No time for love? The impact of ICTs on time allocation and relationships in Japan *

Kiho Muroga‡

August 10, 2022

Abstract

This paper examines the ways in which Information and Communication Technologies (ICTs) have changed how we interact socially, and the resulting impact on time allocation and relationships. Specifically, we use regional variation in broadband internet coverage in Japan to examine the impact of ICTs on time allocation, time spent alone, participation in social activities, and marriage. Our estimates show that access to the internet is associated with a substantial increase not only in leisure time but also in time spent alone, especially in leisure activities. In addition, we find that internet availability decreases the marriage probability and increases the divorce rate of individuals. Overall, the results show that while ICTs have changed how we allocate our time and interact socially, in terms of long-term relationships, these new technologies have tended to introduce potential sources of social instability by reducing the likelihood of marriage, increasing the likelihood of divorce, and increasing the amount of solitary time for many.

Keywords: Time Allocation, Solitary Time, Leisure, Internet, ICTs, Labor Supply

*Deepest appreciation is expressed to my advisor, Daiji Kawaguchi, for his continued guidance and support, and I am also grateful to Joshua Angrist, David Card, Charles Crabtree, Taiyo Fukai, Yuji Genda, Keisuke Kawata, Ayako Kondo, David Neumark, Takahiro Toriyabe, Shintaro Yamaguchi, and seminar participants at Labor Economics Conference, UTokyo Center for Contemporary Japanese Studies, and Kyushu University for their useful comments and discussions from which this study has greatly benefitted. This research is supported by JSPS KAKENHI Grant Number 19K20878. Any errors and omissions remain the responsibility of the author.

†Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan

‡Email: kiho.muroga@econ.kyushu-u.ac.jp, ORCID: 0000-0003-1760-9886

JEL Codes: J10, J20, J22

1 Introduction

Technological progress continuously transforms our way of living, and advances in the internet, social media and other forms of Information and Communications Technologies (ICTs) in the last two decades have not only dramatically changed the economic and cultural landscape but have also led to a major shift toward new types of social interactions. Social scientists have long studied the ways in which the internet has changed how we communicate. While the mainstream media has tended to focus on the negative effects in terms of increased isolation, especially among youth, several studies have found that online networking has positive aspects in strengthening social networks (Antoci, Sabatini and Sodini, 2015; Ellison, Steinfield and Lampe, 2007). This study aims to contribute to this literature by clarifying the causal effect of the internet on time allocation and social interaction by exploiting regional variation in the broadband internet coverage rate across Japan.

The internet is used in many different ways, so its potential effects on social interaction are multidimensional through changes in the value of leisure time, the cost of communication, and the cost of meeting others, including potential marriage partners. On the one hand, the internet might increase the value of leisure time through movie streaming services or interesting websites to explore. Aguiar, Bils, Charles and Hurst (2021) show that recreational computer activities increased the value of leisure time. If this is the case, then social interaction might decrease and "solitary time", or time spent alone, might increase. On the other hand, technological advancements and social networking services might encourage us to communicate more frequently, since instant messaging, online video calls, Facebook, and Twitter reduce communication costs. When applied to the marriage market, online dating services as well as the platforms mentioned above decrease the cost of meeting partners, which might increase social interaction and lead to an increase in marriages.

Evidence about these potential communication changes is of particular interest for at least three reasons: social capital, solitary activity, and relationships and marriage. First, the internet may affect social capital, which is defined as the variety of social interactions, networks, and groups that link people in society together. A person with substantial social capital not only has robust social relationships but also better access to credit, economic opportunities and innovation. Phan and Airoldi (2015) further shows that the formation of social relationships may also serve as a coping mechanism to deal with high stress situations and build resilience in communities.

However, other studies have shown the potential for new technologies to destroy social capital. Olken (2009), for example, uses exogenous regional differences in TV penetration and speed to examine the effect of television and radio on social capital, and finds that improved signal reception leads to less participation in social organizations. Similarly, Geraci, Nardotto, Reggiani and Sabatini (2018) find that access to broadband internet has caused a significant decline in forms of offline interaction and civic engagement in the UK. On the other hand, Bauernschuster, Falck and Woessmann (2014) find no negative effects of the internet on social capital in Germany. Thus, we have mixed results about the effect of internet use on social capital. This paper aims to help clarify this ambiguity by examining the effect of internet access on time spent participating in social and volunteer activities.

Further, a social issue related to the destruction of social capital is the emergence of Solitary Non-Employed Persons (SNEPs), which has become a serious problem in Japan in recent decades. Genda (2013) defines SNEPs as single and non-employed people aged 20-59 who spend virtually all of their time alone or only with their families. He argues that because SNEPs increase the number of public assistance recipients, this leads to social instability. Figure 1 shows that the number of SNEPs in Japan doubled from 746,000 in 1996 to 1,623,000 in 2011. As broadband internet diffusion increased dramatically in Japan during this period, it is thus a potential contributor to the rise in SNEPs.

A third potential impact of increased internet access may be its effect on relationships and marriage. While the development of deep relationships leading to marriage are time intensive, from interacting socially to getting to know each other better and then deciding to get married, if the internet causes people to no longer spend enough hours with potential partners, this can lead to increased solitary time, if not loneliness. Thus, more time spent alone due to increased internet access may also affect our relationship and marriage decisions. This is a major concern for Japan, as the marriage rate has been decreasing for decades. Figures 2 and 3 show that the marriage rates for those aged 25-29, 30-34, and 35-39 years old have decreased since 1970. We also see a decreasing number of relationships among the younger generations, with Figures 4 and 5 showing that the percentage of single males and females aged 18-34 years old who are not in any relationship has been increasing since the 2000s. Kuga (2013) mentions that this decreasing number of relationships is one of the main reasons for the observed delayed marriage and low fertility rates in Japan.

In addition to examining these three effects discussed above, this paper is also related to the broader literature in economics on the effect of the internet. The internet has changed our lives in manifold and obvious ways, so researchers and policymakers have been interested in the effects on society. In common with this paper, other studies have investigated the effect of the internet on many aspects of life by using regional variation in internet access. These include Dettling (2017), who finds an increase in female labor force participation due to remote work enabled by the internet, Akerman, Ingvil and Mogstad (2015), who show that broadband internet improves the labor market outcomes and productivity of skilled workers but worsens those of unskilled workers, and Bhuller, Kostøl and Vigtel (2019), who find that internet access provides better labor market matching. Beyond labor market effects, Falck, Gold and Heblich (2014) finds a negative effect of the internet on voter turnout, and Bhuller, Havnes, Leuven and Mogstad (2013) find an increase in the rate of sex crimes. To this literature, we contribute insights on time allocation, time spent alone, and relationships and marriage.

One of the challenges of analyzing the impact of internet diffusion is the endogeneity of internet usage. Due to the lack of exogenous internet *usage* data, it is difficult to identify causal effects if, for example, more educated or higher income individuals use the internet more than others. To address this challenge, some studies have used the internet *coverage* rate for the analysis, taking advantage of the fact that internet diffusion was delayed in some regions due to exogenous factors (Akerman, Ingvil and Mogstad, 2015; Bhuller, Kostøl and Vigtel, 2019), while others have used an instrumental variable (IV) methodology to take advantage of the fact that, for technical reasons, the internet line speed slows down rapidly when the distance from the base station exceeds a certain threshold (Falck, Gold and Heblich, 2014; Gürtzgen, né Nolte, Pohlan and van den Berg, 2021).

This paper contributes to the literature by adopting broadband internet diffusion with a new instrumental variable, ratio of mountainous area, which is a geographical source of exogenous variation in the broadband coverage rate. Because of regional difficulties that increased construction costs, access to broadband internet could not initially be implemented in mountainous areas of Japan, so in our analysis, we use the ratio of mountainous areas as our IV and a unique Japanese data set to exploit the spatial and temporal variation in the availability of broadband internet to estimate its effect on time allocation, time spent alone, participation in social activities, relationships, and marriage.

Since one potential effect of increased internet access on social interaction is through changes in the value of leisure time (Aguiar, Bils, Charles and Hurst, 2021), we first estimate the change in time allocated to work, household, leisure and maintenance and find that increased internet access shifted the time allocation from work to leisure activities. A 10% increase in the internet coverage rate led to the time devoted to work decreasing by 21.4 minutes on average per week while leisure minutes increased by 22.0. As shown in Table 1, the average number of working and leisure minutes per day in 2006 were 292.15 and 373.79, respectively, so a 10% increase in the internet coverage rate caused an 1.05% decrease in working minutes and a 0.85% increase in leisure minutes per week. In contrast, we did not find any statistically significant effect on household and maintenance time.

Furthermore, we did find a statistically significant effect of increased internet access on time spent alone, or "solitary time", especially for work and leisure. A 10% increase in the internet coverage rate caused minutes per week spent in solitary leisure to increase by

11.4, and in solitary work activities to decrease by 8.0. We also found the internet diffusion decreased participation in social activities. Our estimates also show statistically significant results on marriage in the full sample, which intuitively is because an increase in time spent alone decreases the marriage rate. Looking at a subgroup analysis by age, we found that improved internet access lowered the probability of marriage and increased the probability of divorce.

The paper proceeds as follows: Section 2 describes the expansion of broadband internet in Japan and Section 3 describes our data sets, the *Survey on Time Use and Leisure Activities* and the *Status of Development of Broadband Infrastructure*. Section 4 discusses our empirical strategy, Section 5 presents our estimation results, and Section 6 concludes by outlining several policy implications.

2 Broadband Internet Diffusion in Japan

2.1 Background on Broadband Internet Diffusion

Since the days of dial-up internet, there has been an interest in improving internet access and speeds. What is commonly known as broadband internet actually consists of a range of technologies, from CATV provided by incumbent cable TV companies, to DSL through telephone wires, to fiber-to-the-home (FTTH). As in many countries, the Ministry of Internal Affairs and Communications (2010) explains that broadband internet service in Japan was diffused first by CATV and DSL, and then increased in speed and capacity through FTTH.

So-called dial-up internet, using a non-dedicated portion of the telephone line, was the main internet system before broadband internet service was introduced. CATV started service in 1996 as Japan's first broadband internet, [1] but despite the appeal of broadband, dial-up remained more prevalent for a number of years, with 11,000,000 dial-up subscribers compared to 140,000 for CATV in 2000, for example.

[1] The service was called "Musashino-Mitaka Cable TV".

The nationwide diffusion of broadband internet infrastructure was initiated by the enactment in November 2000 of the *Basic Act on the Formation of an Advanced Information and Telecommunications Network Society* (*kodo-johotshushin-network-shakai-kihonho* in Japanese), which defined an "e-Japan" strategy (*e-Japan senryaku*) to develop high-speed access. DSL began service in 2000 and FTTH in 2001, providing speeds of 1.5 - 40 Mbps and 100 Mbps - 1 Gbps, respectively. Figure 6 shows broadband internet subscriptions since 1999, and we can see that subscriptions exploded under the e-Japan strategy, from 140,000 in 2000 to 23 million in 2005, consisting of 3.3, 14.5 and 5.45 million subscribers for CATV, DSL, and FTTH, respectively.

Since dial-up internet technology relied on the non-dedicated use of the telephone line, there was no regional variation in the internet coverage rate at that time, as all regions had equal access to low-quality internet over the legacy telephone wires. However, broadband internet infrastructure requires new construction (even DSL, which is also transmitted over telephone lines), so we use prefectural variations in the speed of broadband internet development as the identification strategy for this study. As the construction of broadband internet infrastructure depends not only on available financing but also on geographical features that make construction difficult, broadband could not be rolled out simultaneously across Japan. Instead, because of regional difficulties that increased construction cost, access to broadband internet could not initially be implemented in remote mountainous areas and far-flung islands. We follow the literature by exploiting these exogenous geographical characteristics (Olken, 2009; Bhuller, Havnes, Leuven and Mogstad, 2013; Bhuller, Kostøl and Vigtel, 2019) to estimate the causal effects of broadband internet access on time allocation, time spent alone, and relationships and marriage.

While the literature has tended to use the DSL coverage rate, we use the FTTH coverage rate in our analysis, for two main reasons. First, due to data limitations, we have access only to the prefectural level internet coverage rate, but DSL internet speed depends on distance from base stations, so prefectural level data would provide only a vague analysis. FTTH internet speed, on the other hand, does not depend on distance from a base station, and so we can analyze the effect of FTTH precisely even with prefectural level data. Second, DSL was already highly diffused in 2011 with almost a 100% coverage rate in many prefectures, so regional variation cannot be used as an identification tool during this period. FTTH, on the other hand, shows substantial regional variation in 2011, as seen in Figures 7 and 8, so FTTH is an appropriate identification strategy for our analysis.

2.2 Determinants of the Broadband Internet Diffusion Rate

In the previous section, we discussed our use of the FTTH broadband internet coverage rate as our identification strategy. This section confirms that regional differences in internet coverage are due to geographic factors.

Geographic factors proliferate in the literature as one of the reasons for observed regional differences in internet coverage. From a geographic perspective, the digital divide is particularly noteworthy in disadvantaged areas such as mountainous regions, remote islands, and marginal areas of the country, and in the early days of the internet, organizations and residents in disadvantaged areas had limited access. (Arai, Naganuma and Satake, 2012). It is further pointed out that the initial cost of broadband development in mountainous areas is high due to, for example, long installation distances and the need to install new stations and poles (Ministry of Internal Affairs and Communications, 2007).

Figure 7 shows the coverage rate by prefecture in 2006, 2011, and 2016, and we can see not only prefectural variation but also intertemporal changes in broadband even among prefectures of similar cultural, economic and geographic zones. Ibaraki, Tochigi, and Gunma prefectures in the northern Kanto region, for example, are considered to belong to the same economic, cultural and geographic zone to the north of Tokyo. In 2006, Tochigi had the highest coverage rate, but by 2011, Tochigi and Gunma had similar coverage, indicating that Ibaraki was lagging behind in 2011. As another example, Akita prefecture in the Tohoku region showed higher coverage rate than Iwate prefecture in the same region in

2006 but by 2011, they were at the same level. In these examples, we can see that similar prefectures belonging to the same region with similar economic and cultural characteristics show differences in the diffusion rate, so it can be inferred that some other factor affected the internet coverage rate in Japan. In this study, we focus on geographical factors; specifically, the mountainous area ratio.

According to the Broadband Infrastructure Development Status (BIDS) survey of the Ministry of Internal Affairs and Communications (MIC), although there were regional differences in the broadband diffusion rate in 2006, the diffusion rate had reached close to 100% in most regions of Japan by 2016. Between 2006 and 2016, when broadband internet spread nationwide, the change in the coverage rate is considered to be larger in mountainous areas which had previously lagged and smaller in the plains areas which have fewer geographical barriers and which had already had a high coverage rate in 2006.

In order to confirm that the coverage rate is indeed determined by geographic characteristics, we calculate the correlation between the coverage rate and the percentage of mountainous areas by prefecture. For the coverage rate, using BIDS data, we take the first difference of the coverage rate between 2006 and 2016. For the percentage of mountainous areas, we use data from the Census of Agriculture and Forestry. Since geographical characteristics are regarded as constant, we use the most recent data which was collected in 2000. The estimation equation is the following:

$$DiffCov_{pt} = \gamma_1 Mountain_p + \gamma_2 X_{pt} + v_{pt}, \tag{1}$$

where $DiffCov_{pt}$ is the first difference in the coverage rate between 2006 and 2016, $Mountain_p$ is the ratio of mountainous areas in prefecture p in 2000, which is considered to be constant over time, and X_{pt} are control variables in 2006 covering an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, and log of average wage bill.

First, we draw a scatterplot of the correlation of the first difference in the internet coverage rate and percentage of mountainous areas. As shown in Figure 9 and Table 3, the two variables are positively correlated and statistically significant. Even after we include the control variables, the correlation remains statistically significant, so we can conclude that the prefectural variation in the rollout of broadband internet does indeed depend on geographical characteristics.

3 Data

To estimate the impact of internet access on solitary time and marital status, we use two data sources provided by Ministry of Internal Affairs and Communications.

3.1 Survey on Time Use and Leisure Activities

The Survey on Time Use and Leisure Activities is a major data source for our study. This survey has collected the time allocation of the Japanese general public every 5 years since 1976, so it has a repeated cross-sectional data structure. The sample size is around 190 thousand each survey year, providing the most detailed large sample time allocation survey data in Japan.

The survey is fielded over a nine-day period including two weekends in October and each respondent is given two days to reply. Each household member aged 10 or older reports their activities in 15-minute intervals from among 20 kinds of activities.[2] In addition, each respondent is asked to select an answer to the question "With whom did you spend time together?" for each 15-minute interval from among the following categories: 1. alone, 2. family, 3. friends in school or colleagues, and 4. others. Following Genda (2013), we use the

[2]The possible activities are: 1. Work, 2. Schoolwork, 3. Commuting to/from school or work, 4. Studying and Researching, 5. Housework, 6. Child Care, 7. Shopping, 8. Sleep, 9. Personal Care, 10. Meals, 11. Medical Examination or Treatment, 12. TV, Radio, Reading, 13. Rest and Relaxation, 14. Hobbies and Amusements, 15. Sports, 16. Volunteer and Social Activities, 17. Social Life, 18. Travel Other than Commuting, 19. Caring and Nursing, and 20. Other Activities.

total number of minutes each respondent chose "alone" in a day as our "solitary time", or "time spent alone" measure. [3]

Following Lee, Kawaguchi and Hamermesh (2012), we collapse the 20 survey activities into four categories: work, household, leisure, and maintenance, and the detailed classification provided in Table 4. Using these four activities as outcome variables, we calculate the total minutes of solitary time for each respondent for each of those four activities. While Lee, Kawaguchi and Hamermesh (2012) consider sleeping to be a maintenance activity, we do not include sleeping hours in our analysis because our survey considers sleeping to be, by definition, a solitary activity.

3.2 Development Status of Broadband Infrastructure

The Ministry of Internal Affairs and Communications has surveyed the broadband internet coverage rate for each municipality since 2006 as a mechanism for clarifying differences in regional development. Although the survey is conducted at the municipal level, for reasons of confidentiality, we were provided access only to prefectural level data by the Ministry of Internal Affairs and Communications, so we use the prefectural level coverage rate for 2006, 2011, and 2016 for our analysis. The coverage rate of broadband FTTH internet for each prefecture, Cov_{pt}, is calculated as follows:

$$Cov_{pt} = \frac{BBhh_{pt}}{hh_{pt}}, \tag{2}$$

where $BBhh_{pt}$ is the number of households of prefecture p in year t that have access to FTTH internet and hh_{pt} is the total number of households in prefecture p at year t.

Figure 7 shows the coverage rate of FTTH by prefecture for 2006, 2011, and 2016. We can see wide variation in coverage rate by prefecture in 2006. Prefectures with coverage rates above 80% included Saitama, Chiba, Tokyo, Kanagawa, Aichi, Shiga, Kyoto, Osaka, Hyogo,

[3] Although Genda (2013) defines SNEPs as 'single and non-employed people aged 20-59 who spend time alone or only together with family', we use the more strict measure of time spent alone.

Nara, Wakayama, Hiroshima, and Fukuoka. As broadband infrastructure has diffused widely since 2006, the coverage rate of most prefectures exceeded 80% in 2011, with only Aomori, Iwate, Akita, Kagawa, Kochi, Nagasaki, Kumamoto, Miyazaki, and Kagoshima remaining below this level. In 2016, the coverage rate was close to 100% in most prefectures. Figure 8 shows the diffusion rate of FTTH coverage for 10 selected prefectures. This figure also shows that as of 2006, there was a large difference in coverage in each prefecture, but the gap has gradually narrowed.

3.3 Summary Statistics

Summary statistics for the key variables are summarized in Tables 1 and 2. Table 1 shows the mean values of our outcome variables and the internet FTTH broadband coverage rate. The outcome variables are minutes per day spent in work, household, leisure, maintenance, solitary, and volunteer activities, as well as the marriage rate. Standard deviations are in parentheses. Solitary time is further broken down into four categories: work, household, leisure, and maintenance activities. We see that working minutes per day slightly decreased and leisure minutes per day slightly increased in 2011, but it was close to its original level in 2016. In addition, solitary minutes per day, solitary leisure minutes per day, and solitary maintenance minutes per day slightly increased in 2011 and decreased in 2016. Table 1 also shows the average broadband internet coverage rate in 2006, 2011, and 2016 and we see that the coverage rate was already 72% in 2006 and increased to 99% in 2016. Table 2 shows our control variables: education, income, family type, age, and gender. We do not see any significant difference in these variables between 2006 and 2016.

4 Model

We focus on the effect of the internet on time allocation, solitary time, social activity, marriage, and divorce. While the Status of Development of Broadband Infrastructure survey has been conducted annually since 2006, the Survey on Time Use and Leisure Activities has been conducted only every 5 years, so the data period for our analysis is 2006, 2011, and 2016. Following the literature (Bhuller, Havnes, Leuven and Mogstad, 2013; Bhuller, Kostøl and Vigtel, 2019), we use the internet *coverage* rate rather than actual internet *usage* rate because we need to address the endogenous issue, as we'll discuss in more detail later.

We first estimate the effect of broadband internet access on our outcome measures using an ordinary least squares (OLS) regression strategy. The observation unit is the individual-prefecture-year, and the estimation equation is the following:

$$y_{ist} = \gamma_1 Cov_{pt} + \gamma_2 X_{ist} + \theta_t + \eta_s + \eta_s t + \delta R_{pt} + v_{ist}, \tag{3}$$

where y_{ist} are the outcome variables described above, Cov_{pt} is the percentage of the population of prefecture p that resided in a housing unit that was covered by FTTH broadband internet in year t, X_{ist} are demographic variables covering education, income, age, gender, and family type, [4] θ_t is year fixed effects, η_s is municipality fixed effects, t a linear trend, R_{pt} a vector of prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill, and v_{ist} is the error term. Standard errors are clustered at the prefecture level.

4.1 Identification Strategy

The coefficient of interest is γ_1, which indicates the effect of the FTTH broadband coverage rate on the outcome variables. As Akerman, Ingvil and Mogstad (2015) discuss, the key threat to the identification of γ_1 is that the timing of the diffusion of broadband internet

[4] We use the following categories for the demographic dummy variables: 9, 12, and 14 years for education; less than 1 million JPY, 1-1.99, 2-2.99, 3-3.99, 4-4.99, 5-5.99, 6-6.99, 7-7.99, 8-8.99, 9-9.99, 10-14.99, and greater than or equal to 15 million JPY for income; age 10-112 for individual years of age; couple, couple and children, couple and parents, couple and one parent, couple with children and parents, couple with children and one parent, motherless family, fatherless family, single, others, and older couple for family type.

might be related to different underlying trends in time allocation. Our identification strategy controls for municipality and year fixed effects, and it also relies on two features of the policy to expand broadband internet availability. First, most of the time-variant factors for internet availability tend to change very little over time. Second, the timing of the diffusion does not correlate with key correlates of time allocation, especially local economic conditions.

First, in order to check whether the data are consistent with the first feature, we estimate the following equations:

$$Cov_{pt} = \theta_t + \eta_p + v_{pt}, \tag{4}$$

$$Cov_{pt} = \theta_t + \eta_p + \delta R_{pt} + v_{pt}, \tag{5}$$

where θ_t denotes year fixed effects, η_p prefecture fixed effects, R_{pt} prefecture characteristics such as index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, and log of average wage bill. The R^2 for equation (5) and (6) are 0.85 and 0.87, indicating that 85 percent of the variation in broadband internet availability can be attributed to time-invariant prefecture characteristics and common time effects, while 2 percent of the variation can be attributed to a large set of time-varying variables.

Second, we examine the relationship between the timing of broadband diffusion and baseline prefecture characteristics using the following estimation equation:

$$\Delta Cov_{pt} = \eta_p + [\theta_t \times R_p]'\psi_t + v_{pt}, \tag{6}$$

where $\Delta Cov_{pt} = Cov_{pt} - Cov_{p,t-1}$, θ_t is a vector of year fixed effects, and R_p is the same vector of prefecture characteristics in the year 2000. Figure 10 shows the estimated coefficients and 95 percent confidence intervals of the vector ψ_t for every t. As the timing of the expansion does not correlate with baseline characteristics, this supports our identification strategy.

4.2 Instrumental Variable Estimation

However, even though in our OLS estimation we controll for municipality and year fixed effects and a time trend, and notwithstanding that time-variant factors in each prefecture do not correlate with the timing of broadband internet diffusion, we still have concerns about potential endogeneity caused by unobserved time-variant factors. For example, more broadband internet may be deployed in areas where people are more quickly adapting to cutting-edge technology and information. Such a positive correlation between coverage rate and unobserved time-variant factors overstates the causal effect γ_1.

In order to deal with this concern, we use the interaction term between the ratio of mountainous area by prefecture and year fixed effects as an instrumental variable, since the ratio of mountainous area is expected to lead to differences in the trends in broadband internet availability across prefectures. For our IV estimation, we use the following first stage estimation equation:

$$Cov_{pt} = \mu_1 Mountain_p * \theta_t + \mu_2 X_{ist} + \theta_t + \eta_s + \eta_s t + \delta R_{pt} + v_{ist}, \tag{7}$$

where $Mountain_p$ is the percentage of mountainous area in prefecture p in 2000 which is considered to be constant over time and Cov_{pt}, X_{ist}, θ_t, η_s, t, R_{pt}, and v_{ist} are the same as in the OLS estimation.

Because of regional difficulties and the large construction cost, FTTH broadband infrastructure in mountainous areas could not be conducted easily, so $Mountain_p * \theta_t$ year fixed effects should be relatively more negative in the earlier years of the sample than the later years. The coefficients μ_1 are expected to be negative with their magnitude decreasing over time and we omit $Mountain_p * \theta_{t=2016}$ for the identification. Table 5 presents the first stage estimation results which exhibit the expected relationship. Therefore, we conclude that variations in the diffusion of broadband internet infrastructure over time do depend on geographical characteristics.

The second stage estimation equation is the same as that for the OLS estimation:

$$y_{ist} = \gamma_1 Cov_{pt} + \gamma_2 X_{ist} + \theta_t + \eta_s + \eta_s t + \delta R_{pt} + v_{ist}. \quad (8)$$

While it is not possible to test the exclusion restriction directly, we can test this assumption by performing a placebo test of the reduced form effect of the instrument on outcome variable before FTTH broadband internet was available. If the ratio of mountainous areas correlates with the trend in outcome variable at that time, then the exclusion restriction would have been violated during the period when the FTTH broadband internet was available. In this placebo test, we focus on the period from 1995 to 2000, as FTTH broadband internet was not available until 2001. Specifically, we will examine the impact of mountainous areas on working time. [5][6] Figure 11 shows the results of the reduced form analysis from 1995 to 2000, which includes all the control variables discussed above. As there is no significant impact of mountainous areas on working time in any of the years shown, and the results also do not show any clear trend or pattern, this suggests that the exclusion restriction is satisfied.

[5]Since our main data, the Survey on Time Use and Leisure Activities, is conducted every five years, the only available individual data prior to 2000 is that as of 1996. Because it is not possible to see trends with only one year's data, the Labor Force Survey, which is conducted annually, will be used for this analysis.

[6]The Labor Force Survey (LFS) also conducted by the Ministry of Internal Affairs and Communications (MIC). LFS is a monthly survey which collects information on all household members aged 15 or older in households dwelling in the sampled units. The LFS adopts a rotating sampling structure that surveys the same household for two consecutive months, and then after a 10-month break, it again surveys the same households for two months. The annual sample size is about 240,000 individuals from 120,000 households, and this survey provides the most detailed large sample labor force survey data in Japan. The LFS collects information on household members, including each member's labor-force status and hours worked during the last week of each survey month, age, education, and annual labor earnings. The survey also records the highest educational attainment as follows: (1) junior-high school, (2) high school, (3) junior college and technical college, and (4) four-year college and graduate school. We use individual data on labor force participation.

5 Estimation Results

5.1 Internet Diffusion and Time Allocation

First, we focus on the effect of the internet on time allocation, using time spent in work, household, leisure, and maintenance activities for outcome variables, in order to assess a range of socially important effects.

We find that roll-out of the broadband internet changes time allocation. Table 6 shows results from the regressions with four different outcomes: working time (Columns 1 and 2), household time (Columns 3 and 4), leisure time (Columns 5 and 6), and maintenance time (Columns 7 and 8). We present ordinary least squares (OLS) and IV estimates for each outcome. Outcome variables are defined as number of minutes per week.

The OLS results show that broadband internet has decreased working time (Column 1) and increased household and leisure time (Columns 3 and 5). A 10% increase in internet coverage causes working time to decrease on average 14.3 minutes per week, a result that is statistically significant at the 1% level. Column 3 of Table 6 shows that expanded internet coverage increased time spent on household activities. Specifically, a 10% increase in internet coverage increased household time by an average of 5.7 minutes per week. Columns 5 and 7 show the results for leisure and maintenance, and we see that a 10% increase in internet coverage increased leisure by 11.9 minutes and decreased maintenance by 2.8 minutes per week, which is not statistically significant.

The estimations with our IVs confirm that these findings are causal. Column 2, 4, 6, and 8 shows the IV estimation results. We find that a 10% increase in internet coverage decreases work activity by 21.4 minutes per week on average, which is statistically significant at the 1% level. As average working minutes was 292.15 minutes per day in 2006 (from Table 1), a 10% increase in internet coverage leads to an 1.05% decrease in working minutes per week.[7] In addition, column 6 shows that the leisure activities increase 22.2 minutes per week, or a

[7]The calculation formula is as follows: $\frac{21.4}{292.15\times 7}$

0.85% increase, since average leisure minutes per day was 373.79 (Table 1).[8] We did not find any statistically significant results for household and maintenance time.

We find that leisure time increases, which is consistent with the increase in the value of leisure time shown by previous study (Aguiar, Bils, Charles and Hurst, 2021). Since they have shown that computer use and video games, especially for recreational purposes, increased the value of leisure time, so we will break down leisure time in more detail and analyze what leisure time activities increased. According to the definition of the Survey on Time Use and Leisure Activities, leisure time can be divided into the following eight categories: 1. TV, Radio, Newspaper, Magazine, Internet, 2. Rest and Relaxation, 3. Hobbies and Amusements, 4. Sports, 5. Social and Volunteer and Activities, 6. Social Life, 7. Travel Other than Commuting, 8. Other Activities.

The OLS and IV estimation results are shown in Figures 12 and 13, and the both estimates indicate that time in the first category, "TV, Radio, Newspaper, Magazine, Internet" increases with the spread of the internet. This result is consistent with Aguiar, Bils, Charles and Hurst (2021). Additionally, we find that social and volunteer activities and social life decrease with the spread of the internet from our IV estimation (Figure 13). [9] We don't see any statistically significant results for the other leisure categories. These results indicate that the diffusion of the internet has led to an increase in leisure activities performed by individuals (TV, Radio, Newspaper, Magazine, Internet) and a decrease in leisure activities involving people (Social and Volunteer Activities and Social Life).

5.2 Internet Diffusion and Solitary Time

In the previous section, we found that increased broadband internet access has changed our time allocation; specifically, that time spent working has decreased and time spent in leisure activities has increased. The leisure category analysis also showed that leisure time spent

[8]The calculation formula is as follows: $\frac{22.2}{373.79 \times 7}$

[9]We discuss this point in more detail later in our analysis for social activities.

engaging with others decreased, while leisure time spent doing things individually increased. Considering the above results, in this section, we examine the extent to which internet access has impacted the time spent alone, or solitary time. In addition, we decompose solitary time into time spent in the four activities (work, household, leisure, maintenance) in order to obtain a more detailed understanding. For this analysis, we use same estimation model with the previous equation, but the outcome variables are solitary time and its decomposition into solitary working, household, leisure, and maintenance minutes per week.

The results are shown in Table 7. Column 1 indicates the effect of the internet on the total time spent alone per week. A 10% increase in internet coverage increases solitary time by 6.8 (OLS) or 3.9 (IV) minutes per week on average, which is not statistically significant. Columns 3-10 of Table 7 show the decomposition results indicating the solitary time spent in each of the four activities: work, household, leisure, and maintenance. Although Columns 6, 9, and 10 show that internet expansion did not statistically significantly affect solitary household or maintenance time, from Columns 7 and 8, we see a statistically significant increase in solitary leisure time. Our IV estimates show that a 10% increase in internet coverage increases solitary leisure time by 11.4 minutes per week on average. As average solitary leisure minutes per day was 137.65 in 2006, this means that a 10% increase in internet coverage caused a 1.1% increase in solitary leisure per week. These results should not be surprising, as these leisure activities are the ones that emphasize individual interests and needs.

5.3 Internet Access and Social Activities

One of the concerns since the early days of the internet is that it might initiate a change in how people interact that, in turn, might negatively impact social capital. The internet is only the latest Information and Communication Technology (ICT) that has disrupted – for good and for bad – peoples lives. Olken (2009), for example, shows that access to new technology such as TV and radio caused a significant decline in face-to-face interaction because people began to spend more time watching television and listening to the radio. If the same applies to broadband internet, we may find a destruction of social capital. However, the literature provides mixed results regarding the effect of internet usage on social capital (Geraci, Nardotto, Reggiani and Sabatini, 2018; Bauernschuster, Falck and Woessmann, 2014), probably because, unlike TV or radio, the internet has in many ways enabled increased social interaction by reducing communication costs, beginning with asynchronous forms such as email, facebook or Twitter. With broadband expansion, sychronous forms of communication such as online video calls have become possible which better replicate actual face-to-face communication. In order to clarify the effect that broadband internet expansion has had on social capital, here we examine the impact on time spent participating in social and volunteer activities.

For this analysis, we use the same estimation equation with a different outcome variable, time spent participating in social and volunteer activities. Table 8 presents the estimation results, and the OLS estimate show that a 10% increase in broadband internet coverage decreased participation in social and volunteer activities by 1.9 minutes per week, and this is statistically significant at 1% level (Column 1). We do see statistically significant result with our IV estimation. A 10% increase in broadband internet coverage reduced participation in social and volunteer activities by 6.6 minutes per week, which is statistically significant at the 1% level (Column 2). Thus, our results are consistent with the literature that finds that new technologies can decrease social and volunteer activities and thus may have a negative effect on social capital. Furthermore, social and volunteer activity tends to be low in Japan, at only 4.63, 4.08, and 14.22 minutes per day in 2006, 2011, and 2016 (Table 1), so changes in internet access have had a great impact.

5.4 Internet Access, Marriage, and Divorce

One interesting question regarding increased internet access is its potential effects on long-term relationships and marriage. Our findings above show that internet access has increased leisure activities that have an individual focus, and have also reduced participation in social and volunteer activities. How has the internet affected more intimate relationships and marriage? We explore that question in this section.

First, it goes without saying that developing a long-term relationship is a time-intensive process; from first meeting, to going out together, getting to know each other and, ultimately, marriage. However, as we have found, increased internet access has increased the leisure time we spend alone. Is it the case that due to increased internet use, we no longer have enough time for love? It is possible that, with the internet a substitute to dating for leisure activity, we do not spend enough time in relationships that could potentially lead to marriage. As mentioned earlier, if this is true, then this is a major concern of the Japanese government. Figures 4 and 5 show that the percentage of singles (both males and females) aged 18-34 years old who are not in any long-term relationship has increased since the 2000s. Also, Figures 2 and 3 show that marriage rates have decreased since 1970. This evidence motivates us to estimate the effect of internet access on marriage.

For this analysis, we use the same estimation equation with marriage as the outcome variable, $Married_{ist}$, which is a dummy variable that takes 1 if individual i in municipality s and year t is married, otherwise it takes zero. The results are shown in Table 9. For entire sample, our IV estimate shows that a 10% increase in internet coverage decreases the marriage probability by 0.25%, which is statistically significant at the 5% level (Column 2). We don't see statistically significant result with OLS (Column 1).

As this initial result is based on the complete pooled sample but internet usage may differ among age groups, we next conduct a subgroup analysis by age. For the subgroup analysis, we divided the sample into individuals in their twenties, thirties, forties, and fifties[10]. The results of this estimation are presented in Columns 3-10 of Table 9, and we see that internet access decreases the probability of marriage for those in their twenties, with a 10% increase in internet access decreasing the marriage probability by 1.58% (Column 4). However, we

[10]Same subsample analysis was conducted for the sample over sixties, but the results were not statistically significant.

do not see any statistically significant results for any other age group (Columns 5-10). Thus, we can conclude that an increase in time spent alone due to increased internet access does indeed lower the marriage rate for those in their twenties.

In addition to marriage, we wondered if internet access might have an effect on the divorce rate as well, because divorce, which had traditionally been shunned in Japan, has increased in recent decades. Since the internet allows people to reach beyond their immediate surroundings and potentially begin a new life by meeting new partners by using an online dating service, it is conceivable that internet technology may enable divorce by decreasing the cost of searching for a new partner. In order to test this divorce hypothesis, we use the same equation with outcome variable, $Divorced_{ist}$, a dummy variable taking 1 if individual i in municipality s and year t is divorced, otherwise zero.

Table 10 shows that the probability of divorce for entire sample is increased by the internet coverage, with a 10% increase in internet coverage increasing the probability of divorce by 0.26% (Column 2), which is similar to our OLS estimate (0.25 vs 0.26). We also see that the probability of divorce for individuals in their thirties and forties are increased by 0.48% and 1.27% with a 10% increase in internet coverage, which are statistically significant at the 5% and 1% level (Columns 6 and 8). We thus conclude that increased internet access increased the probability of divorce, at least for the individuals in their thirties and forties, due to the decreased cost of searching for a new partner.

6 Conclusion

This paper examined the impact of increased access to broadband internet on time allocation, time spent alone, participation in social and volunteer activities, and marriage and divorce. We found that increased internet access is associated with a substantial increase in time spent on leisure activities and a decrease in time spent working, as well as an increase in solitary time, especially on leisure, which is more individually-focused activities. We also found the internet diffusion decreased participation in social activities. As for long-term relationships, we found that the internet decreased the probability of marriage and increased the probability of divorce. Thus, returning to the question posed in the title of this paper, we can say that, at least for the younger generations, increased access to the internet may provide new opportunities for spending leisure time that crowds out social interaction which may eventually lead to marriage. However, on the other hand, the internet has also decreased the cost of finding new partners for those unhappy in their existing marriage and contemplating divorce. Thus, taken together, we may say that the internet provides no time for love, but ample opportunity to search for new love.

Another social issue related to internet usage is the growing ranks of Solitary, Non-Employed Persons (SNEPs), which Genda (2013) argues increases the number of public assistance recipients, which can potentially cause social instability. The impact of internet coverage on time spent alone, or solitary time, is something that policy makers should consider. On the other hand, in terms of individual happiness or utility, the internet has contributed positively in other ways. For example, the estimated increase in the probability of divorce can be considered a social welfare expansion at the level of the individual due to the decreased cost of searching for a new partner if one is currently unhappy in their marriage. The social welfare impact of the internet is indeed complex, with countervailing effects at the individual and societal levels.

In our future work, we would like to estimate the dynamic impact of the internet on time allocation, solitary time, and marriage. As habits tend to be formed during childhood, increased use of the internet when we are children may lead to habits associated with more solitary activities as adults. This may also affect long-term relationships and marriage, which would have profound implications for future population trends in Japan.

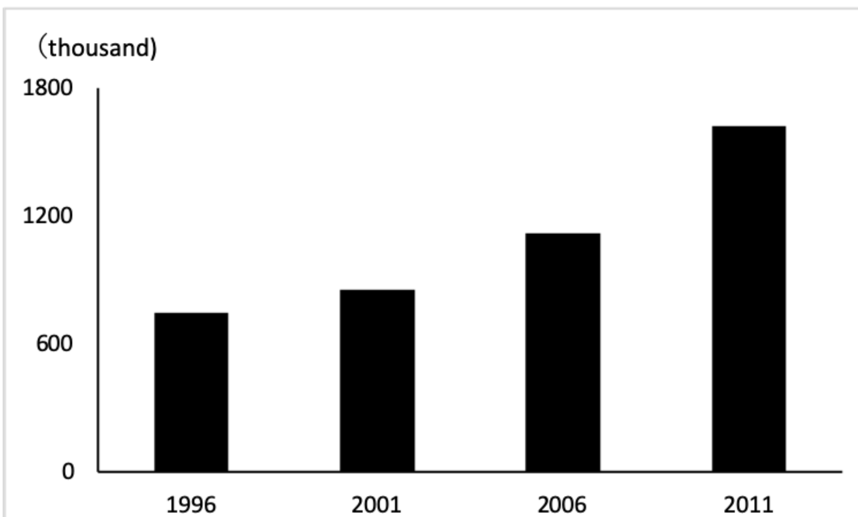

Figure 1: Solitary Non-employed Persons (SNEPs) in Japan
Source: Genda (2013)

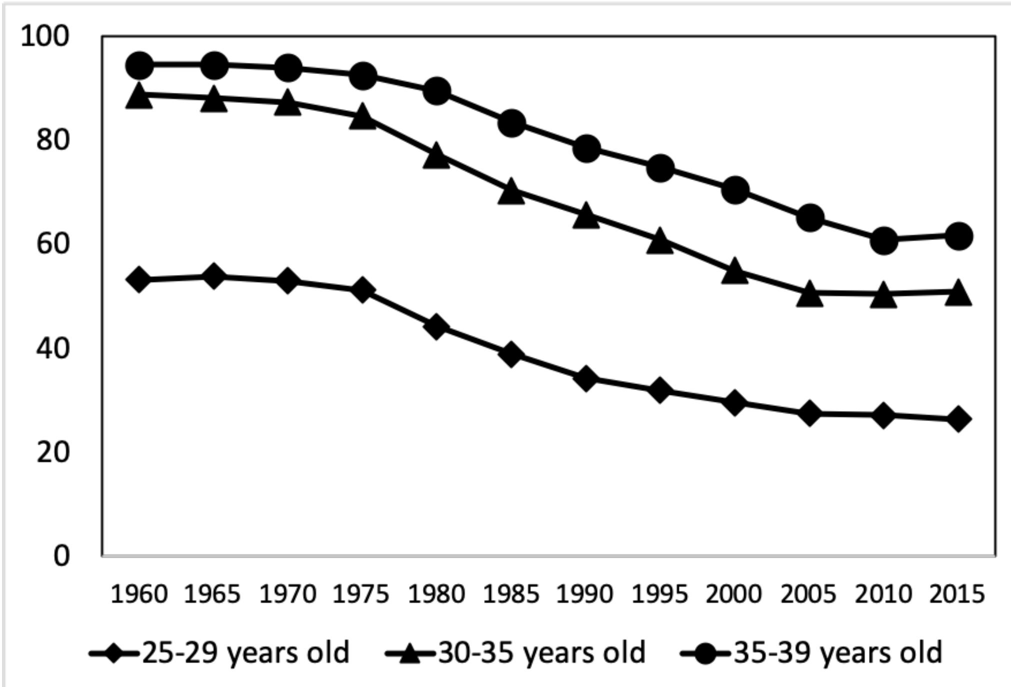

Figure 2: Percentage of Married Males, by Age
Source: Japan Census

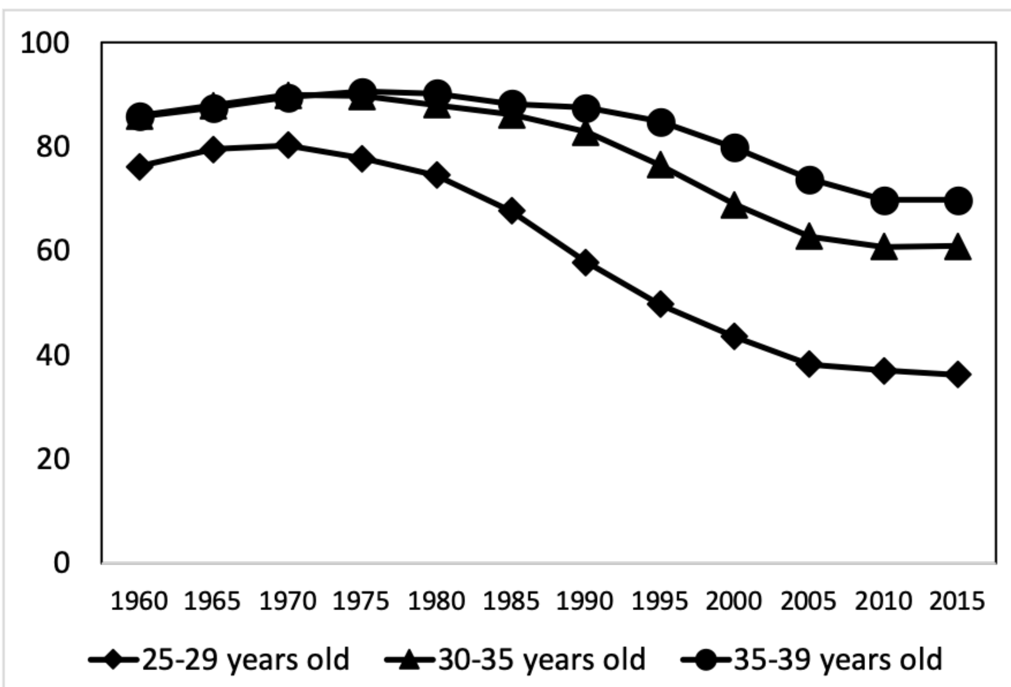

Figure 3: Percentage of Married Females, by Age
Source: Japan Census

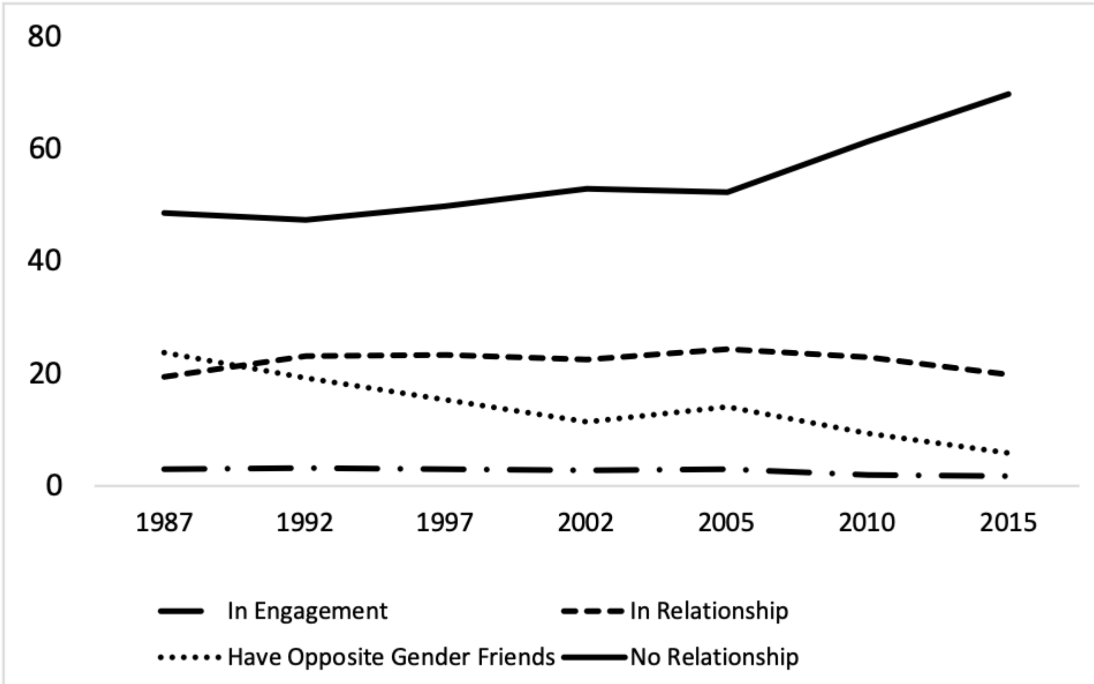

Figure 4: Relationship Status of Single Males Aged 18-34 (Percent)
Source: Annual Population and Social Security Surveys (The National Fertility Survey)

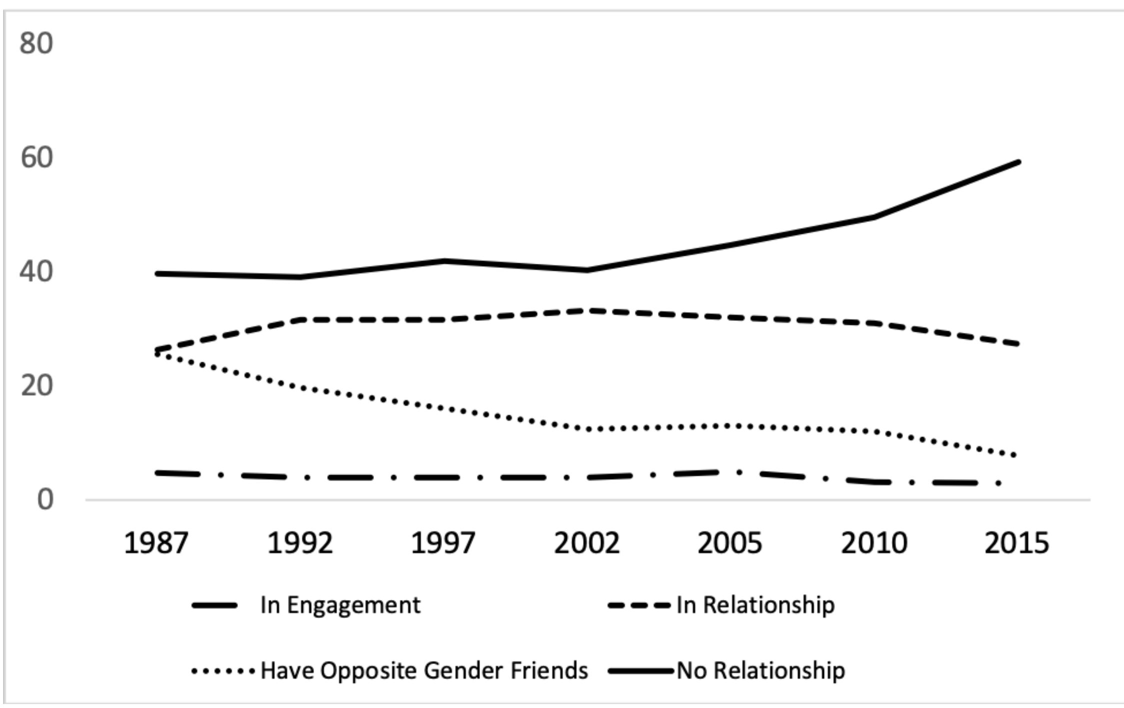

Figure 5: Relationship Status of Single Females Aged 18-34 (Percent)
Source: Annual Population and Social Security Surveys (The National Fertility Survey)

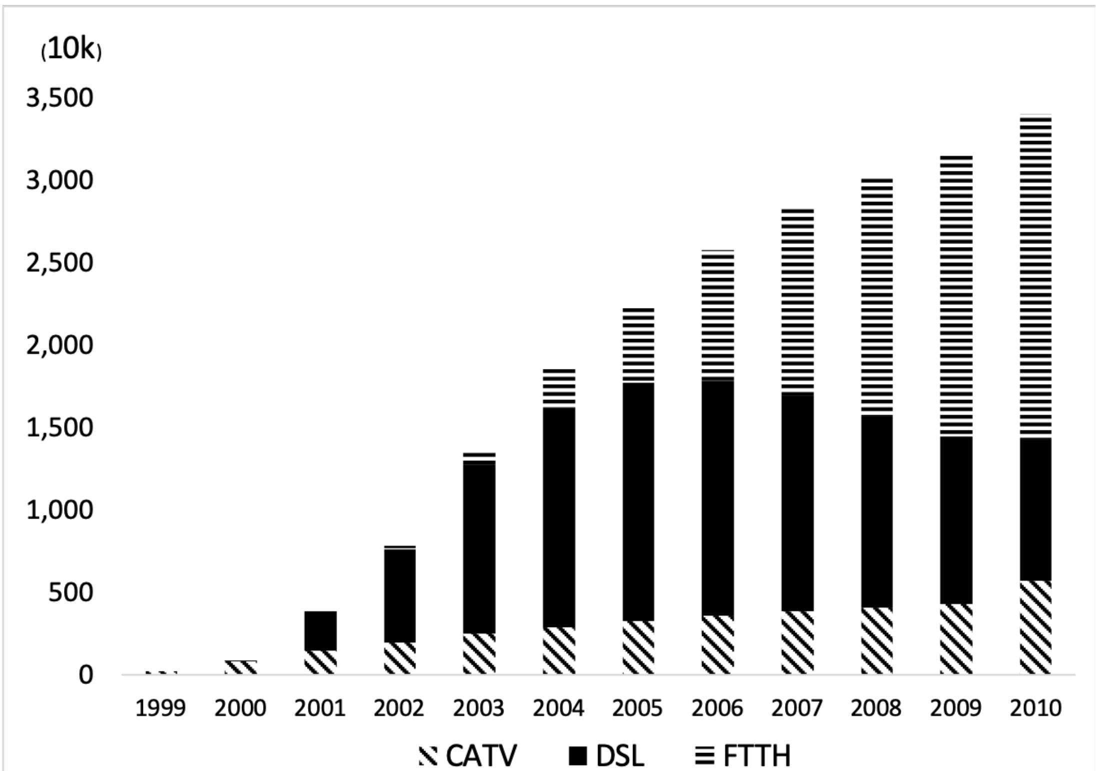

Figure 6: Broadband Internet Subscribers, by Type
Source: Ministry of Internal Affairs and Communications (2010)

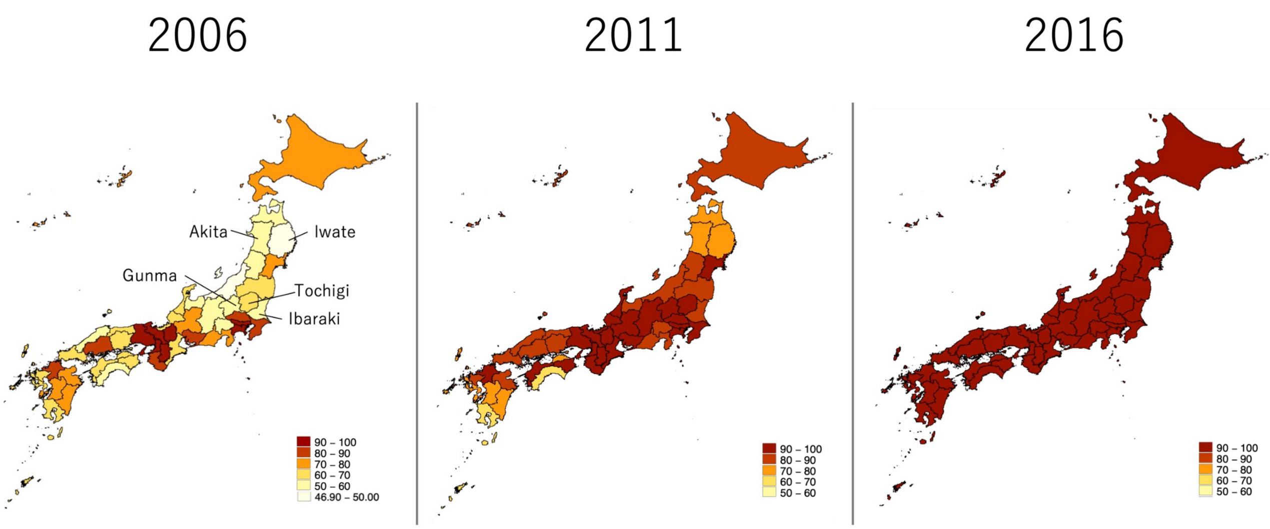

Figure 7: Coverage Rate of FTTH by Prefecture in 2006, 2011, and 2016

Source: Broadband Infrastructure Development Survey, Japan Ministry of Internal Affairs and Communications

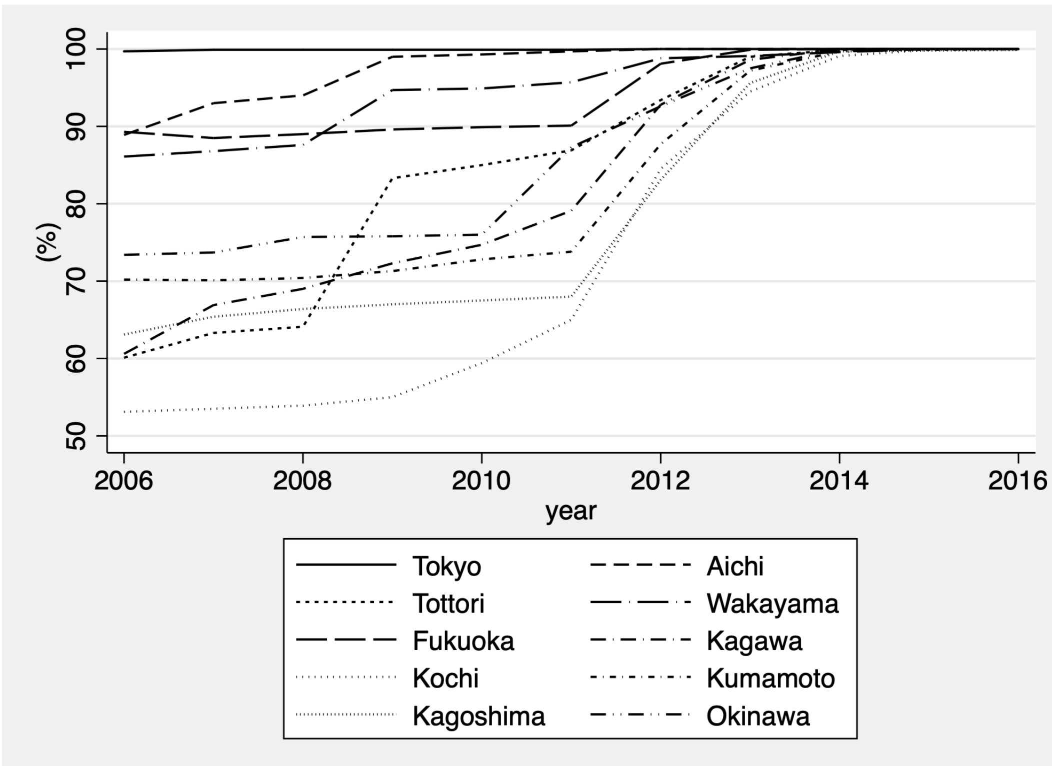

Figure 8: Diffusion Rate of FTTH by Prefecture

Source: Broadband Infrastructure Development Survey, Japan Ministry of Internal Affairs and Communications

Notes: This figure reports the diffusion rate of FTTH broadband internet for 10 selected prefectures.

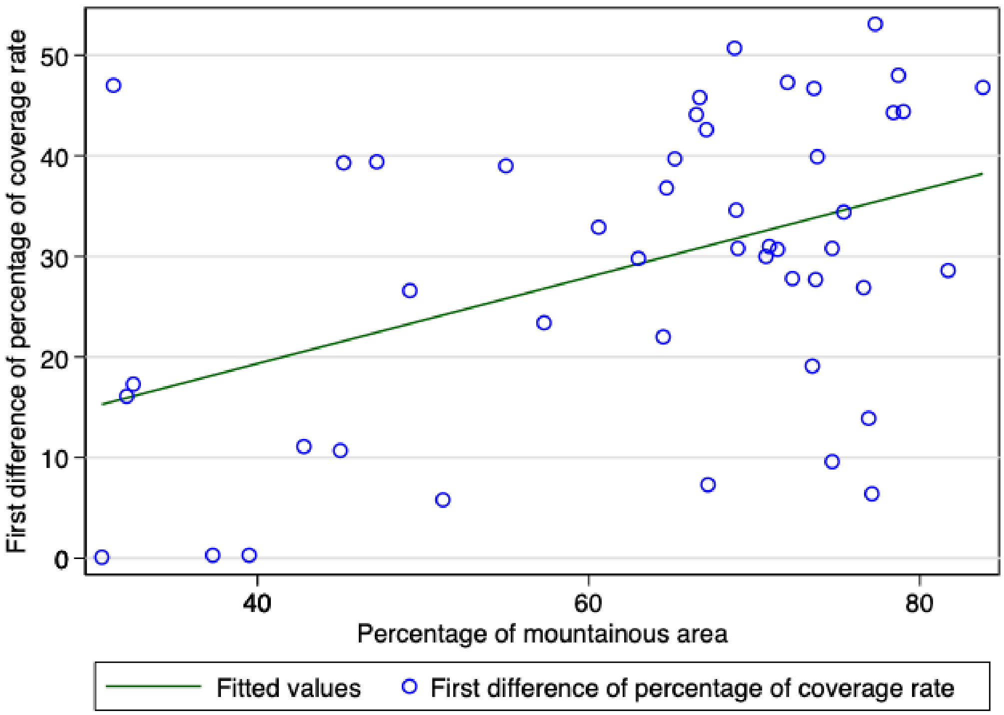

Figure 9: Correlation of Coverage Rate and Percentage of Mountainous Area

Source: Census of Agriculture and Forestry
Notes: This figure shows the scatterplot of the correlation of the first difference in the coverage rate between 2006 and 2016 and percentage of mountainous areas.

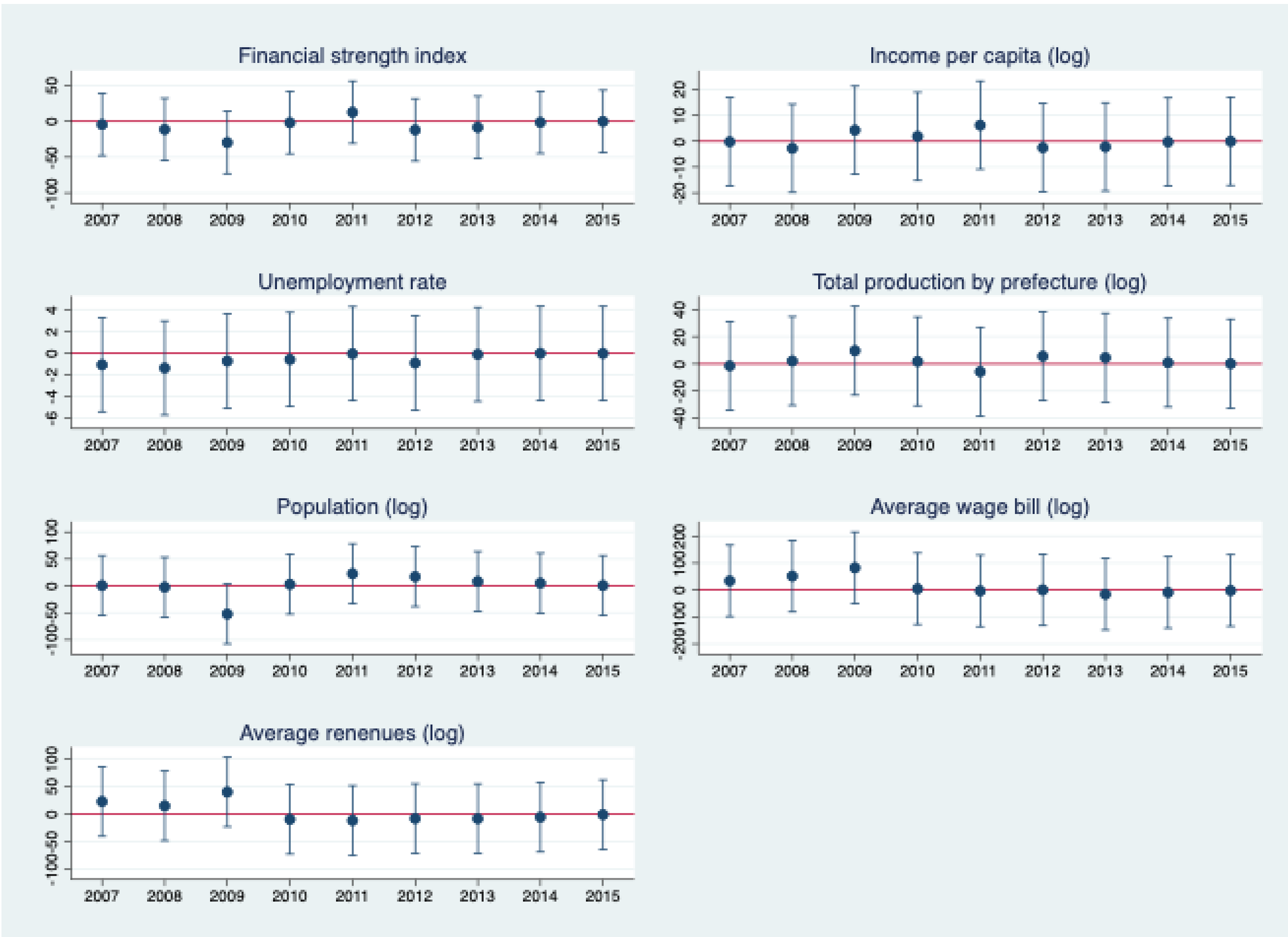

Figure 10: Timing of Broadband Internet Diffusion by Prefecture Characteristics

Notes: This figure reports the estimated coefficients and 95 % confidence intervals of the vector ψ for each year from 2007-2015.

Figure 11: Reduced-Form Relationship between Percentage of Mountainous Area and Working Time, 1995-2000

Notes: This figure reports the coefficients and 95% confidence intervals of the vector $Mountain_p * \theta_t$ from the reduced form estimation, including all control variables. Coefficients are relative to the base year of 2000. The period 1995 to 2000 is prior to the introduction of broadband FTTH internet access.

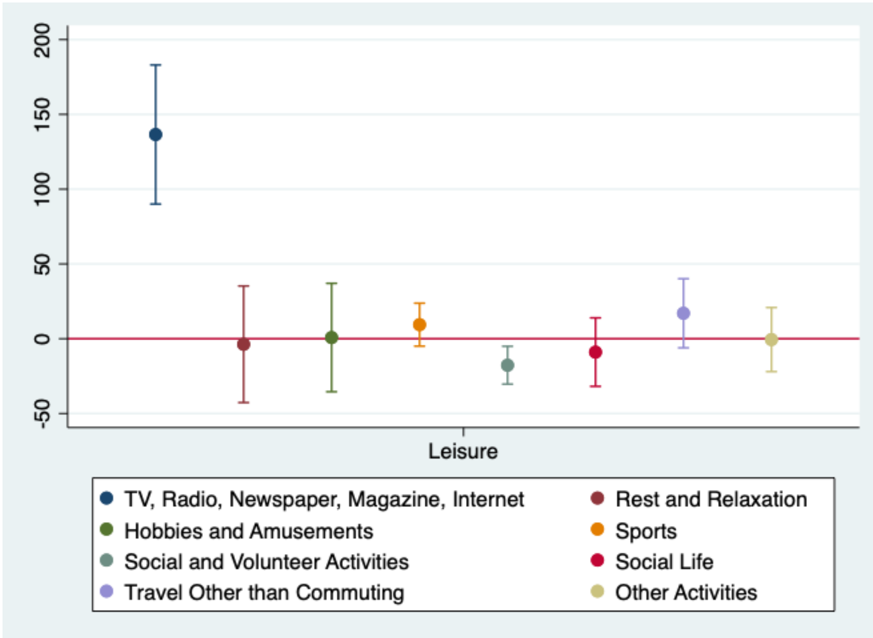

Figure 12: Leisure Time Analysis Results by Category (OLS)

Notes: This figure reports the coefficients and 95% confidence intervals from the OLS estimation, including all control variables.

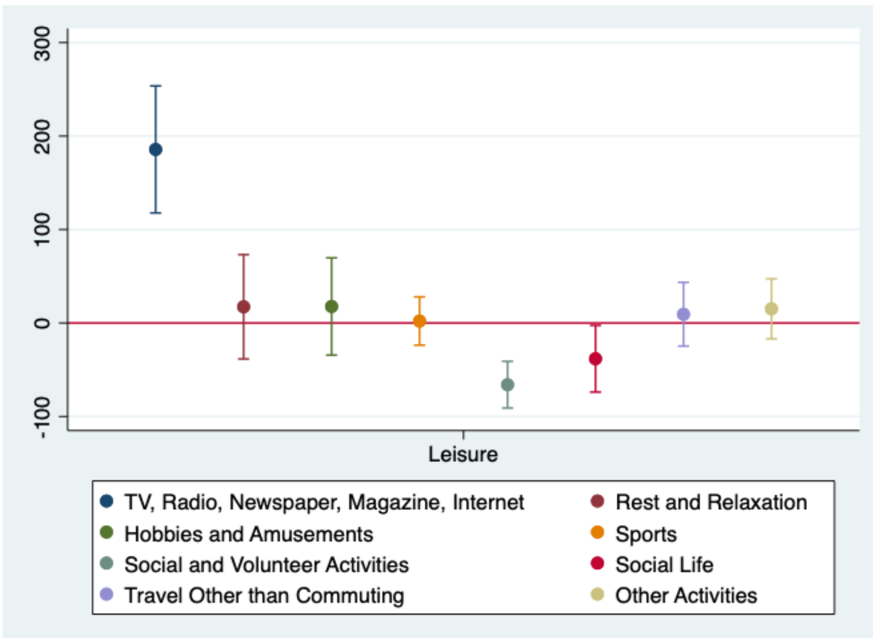

Figure 13: Leisure Time Analysis Results by Category (IV)

Notes: This figure reports the coefficients and 95% confidence intervals from the IV estimation, including all control variables.

Table 1: Summary Statistics 1

			2006	2011	2016
Outcome Variables					
	Working minutes per day		292.15	283.20	289.09
			(301.99)	(304.02)	(308.23)
	Household minutes per day		128.18	130.05	127.54
			(177.01)	(177.06)	(177.27)
	Leisure minutes per day		373.79	378.44	374.29
			(230.20)	(234.76)	(240.88)
	Maintenance minutes per day		183.59	186.20	189.49
			(99.45)	(97.98)	(106.96)
	Solitary minutes per day		309.74	320.04	305.95
			(278.87)	(287.85)	(297.44)
		Solitary working minutes	54.63	53.56	53.85
			(121.11)	(121.25)	(123.97)
		Solitary household minutes	54.35	54.32	48.92
			(105.01)	(103.72)	(99.08)
		Solitary leisure minutes	137.65	146.35	140.81
			(179.81)	(189.97)	(192.49)
		Solitary maintenance minutes	63.09	65.75	62.37
			(82.23)	(83.55)	(88.08)
	Volunteer participation minutes per day		4.63	4.08	14.22
			(37.64)	(34.19)	(54.43)
	Marriage rate		0.66	0.66	0.66
			(0.47)	(0.47)	(0.47)
FTTH broadband coverage rate			0.72	0.89	0.99
			(0.16)	(0.09)	(0.01)
Observations			351,202	351,515	350,744

Notes: Standard errors in parentheses.

Table 2: Summary Statistics 2

			2006	2011	2016
Control Variables					
	Education (%)				
		9 years	0.19	0.17	0.17
			(0.39)	(0.37)	(0.38)
		12 years	0.46	0.44	0.38
			(0.49)	(0.49)	(0.49)
		14 years	0.14	0.16	0.20
			(0.35)	(0.36)	(0.40)
		more than 16 years	0.19	0.21	0.25
			(0.39)	(0.41)	(0.43)
	Income (%)				
		less than 1 million JPY	0.04	0.03	0.04
			(0.21)	(0.19)	(0.19)
		1-1.99 million JPY	0.08	0.07	0.08
			(0.27)	(0.26)	(0.27)
		2-2.99 million JPY	0.11	0.11	0.12
			(0.32)	(0.31)	(0.32)
		3-3.99 million JPY	0.13	0.12	0.12
			(0.34)	(0.33)	(0.32)
		4-4.99 million JPY	0.11	0.11	0.11
			(0.32)	(0.32)	(0.31)
		5-5.99 million JPY	0.10	0.11	0.11
			(0.30)	(0.31)	(0.31)
		6-6.99 million JPY	0.08	0.08	0.09
			(0.20)	(0.28)	(0.29)
		7-7.99 million JPY	0.07	0.07	0.08
			(0.25)	(0.25)	(0.27)
		8-8.99 million JPY	0.06	0.06	0.06
			(0.24)	(0.24)	(0.24)
		9-9.99 million JPY	0.04	0.05	0.05
			(0.21)	(0.21)	(0.22)
		10-14.99 million JPY	0.09	0.10	0.11
			(0.29)	(0.30)	(0.31)
		greater than or equal to 15 million JPY	0.03	0.03	0.04
			(0.17)	(0.18)	(0.19)
	Family type (%)				
		couple	0.10	0.09	0.08
			(0.30)	(0.29)	(0.27)
		couple and kids	0.39	0.40	0.40
			(0.48)	(0.49)	(0.49)
		couple and their parents	0.00	0.00	0.01
			(0.08)	(0.08)	(0.08)
		couple and their single parent	0.02	0.02	0.02
			(0.14)	(0.14)	(0.14)
		couple with kids and their parents	0.05	0.04	0.03
			(0.22)	(0.19)	(0.17)
		couple with kids and their single parent	0.06	0.05	0.04
			(0.25)	(0.23)	(0.20)
		motherless family	0.00	0.00	0.00
			(0.03)	(0.04)	(0.04)
		fatherless family	0.01	0.01	0.01
			(0.11)	(0.11)	(0.11)
		single	0.10	0.11	0.13
			(0.30)	(0.31)	(0.34)
		others	0.12	0.12	0.13
			(0.33)	(0.33)	(0.34)
		older couple	0.09	0.10	0.12
			(0.28)	(0.30)	(0.33)
	Age		46.39	47.86	49.10
			(20.30)	(20.68)	(21.02)
	Gender (Male=1 Female=0)		0.48	0.48	0.49
			(0.49)	(0.49)	(0.50)
Observations			351,202	351,515	350,744

Notes: Standard errors in parentheses.

Table 3: Correlation of Coverage Rate and Percentage of Mountainous Area

	First difference of coverage rate	First difference of coverage rate
Ratio of mountainous area	0.431***	0.266*
	(0.132)	(0.154)
Financial strength index		✓
Income per capita (log)		✓
Unemployment rate		✓
Population (log)		✓
Total production (log)		✓
Average revenues (log)		✓
Average wage bill (log)		✓
Observations	47	47
R-squared	0.191	0.564

Notes: We took the first difference of the coverage rate between 2006 and 2016. We used the data in 2000 for ratio of mountainous area. All other control variables are data in 2006.
Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Time Classification (Lee, Kawaguchi and Hamermesh, 2012)

Working activities	Work
	Schoolwork
	Commuting to/from school or work
	Studying and Researching
Household activities	Housework
	Child Care
	Shopping
Leisure activities	TV, Radio, Newspaper, Magazine, Internet
	Rest and Relaxation
	Hobbies and Amusements
	Sports
	Social and Volunteer and Activities
	Social Life
	Travel Other than Commuting
	Other Activities
Maintenance activities	Personal Care
	Meals
	Medical Examination or Treatment
	Caring and Nursing

Table 5: First Stage Estimates

Dependent variable: coverage rate	
Ratio of mountainous area*2006	-0.074***
	(0.005)
Ratio of mountainous area*2011	-0.035***
	(0.004)
Observations	922,435

Notes: We controlled for the following variables: demographic characteristics including education, age, gender, industry, occupation, and firm size; year and municipality fixed effects; linear trend; and prefectural characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, and log of average wage bill. Standard errors in parentheses are clustered at the prefecture level.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Effects on Time Allocation

	Working time		Household time		Leisure time		Maintenance time	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Coverage rate	-143.6***	-214.7***	57.31**	33.21	119.2***	222.5***	0.275	-47.22
	(49.82)	(59.90)	(27.12)	(34.25)	(39.62)	(52.99)	(17.37)	(41.03)
Observations	922,435	922,435	922,435	922,435	922,435	922,435	922,435	922,435
F-Statistic		76.47		76.47		76.47		76.47
Demographic control	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓
Linear trend	✓	✓	✓	✓	✓	✓	✓	✓
Prefecture characteristics	✓	✓	✓	✓	✓	✓	✓	✓
R-squared	0.259	0.164	0.328	0.303	0.115	0.078	0.076	0.057

Notes: Outcome variables are defined as number of minutes per week. We controlled following variables: demographic variables, which covers education, income, age, gender, and family type, year fixed effects, municipality fixed effects, linear trend, prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill. Clustered standard errors in parentheses. Standard errors are clustered at the prefecture level.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Effects on Solitary Time

	Solitary time		Solitary working time		Solitary household time		Solitary leisure time		Solitary maintenance time	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Coverage rate	68.40	39.64	-64.68**	-80.37***	47.45**	-10.38	83.19***	113.9***	2.450	16.50
	(51.18)	(61.39)	(25.29)	(25.48)	(15.94)	(22.28)	(31.50)	(41.85)	(15.46)	(18.12)
Observations	922,435	922,435	922,435	922,435	922,435	922,435	922,435	922,435	922,435	922,435
F-Statistic		76.47		76.47		76.47		76.47		76.47
Demographic control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Linear trend	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Prefecture characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R-squared	0.073	0.161	0.060	0.042	0.189	0.180	0.073	0.126	0.062	0.153

Notes: Outcome variables are defined as number of minutes per week. We controlled following variables: demographic variables, which covers education, income, age, gender, and family type, year fixed effects, municipality fixed effects, linear trend, prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill. Clustered standard errors in parentheses. Standard errors are clustered at the prefecture level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8: Effects on Social and Volunteer Activities

	Social and Volunteer time	
	OLS	IV
Coverage rate	-19.00***	-66.02***
	(6.379)	(12.75)
Observations	922,435	922,435
F-Statistic		76.47
Demographic control	✓	✓
Year FE	✓	✓
Municipality FE	✓	✓
Linear trend	✓	✓
Prefecture characteristics	✓	✓
R-squared	0.039	0.049

Notes: Outcome variables are defined as number of minutes per week. We controlled following variables: demographic variables, which covers education, income, age, gender, and family type, year fixed effects, municipality fixed effects, linear trend, prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill. Clustered standard errors in parentheses. Standard errors are clustered at the prefecture level.
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Effects on Marriage by Age

	All		Twenties		Thirties		Forties		Fifties	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Coverage rate	0.002	-0.025**	-0.033	-0.158***	-0.056	-0.058	0.026	-0.040	-0.015	-0.028
	(0.010)	(0.011)	(0.037)	(0.045)	(0.035)	(0.039)	(0.024)	(0.028)	(0.021)	(0.022)
Observations	922,435	922,435	80,252	80,252	122,937	122,937	136,889	136,889	146,902	146,902
F-Statistic		76.47		32.17		74.51		90.43		58.92
Demographic control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Linear trend	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Prefecture characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R-squared	0.458	0.471	0.102	0.092	0.074	0.063	0.154	0.141	0.155	0.139

Notes: We controlled following variables: demographic variables, which covers education, income, age, gender, and family type, year fixed effects, municipality fixed effects, linear trend, prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill. 'All' refers to the entire sample, which includes the sample of people in their 60s and older. This table presents the results of the subsample analysis for the under 50s. Clustered standard errors in parentheses. Standard errors are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Effects on Divorce by Age

	All		Twenties		Thirties		Forties		Fifties	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Coverage rate	0.025***	0.026**	0.054*	0.076	0.055**	0.048**	0.104***	0.127***	0.009	0.027
	(0.009)	(0.012)	(0.030)	(0.055)	(0.024)	(0.023)	(0.020)	(0.021)	(0.018)	(0.023)
Observations	922,435	922,435	80,252	80,252	122,937	122,937	136,889	136,889	146,902	146,902
F-Statistic		76.47		32.17		74.51		90.43		58.92
Demographic control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Linear trend	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Prefecture characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R-squared	0.237	0.223	0.069	0.075	0.130	0.129	0.168	0.154	0.120	0.108

Notes: We controlled following variables: demographic variables, which covers education, income, age, gender, and family type, year fixed effects, municipality fixed effects, linear trend, prefecture characteristics including an index of financial strength, log of income per capita, unemployment rate, log of population, log of total production, log of average revenues, log of average wage bill. 'All' refers to the entire sample, which includes the sample of people in their 60s and older. This table presents the results of the subsample analysis for the under 50s. Clustered standard errors in parentheses. Standard errors are clustered at the prefecture level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

References

Aguiar, Mark, Mark Bils, Kerwin Kofi Charles, and Erik Hurst, "Leisure luxuries and the labor supply of young men," *Journal of Political Economy*, 2021, *129* (2), 337–382.

Akerman, Anders, Gaarder Ingvil, and Magne Mogstad, "The skill complementarity of broadband internet," *The Quarterly Journal of Economics*, 2015, *130* (4), 1781–1824.

Antoci, Angelo, Fabio Sabatini, and Mauro Sodini, "Online and offline social participation and social poverty traps: Can social networks save human relations?," *Journal of Mathematical Sociology*, 2015, *39* (4), 229–256.

Arai, Yoshio, Sae Naganuma, and Yasukazu Satake, "Current status and policy responses of broadband development in disadvantaged areas," *University of Tokyo Journal of Human Geography*, 2012, *20*, 14–38.

Bauernschuster, Stefan, Oliver Falck, and Ludger Woessmann, "Surfing alone? The internet and social capital: Evidence from an unforeseeable technological mistake," *Journal of Public Economics*, 2014, *117*, 73–89.

Bhuller, Manudeep, Andreas Ravndal Kostøl, and Trond C. Vigtel, "How broadband internet affects labor market matching," *Working Paper*, 2019.

_, Tarjei Havnes, Edwin Leuven, and Magne Mogstad, "Broadband internet: An information superhighway to sex crime?," *The Review of Economic Studies*, 2013, *80* (4), 1237–1266.

Dettling, Lisa J., "Broadband in the labor market: The impact of residential high-speed internet on married women's labor force participation," *Industrial and Labor Relations Review*, 2017, *70* (2), 451–482.

Ellison, Nicole B., Charles Steinfield, and Cliff Lampe, "The benefits of facebook "friends:" Social capital and college students' use of online social network sites," *Journal of Computer-Mediated Communication*, 2007, *12* (4), 1143–1168.

Falck, Oliver, Robert Gold, and Stephan Heblich, "E-lections: Voting behavior and the internet," *American Economic Review*, 2014, *104* (7), 2238–2265.

Genda, Yuji, "Solitary non-employed persons (SNEPs): A new concept of non-employment," *Japan Labor Review*, 2013, *10* (4), 6–15.

Geraci, Andrea, Mattia Nardotto, Tommaso Reggiani, and Fabio Sabatini, "Broadband internet and social capital," *Working paper*, 2018.

Gürtzgen, Nicole, André Diegmann né Nolte, Laura Pohlan, and Gerard J. van den Berg, "Do digital information technologies help unemployed job seekers find a job? Evidence from the broadband internet expansion in Germany," *European Economic Review*, 2021, *132.*

Kuga, Naoko, "Young people's view of marriage," *Nissei Kisoken Report*, 2013, *191*, 16–25.

Lee, Jungmin, Daiji Kawaguchi, and Daniel S. Hamermesh, "Aggregate impacts of a gift of time," *American Economic Review*, 2012, *102* (3), 612–616.

Ministry of Internal Affairs and Communications, "Results of a fact-finding survey on areas where broadband service is difficult to obtain," Technical Report 2007.

_ , "White Paper on Information and Communications in Japan," 2010.

Olken, Benjamin A., "Do television and radio destroy social capital? Evidence from Indonesian villages," *American Economic Journal: Applied Economics*, 2009, *1* (4), 1–33.

Phan, Tuan Q. and Edoardo M. Airoldi, "A natural experiment of social network formation and dynamics," *Proceedings of the National Academy of Sciences*, 2015, *112* (21), 6595–6600.

No time for love? The impact of ICTs on time allocation and relationships in Japan

本論文では、情報通信技術（ICT）が私たちの社会的交流のあり方を変化させ、その結果、時間配分や人間関係にどのような影響を及ぼしているかを検証している。具体的には、日本におけるブロードバンドインターネット普及率の地域差を用いて、インターネットが時間配分・一人で過ごす時間・社会活動への参加・結婚に対してもたらした影響を検証した。分析の結果、インターネットの普及によって、一人で過ごす時間、特に余暇時間が増加したことが分かった。また、インターネットは私たちの時間配分や社会的交流のあり方を変え、さらに、長期的な視点では、婚姻確率を低下・離婚確率の上昇・一人で過ごす時間の増加によって、社会的不安定性の原因となりうる可能性を示している。