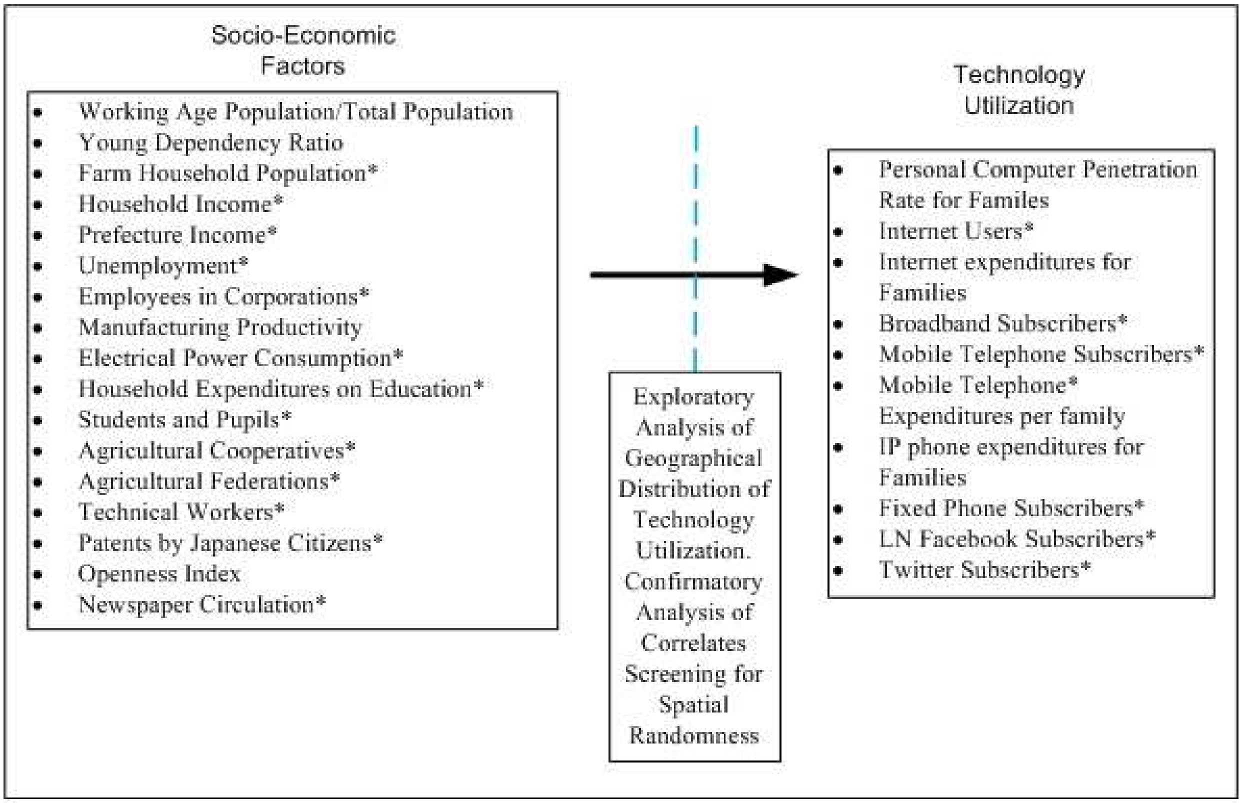
* signif. at 0.05
** signif. at 0.01
*** signif at 0.001

Table 2. Moran's Index for dependent variables, Japan, 2009

		Dependent Variable									
Category	Independent Variable	Personal computer penetration rate for families	Internet users/ 100 pop.	Internet expeditures/ family	Broadband subscribers/capita	Mobile telephone subscribers/ capita	Mobile phone expenditures/ family	IP phone expenditures / family	Fixed phone subscribers/ capita	LN Facebook subscribers/ capita	Twitter Subscribers/ capita
Demographic	Working Age Population (Pop. 20-64) / Total		0.585***			0.236***			-0.481**		
Demographic	Young Dependency Ratio (Pop. 0-19 / Pop. 20-64)		0.239**		-0.183**		0.493***		-0.529***		-0.213***
Demographic	Farm houseold popluation / total population	-0.212**	-0.352**		-0.445***				-0.585***	-0.383***	-0.169**
Economic	Household income per capita	0.772***					0.776***				
Economic	Prefecture income per capita				0.305***						
Economic	Unemployment per capita	-0.248**									
Economic	Employees in corporations per capita	-0.212**									
Economic	Manufacturing productivty (factory output / earned			0.210**							
Infrastructure	Electrical power consumption per capita			0.259***							
Education	Household expenditures on education per capita			0.650***				0.552***	-0.651***		
Education	Students and pupils per capita									0.146*	0.307***
Cooperatives	Agricultural cooperatives per capita					-0.101*					
Cooperatives	Agricultural federations per capita						0.429***				
R&D	Technical workers per capita			0.336***							
R&D	Patents registered by Japanese citizens per capita				0.200*	0.778***				0.620***	0.686***
Openness	Openness Index for prefectures										
Openness	Newspaper circulation (mornings) per capita		0.250**		0.176**		-0.257*	0.256*			
	Regression adjusted R square and significance level	0.799***	0.757***	0.741***	0.883***	0.906***	0.535***	0.440***	0.608***	0.819***	0.910***
	sample size (N)	47	47	47	47	47	47	47	47	47	47
	OLS REGRESSION TESTS										
	Joint Wald Statistic	393.3***	209.5***	152.4***	423.5***	200.5***	131.0***	37.3***	136.3***	423.0***	0.910***
	Koenker (BP) Statistic	1.565	3.939	10.257*	5.906	11.738**	1.856	2.477	1.037	7.637	4.613
	Jarque-Bera Statistic	0.055	1.045	3.260	0.874	5.987	1.641	2.945	1.421	0.828	1.123
	SPATIAL AUTOCORRELATION OF RESIDUALS										
	Moran's Index	-0.222*	-0.113	-0.033	0.011	0.016	-0.074	-0.212	-0.034	0.092	-0.173

* signif. at 0.05
** signif. at 0.01
*** signif at 0.001

Table 3. Standardized regression results for dependent variables, 2009, Japan



Note: * per capita

Figure 1. Conceptual Model of Technology Utilization

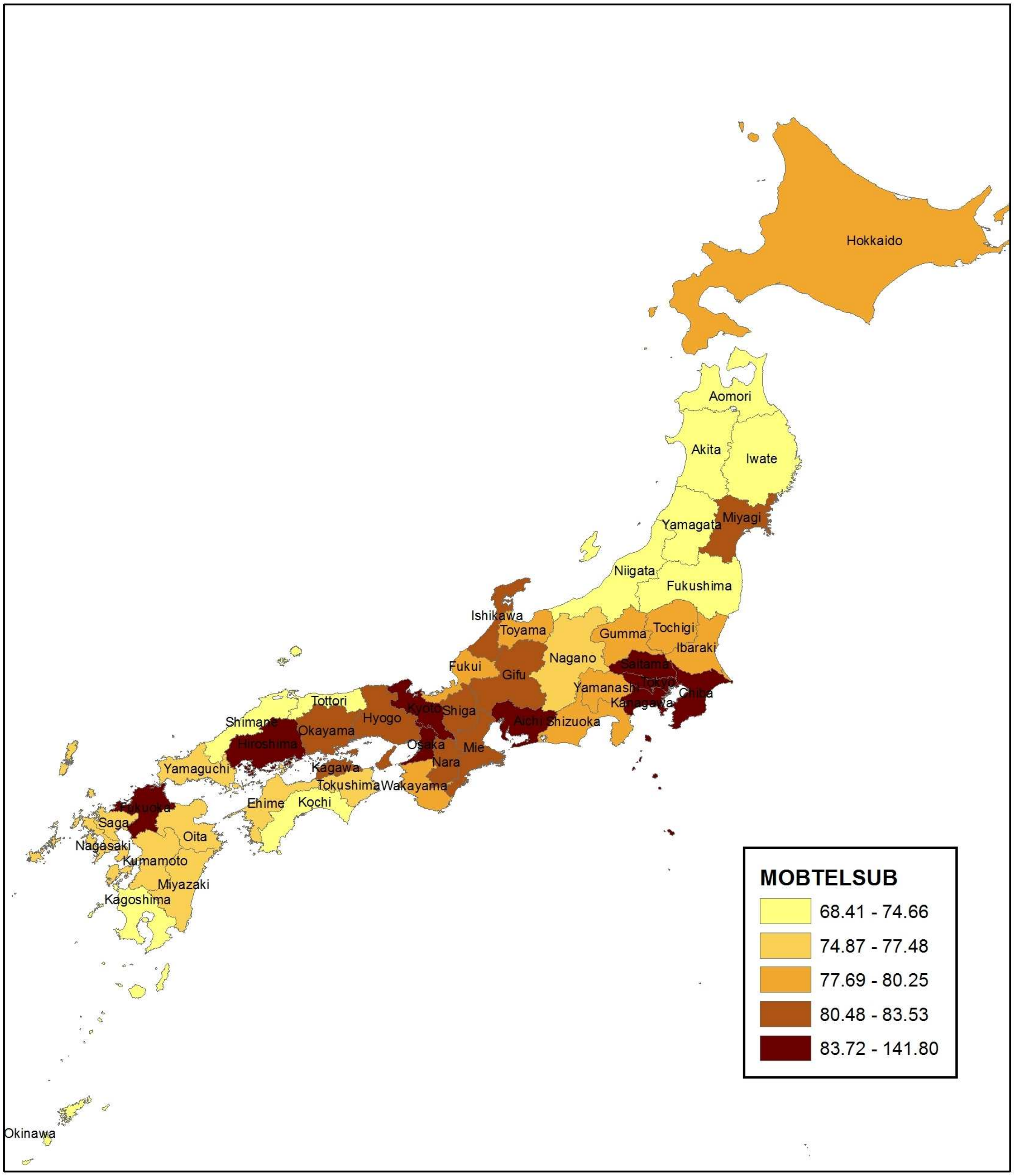


Figure 2. Mobile Telephone Subscribers per Capita, by Prefecture, Japan, 2009

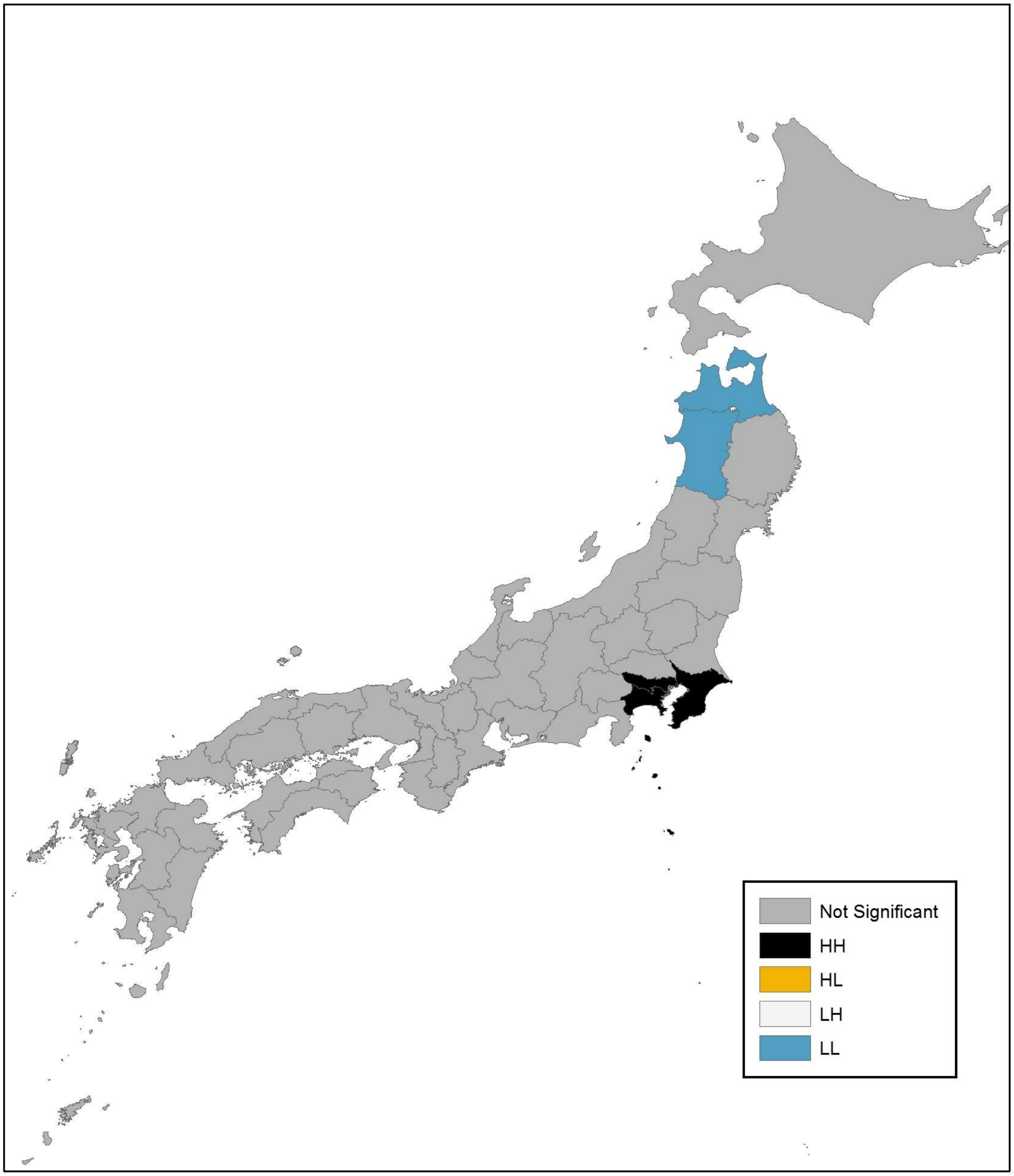


Figure 3. Local Spatial Autocorrelation Analysis of Mobile Telephone Subscribers per Capita, by Prefecture, Japan, 2009

Note: In the legend, "HH" (High-High) indicates a state with high mobile telephone subscriptions per capita surrounded by other states with similarly high values. In other words, "HH" indicates a statistically significant cluster of states with high mobile telephone subscription per capita. Other items of the legend can be interpreted similarly.

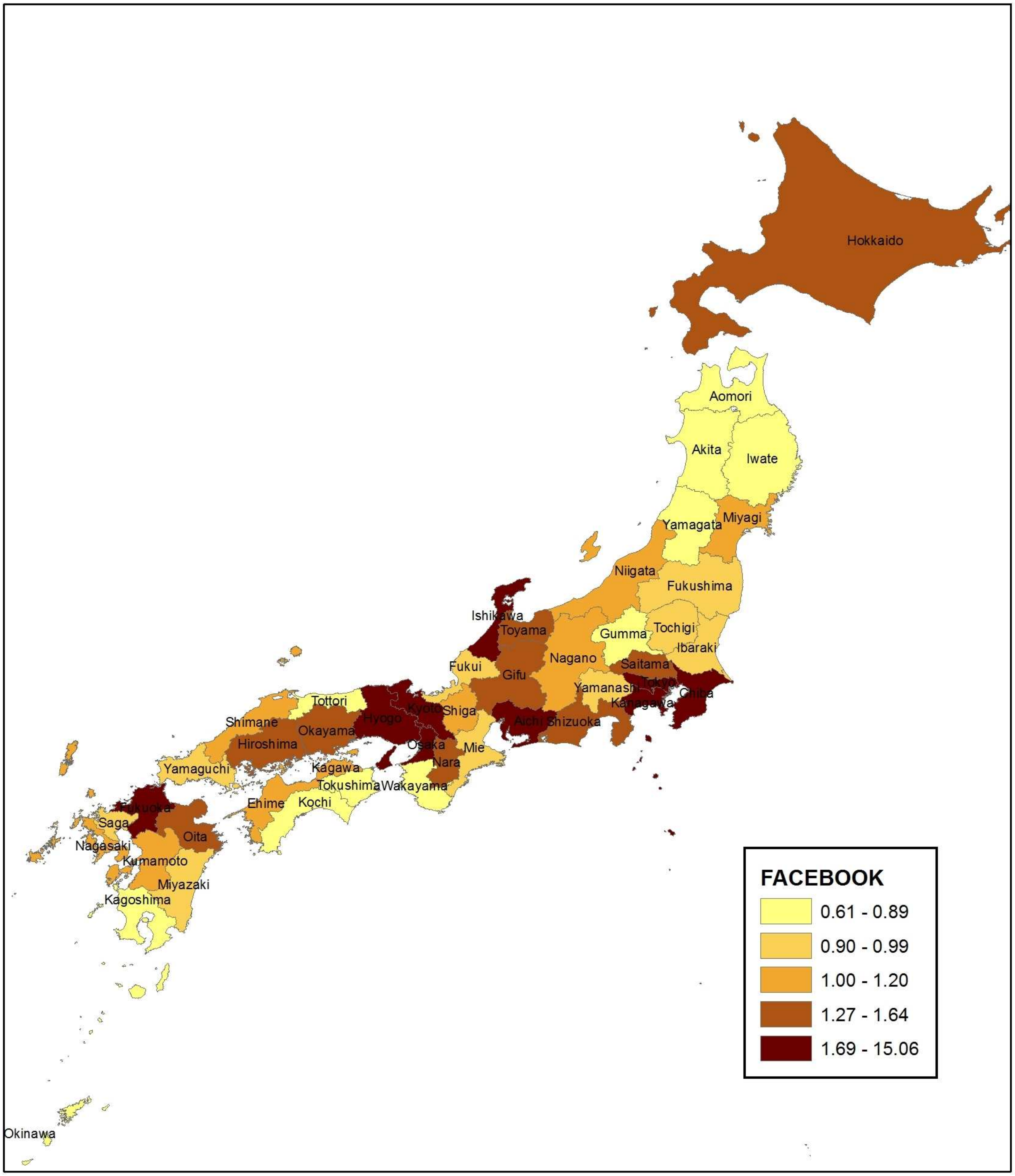


Figure 4. Facebook Subscribers per Capita, by Prefecture, Japan, 2010

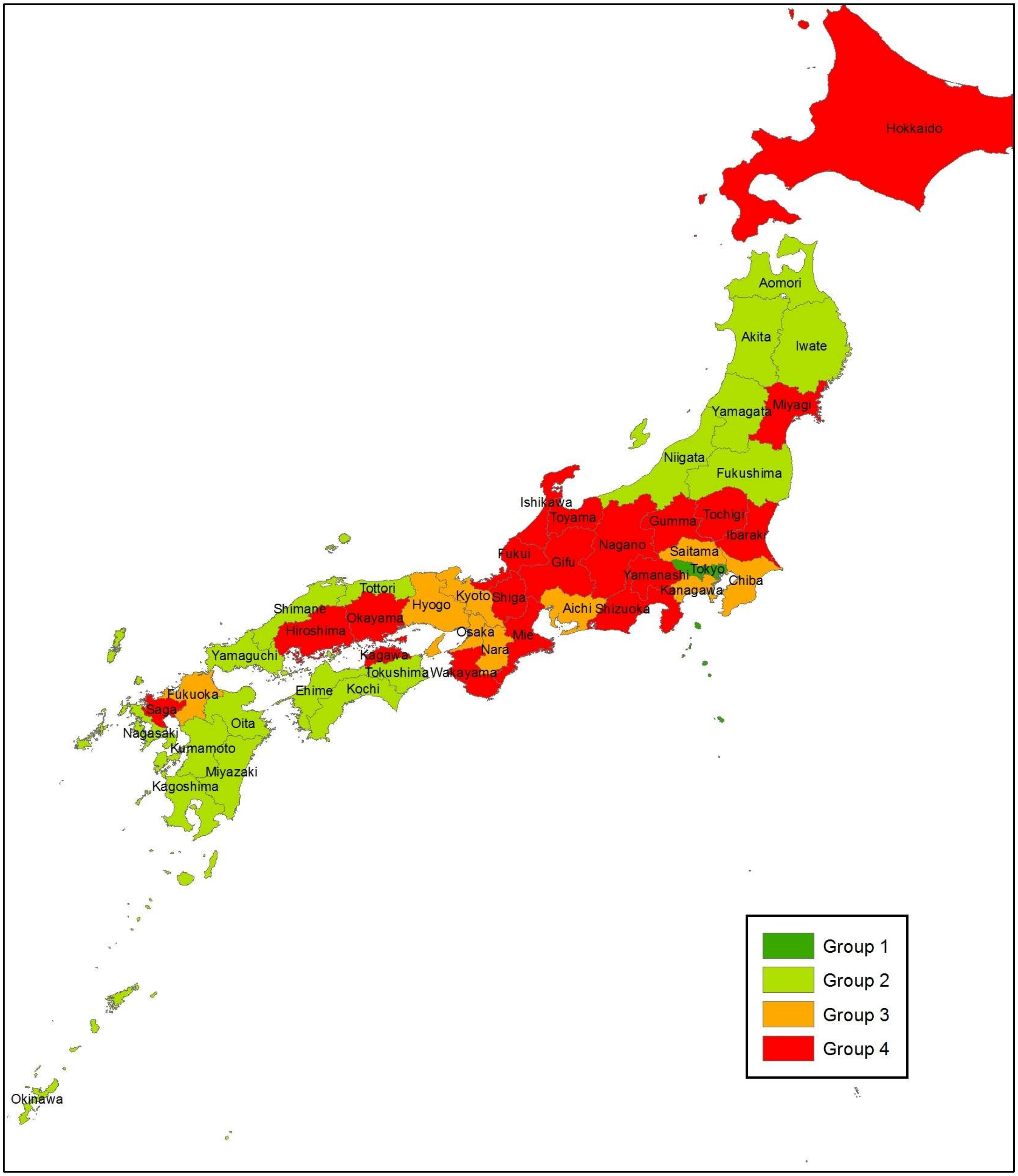


Figure 5. K-Means Cluster Analysis of Dependent Variables, by Prefecture, Japan, 2009-2010

The map plots the four cluster groups identified by k-means cluster analysis of all ten dependent variables for Japan's prefectures.