Digital Divide in East Asia:
Evidence from Japan, South Korea and Singapore

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Working Paper Series Vol. 2005-26
November 2005

The International Centre for the Study of East Asian Development, Kitakyushu

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ABSTRACT: We examine the extent and causes of digital inequality in the three countries of East Asia – Japan, South Korea and Singapore. We take advantage of individual-level microdata collected in the three countries between 1997 and 2000, and highlight differences in the socio-economic and demographic patterns of technology adoption, usage, and skills across countries and over time. Despite the high overall rates of ICT diffusion in all three countries, there remains a clear divide in access and use between various demographic groups. We find that household income, education and gender are the key determinants of digital inequality in all three countries, but there is sizeable variation in their magnitudes. In general, we find that inequality in ICT access, use and skills reflects pre-existing inequality in other areas of economy and society in the three countries.

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Introduction

We live in a world immersed in information. Information communication technologies (ICT) such as computers, the Internet and mobile phones facilitate our access to information as well as change the ways in which we process information. Despite the exponential growth of ICT use in recent years, it has become increasingly clear that a separation (or a gap) between information haves- and have-nots is emerging between certain demographic groups and between countries. This gap has come to be known as the "digital divide." The 29 OECD member states contain 90 percent of all Internet users in the world; there are more Internet users in Sweden than in the entire continent of Africa (Norris 2000). International organizations such as the OECD, ILO, United Nations, APEC and the World Bank recognize that the digital divide is a problem that public policy must begin to address.

At the macro level, researchers have theorized and estimated the gains from technological investments vis-à-vis improvements in human capital (Black and Lynch 1996; Nelson and Phelps 1966; Solo 1966). Today, ICT is viewed as a sure investment in an economy's future growth. The U.S. Federal Reserve estimates that two-thirds of the productivity gains achieved in the U.S. in the late 1990s can be attributed to ICT investments. Hoping to follow the U.S.'s lead, Japan, South Korea and a number of other Asian countries have targeted ICT as the key industry for their economies' future prospects and are promoting the industry via government-funded investment in ICT research and development, targeted tax credits and export subsidies. Economists and policymakers advocate that developing countries can take advantage of the "leapfrog effect" by learning from the successful contribution of ICT to economic growth among the developed countries and trying to stimulate the use of ICT by their citizens (Mansell 2001).

The direct returns from such investments may be substantial, but equally important are the social benefits derived from positive externalities associated with ICT diffusion and improvements to the skill base (OECD 2001). Gaining access to ICT leads to higher rates of economic growth because these technologies presumably have large positive spillovers to other facets of the economy, and lead to higher skill and education levels among the workforce.

In this paper, we assess the magnitude of the digital divide within and across countries and over time in the three countries of East Asia – Japan, South Korea and Singapore. We first review the available data and facts regarding differences in ICT access and usage in the three countries. Our empirical contribution is the examination of the determinants of digital inequality within the three countries. Our general hypothesis is that digital inequality reflects pre-existing inequalities in other areas of the economy and society. We therefore examine the possibility that persisting inequality in such areas as gender, education and income levels may carry over to inequality in ICT access and use. We take advantage of individual-level microdata collected in the three countries, and highlight differences in the socio-economic and demographic patterns of technology adoption and usage across countries and over time.

Our study offers contributions in several areas. First, the current study is the first cross-country examination of the digital divide in East Asia using microdata. Scholarly research on the extent, causes and consequences of the digital divide outside of the U.S. remains few. Our research aims to fill this void. The paucity of previous research on the digital divide in East Asia is of grave concern given the importance of technology in these countries' economies and social fabric. Because the social and institutional base between the U.S. and East Asia differ in a variety of ways – e.g. English literacy, gender inequality, racial and ethnic integration, income levels, and human capital base – the determinants of ICT diffusion may not necessarily be consistent nor comparable between the U.S. and East Asia. Our examination of East Asia is further motivated by the diversity in the social, economic and political base among the three countries we consider: Japan accounts for much of the innovations in ICT but has low levels of English literacy, Singapore represents a highly authoritarian political structure where English represents (one of four) official languages, South Korea tends to adopt technologies developed elsewhere and is also viewed as one of the notable examples of leapfrogging in broadband diffusion, etc. These differences suggest that regional generalizations, i.e. generalizing patterns of ICT usage in the Asia region as a whole, may not be appropriate.

Second, our research focus on the digital divide *within* countries complements previous research which has examined the digital divide *across* countries. There is now a sizeable collection of empirical studies assessing ICT diffusion in an international context (Caselli and Coleman II 2001; Chinn and Fairlie 2004; Hargittai 1999; Quibria et al 2003; Wong 2002). These studies mainly consist of macro-level generalizations that rely on economic indicators such as GDP per capita, human capital base and industry competitiveness. To date, we are not aware of studies that have systematically investigated the digital divide at the individual level in a multinational context. Our research results therefore offer the missing link between the macro- and the micro- determinants of ICT diffusion in East Asia.

And third, our data sources allow us to examine changes in the digital divide over time. Most previous studies have examined patterns of differential access and use at a single point in time. However, understanding the dynamics of differential access requires a time perspective (Castells 2001). Generalizations and policy implications based on one-time analysis may therefore be misleading. Certain gaps may be observed at one point but become less (or more) important over time.

Digital Inequality across Countries: The Case of Japan, South Korea and Singapore

In November of 2003, the International Telecommunications Union (ITU) released the results of their Digital Access Index (DAI) project which evaluated ICT accessibility in 178 countries (ITU 2003). 25 countries made the top list of "high access countries," among which 5 were from the Asia-Pacific region. These were the Asian NIEs countries and Japan (ranking in parenthesis): South Korea (4), Hong Kong (7), Taiwan (9), Singapore (14) and Japan (15). The total gain in rankings was equally impressive for the Asian economies. Between 1998 and 2002, South Korea made the greatest improvement in ICT access, followed by Taiwan, Singapore, and Hong Kong. However, ITU also explains that there remains considerable variation in ICT diffusion between the developing and developed economies of Asia. In fact, Wong (2002) explains that the digital divide within Asia is more severe than the existing divide across all countries, particularly in the Internet related areas.[1]

Table 1 shows the commonly used indicators of ICT diffusion in Japan, South Korea and Singapore: Computer ownership at home and the number of Internet users per 100 inhabitants. The years 1997 to 2002 are generally viewed as the growth years of ICT and the data show this.[2] In all three countries, computer ownership and Internet use increased drastically. The majority of households now own computers in their homes, and the majority of individuals now use the Internet. South Korea leads the three countries in both areas.

TABLE 1 ABOUT HERE

What factors lead to differences in ICT diffusion across countries? GDP per capita and education levels are important indicators, but a significant variation remains even after

[1] Wong (2002) explains that "the Asian countries as a group exhibit a *higher* disparity in ICT diffusion than the non-Asian ones, after controlling for their level of economic development or competitiveness" (p.185).
[2] For example, Castells (2001) explains that the period from 1998 to 2000 was the key period in the diffusion of the Internet in the U.S.

controlling for these and other economic indicators. In particular, several studies have shown that the high level of Internet penetration in South Korea is considerably higher than expected given their income level, suggesting that South Korea is an exceptional case. At the same time, these studies have shown that Internet penetration in Japan is lower than expected for their income level, and that Singapore is performing close to predicted levels.[3]

In the case of South Korea, the rapid diffusion of Internet access is often attributed to their successful launch of broadband.[4] Pointing to leapfrogging and path dependency effects, Kim et al (2003) explain that, "higher income countries could adopt dial-up earlier but did not migrate to broadband, (and that) this could be compounded by a leapfrogging effect if late adopter countries chose an Internet access mix that is more heavily slanted towards broadband" (p.14). On the other hand, their regression analysis of 26 OECD countries finds that the inclusion of variables representing competitiveness and policy measures did not produce any significant results in predicting broadband diffusion in these countries. While aggressive government intervention and policy measures in South Korea are frequently attributed to their successful launch of broadband, Kim et al (2003)'s findings suggest that the reason behind the growth of broadband diffusion in South Korea may lie elsewhere.[5]

In a case study approach of ICT diffusion in Japan, South Korea and Singapore, Aizu (2002) emphasizes that successful broadband deployment has less to do with policy and economic factors, and more to do with social factors such as political situation, individual

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[3] Quibria et al (2003) estimate the gap between actual and predicted Internet access rates. The latter is derived from regressions using PPP adjusted GDP per capita data for 157 countries. They find that actual Internet use in South Korea and Singapore are higher than predicted, while actual Internet use in Japan is lower than predicted given their respective income levels. Aizu (2002) conducts similar analysis and finds that GDP per capita underpredicts Internet penetration in South Korea and overpredicts it in Japan.

[4] In June 2002, South Korea had the highest broadband access rate in the world at 19.1 per 100 inhabitants. This was nearly double the access rate of second-ranked Canada with 10.2 per 100 inhabitants (OECD 2003).

[5] One possibility concerns access prices. However, comparing Internet pricing across countries is complicated given the differences in telecommunications infrastructure, regulations, number of providers offering broadband services, and other factors. For example, broadband access rates in Japan are lower than those in South Korea, and are in fact one of the lowest in the world both in absolute and in relative terms (Ismail and Wu 2003). And yet, Japan ranks number 9 among the OECD economies with respect to broadband access per 100 inhabitants (OECD 2003b).

mentality and cultural context.[6] Japan was the case of too many policy initiatives with few results (e.g. "Towards Advanced Information Society" in 1995 and its subsequent action plans released in 1996 and 1998, and the eJapan Strategy in 2001). The highly-authoritarian top-down approach taken in Singapore led to the introduction of Infocomm 21 and SingaporeONE, but these initiatives achieved little success. The tight media control and censorship by the authorities inhibited the incentives to supply content, especially the premium content that is widely available in broadband in other countries.[7] The cultural context under which free political speech is suppressed also did not help in promoting a community of "Netizens." In the case of South Korea, Aizu gives some credit to government policy, but explains that their success had more to do with the grass-roots, bottom-up factors such as the aggressive culture of Netizens. Kim (2002) also supports the cultural hypothesis by emphasizing the Confucian aspect of South Korea. Korean parents approached computers and the Internet not as a new technology or a gadget, but as a medium of education with potential leading to respectable status or promising future.

English ability may be another cultural factor that differentiates one country's access and use of ICT over another.[8] Over 90 percent of online content is in English (OECD 2001) which may be a barrier to access for non-English speaking groups. The fact that English is an official language in Singapore and Hong Kong may be one reason for the successful adoption of ICT there (as indicated by their inclusion in the "high-access countries" [ITU 2003]). In their case study of Internet use in Singapore, ITU (2001) explains that the "widespread use of English in the educational, health, government and corporate business sector has contributed

[6] For review of policy measures to promote ICT diffusion in South Korea, see also Lee (2002) and Park (2002).
[7] According to the World Economic Forum (2003), Singapore ranked number 3 out of 82 countries with regards to government enforcements and restrictions on Internet content.
[8] The role of English ability in ICT adoption has been examined by several scholars, but their findings are limited due to the lack of available data. For example, Caselli and Coleman (2001) examine the determinants of computer-technology adoption using a large sample of countries and conclude that English language skills of the population does not affect the diffusion of computers. However, their measure of English ability is the proportion of the population who speak English as a first language which is a very crude measure. A majority of the countries are assigned the value zero including all European countries (with the exception of Ireland and the U.K.) which undermines the relationship between English language skills and technology adoption.

to Singapore's high Internet access" (p.28). They examine patterns of Internet use across the four official language groups – Chinese, Malay, Tamil and English – and also across groups of different English speaking abilities. They find that those who do not speak English well have a much lower level of Internet usage. In contrast, Ono and Zavodny (*forthcoming*) suggest that the poor English speaking ability among the Japanese population may have been one source behind the slow adoption of computers and the Internet in Japan relative to the U.S.[9] However, in light of the fact that five Asian countries are now classified as "high-access" countries, ITU (2003) suggests that English may no longer be the decisive factor in technology adoption. In other words, English may not be a barrier to access once ICT diffusion reaches a critical mass.

Determinants of Digital Inequality within Countries

An important policy issue concerning digital inequality within countries is that the benefits of ICT are realized by their citizens as a whole, and not by a small group of privileged elites. As Melody (1987) explains, "a major challenge for public policy will be to find methods to ensure that developments in the information and communication sector do not exacerbate class divisions in society and that its benefits are spread across all classes" (Melody 1987, p.1336). In the developed economies, universal service policies which were originally targeted for telephone services, are now focusing on universal access to computers and the Internet.

The extent of the digital divide within countries may depend on the stage of their ICT diffusion process. Optimists argue that ICT diffusion will eventually reach a saturation point. Similar to the trajectories observed by other media such as the television and the telephone,

[9] This is a common cultural stereotype of the Japanese population, but it is also observed in the statistics. For example, according to the Educational Testing Service (ETS), the mean score of the Test of English as a Foreign Language (TOEFL) was 188 in Japan, 209 in South Korea, and 254 in Singapore (ETS 2003). It should be noted, however, that these scores represent the mean scores among the testtakers only, and cannot be interpreted to be the mean score of the population.

high volume will drive down prices, reduce the skill levels required for use, and the gap between the privileged and the unprivileged will eventually diminish (Compaine 2001).

Pessimists argue that certain gaps may diminish over time, but other gaps may not. For example, younger persons are more likely to be online than older persons, but this is most likely a cohort effect (and not a period effect) where the differences among cohorts are expected to diminish with the succession of cohorts. On the other hand, access for the so-called marginalized groups – women, minorities, low-educated and low-income groups – may not improve over time and require some form of policy intervention.

In the countries where the evidence is available, considerable division in access and use remains across various demographic groups.[10] While the findings are confined to a handful of developed economies, unequal access to ICT would presumably be larger among the developing economies given the greater overall degrees of inequality and low rates of ICT diffusion in these countries.

The determinants of digital inequality may not be the same across countries when we consider the possibility that the sources of digital inequality may be rooted in pre-existing inequalities in other areas of society. DiMaggio and Hargittai (2004) explain:

> Technologies adapt to ongoing social practices and concerns rather than "influencing" society as an external force (Fischer 1992). Rather than exploit all the possibilities inherent in new technologies, people use them to do what they are already doing more effectively. Technology may contribute to change by influencing actors' opportunities, constraints, and incentives; but its relationship to the social world is co-evolutionary, not causal.

Comparing digital inequality across countries thus requires a closer examination of the country-specific factors. For example, in the U.S., there is ample evidence that persistent inequality in race and ethnicity carries over to ICT access and use (Fairlie 2003, 2004; Ono and Zavodny 2003b). In Japan where gender inequality remains one of the most pronounced

[10] See DiMaggio and Hargittai (2004) for review of literature in U.S. and elsewhere.

among the industrialized economies, there is a sizeable gender gap in ICT access and use, a pattern which is not observed in the U.S. (Ono and Zavodny [*forthcoming*]).

Table 2 highlights selected indicators of inequality in Japan, South Korea and Singapore in the areas of income, education and gender. The PPP adjusted GDP per capita is shown as a reference point to indicate the countries' relative economic standing. First, the economic indicators of inequality show that Singapore has a high degree of income inequality relative to Japan and South Korea. Second, while adult literacy rates are comparable across the three countries, enrolment in tertiary education and university advancement rates are lowest in Singapore suggesting that inequality in educational attainment would be greater in Singapore than in the other two countries. And third, the gender empowerment measure (GEM), which is the composite indicator of gender inequality standardized across countries by the UNDP, indicates that gender inequality is greatest in South Korea and least in Singapore.[11] The extent to which these pre-existing inequalities carry over to ICT use will be evaluated in our empirical analysis.

TABLE 2 ABOUT HERE

Another area which requires close examination is the gap between access and use. Given the rapid proliferation of ICTs in economically developed countries, individuals are now more likely to have access to ICTs, whether in their homes or elsewhere. However, access and use cannot be taken as synonymous because it conflates the distinction between opportunity and choice (DiMaggio and Hargittai 2004). High levels of access may not

[11] UNDP (2003) defines the Gender Empowerment Measure as follows:

The GEM is a composite indicator that captures gender inequality in three key areas: (1) Political participation and decision-making, as measured by women's and men's percentage shares of parliamentary seats; (2) Economic participation and decision-making power, as measured by two indicators – women's and men's percentage shares of positions as legislators, senior officials and managers and women's and men's percentage shares of professional and technical positions; and (3) Power over economic resources, as measured by women's and men's estimated earned income (PPP US$).

necessarily imply high levels of usage. More computers may be available in homes, work places, or public spheres than before, but certain demographic groups may not be using them.

The evidence concerning the gap between access and use has been documented in several empirical studies. In the U.S., Hoffman et al (2001) find that African Americans are just as likely to use the Internet as whites if they have a computer in their home, and conclude that "access translates into usage" with respect to race (p.89). In the study of college students in the U.S., Shashaani (1997) finds that the primary users of home computers were predominantly male, and explain that "the presence of a computer at home, in itself, may not encourage women to use it" (p.46). In a more recent study, Ono and Zavodny (2004) find that among the sample of households with computers in the U.S., women were less likely than men to use computers and the Internet at home in 1997, but were more likely to use both in 2001. In contrast, among households with computers in Japan, women were less likely to use computers and the Internet than men, and this pattern did not change between the years 1997 to 2001. The gap between access and use may therefore depend on the demographic group, the time period, and the country under observation.

Data

Our empirical investigation is made possible through our exclusive access to a set of high-quality, cross-sectional microdata known as *Cyber Life Observations* (CLO). The CLO data were collected by the Nomura Research Institute to examine technology usage in Japan during the years 1997 to 2001. In 1997 and 2000, NRI conducted international surveys that included South Korea and Singapore. All surveys were conducted in October. Identical questionnaires were distributed in all countries for the various years, allowing us to make consistent comparisons across countries and over time. The age of the respondents ranges from 15 to 59. Sample sizes vary from 500 to 1400 across countries and across survey years.

Sample size and summary statistics are reported in the Appendix. The CLO surveys were designed to monitor the activity of various information and communication technologies and are proprietary data. Questions involve both behavioral aspects of ICT (e.g., use, skills, ownership and expenditures) and attitudinal questions (e.g., views about information security and privacy and the effects of ICT on daily communication). The CLO surveys cover a wide range of ICTs, including personal computers, Internet, mobile phones, and a host of other conventional media such as telephones, televisions and video games.

Demographic characteristics include sex, age, education, and household income. Following convention, dummy variables for marital status and working status were included in all regressions as control variables.[12] Year dummies representing the survey years were included to control for changes over time.

The education variables include less than high school, high school, some college and college plus, where the omitted (or the baseline) variable is less than high school. The category "college plus" includes respondents who attended college and those who attended graduate school. The category "some college" was not available in South Korea.

Household income is included as the log of the household income in the countries' respective currencies. Imputation was used in Japan to overcome the sizeable number of missing cases (about 20 percent of the responses).[13] Results using different specifications of household income in Japan confirmed that the outcome did not crucially depend on the missing cases.

We use logistic regressions to estimate the determinants ICT usage in the following areas: Computer ownership and computer use from home, Internet use from any location, and Internet use from home. Internet use from any location is defined as Internet use from home, school or work. We also examine computer skills measured by typing speed and experience

[12] See for example, Hoffman et al (2001) and Ono and Zavodny (2003a, 2003b).
[13] In South Korea and Singapore, missing cases in household income were negligible – 1.4 and 7.0 percent of the responses, respectively.

of using computers. Typing speed is a self-reported measure in four categories ranging from "can barely type" to "can type fast without looking at the keyboard." Experience of using computers consists of eight categories ranging from "have no previous experience" to "over ten years."

Analysis and Results

We begin by examining mean statistics that show changes over time in ICT access and computer skills. Figures 1 and 2 show changes over time with respect to computer ownership at home, computer use at home, Internet use from any location, and Internet use from home. Both figures show considerable increases over time in all countries in the four areas. The high slope observed in South Korea in all four areas is consistent with their number one ranking in the gains in ICT access reported in ITU's global digital access index. In 1997, penetration rates in South Korea were well below those of Singapore. In 2000, South Korea has achieved similar levels of penetration as Singapore, with the exception of Internet use from home. On the other hand, penetration rates in Japan are found to be consistently below those of Singapore and South Korea.

FIGURES 1 TO 3 ABOUT HERE

Figure 3 shows two indicators which were used to approximate measures of computer skills: Proportion of respondents who reported they can barely type, and the proportion who reported they had no prior experience with computers. In Japan and South Korea, the trendline is downward sloping indicating improvements in both areas. In Singapore, the trendlines in both areas are upward sloping, albeit slightly. However, the test of the equality of means show that the difference between the years was not statistically significant, i.e. there were no improvements in computer skills between 1997 and 2000 in the case of Singapore.[14]

Computer ownership and use

We examine patterns of computer ownership and usage at home in Japan, South Korea and Singapore. All regressions are logits. The year dummies are positive in all regressions with the exception of computer use in Singapore, confirming the general trend that ownership and use of computers have improved over time. Columns (a) of Table 3 report the determinants of computer ownership at home. We observe a clear divide in ownership patterns along the lines of education and income. The second set of regressions reported under columns (b) examines computer use among respondents who own computers in their households.[15] The results show a clear divide across the lines of gender, age and education. In all three countries, women, older persons and the less educated are significantly less likely to use computers at home. One exception is income. In Japan and South Korea (but not in Singapore), household income separates computer owners from non-owners, but does not separate the users from non-users among the computer owners. Although a majority of households now own computers in all three countries (see Figure 1), a divide remains when it comes to their actual usage.

TABLE 3 ABOUT HERE

[14] This is also shown in Table 5 - column (a) and Table 6 - column (a). After controlling for other variables, the year dummies for the logit regressions are found to be statistically insignificant.
[15] We conducted the same analysis using the full sample which corresponds to the summary statistics plotted in Figure 1b, i.e. computer use at home not conditional on computers in the home. The results were almost identical to those among the computer owners, and are not reported here.

Internet use

We next examine patterns of Internet use (Table 4). All regressions are logits. Year dummies are positive in all regressions suggesting that Internet access and use have improved over time.[16] Age, education and income clearly distinguish users from non-users regarding Internet use from any location (columns [a]). In Japan and South Korea, there is also a gender divide where women are less likely to be the users. The second set of regressions examines Internet use from home among respondents with computers in their homes (columns [b]).[17] With the exception of Singapore, household income does not affect Internet use from home once the household is equipped with a computer. The results are otherwise similar to Internet use from any location.

TABLE 4 ABOUT HERE

In general, the results for computer use and Internet use are consistent with previous observations of digital inequality – a divide exists along the lines of gender, age, education and income. With some exceptions, the non-users of computers and the Internet – the so-called marginalized users – tend to be females, older, less educated and have lower income than are the users. Our findings also suggest that access does not necessarily imply usage. Even among the individuals who have computers in their homes, we find a clear divide in its actual usage across the lines of age, gender, education and income.

One pattern which consistently distinguishes Singapore from the other two countries concerns the education effect. While education separates the users from the non-users in all three countries, the coefficients for the education categories in Singapore show that their

[16] The question concerning Internet use from any location was not asked in Japan for the year 2000.
[17] We conducted the same analysis using the full sample which corresponds to the summary statistics plotted in Figure 2b, i.e. Internet use at home not conditional on computers in the home. The results were almost identical to those among the computer owners, and are not reported here.

magnitude is considerably larger than in Japan and South Korea. We observe a similar pattern with respect to household income; the significance level and the magnitude of the income coefficients are consistently larger in Singapore relative to the two other countries. The gap in access and use between the low- versus the high-education groups and between the low- versus the high-income groups is therefore greatest in Singapore. This pattern is also observed regarding computer skills which we take up below.

Computer skills

We next examine differences in computer skills across demographic groups. In Table 5, columns (a) show the results of logits predicting the outcome “can barely type.” Columns (b) show the results of ordered logits predicting the four category outcome of typing speed ranging from “can barely type” to “can type without looking at the keyboard.” Age, education and income are found to be strong predictors of typing speed. More education and higher income are associated with faster levels of typing speed, while age has the opposite effect. One exception is in South Korea where household income is not associated with faster typing speed. Gender is one area which shows some variation in the outcome across countries. In Japan, women were significantly more likely to report that they can barely type. In Singapore, women were more likely to report faster typing speed than men.

TABLE 5 ABOUT HERE

Columns (a) of Table 6 show the results of logits predicting the outcome that the respondent had no prior experience with computers. Columns (b) show the results of ordered logits predicting the eight category outcome of prior computer experience ranging from zero to over ten years. Again, age, education and household income are all statistically significant with the predicted signs. More education and higher income are associated with longer experience of using computers, while older persons had less experience with computers. With regards to gender, women in Japan and South Korea have significantly less experience than men, while women in Singapore are just as experienced as men.

Similar to our previous findings on access and use of computers and the Internet, we find that education and income have a larger impact on computer skills in Singapore than in the other two countries.

TABLE 6 ABOUT HERE

Predictions

We have thus far identified the key determinants of digital inequality in the three countries. We next use the results from our analysis to predict ICT access and use in the four key categories of gender, age, income and education. In Table 7, we highlight the areas where inequality was found to be the greatest. The boxes marked by dotted lines indicate areas where inequality was greater than a factor of 5, and the boxes marked by the solid lines indicate areas where it was greater than a factor of 10. For example, in the case of Internet use from any location, the gap between the low- versus the high-education group in Japan was greater than 5.

Inequality is smallest in the area of computer ownership in the home. The high penetration rates of computers achieved by all three countries may have successfully alleviated the divide at least with regards to access in the home. On the other hand, there is still considerable inequality when it comes to the actual usage of computers and the Internet, and also in the ability to type (or use the keyboard). The results again highlight the discrepancy between access and use.

A comparison of the three countries suggests that inequality is greatest in Singapore, especially in the education category. In particular, Internet use from any location among the low-education group is extremely low at merely one percent in comparison to 90 percent among the high-education group. Moreover, the usage rate is not affected by the presence of computers in the home. Inequality in computer skills is also sizeable. Over 90 percent in the low-education group reported that they can barely type, and that they had no previous experience with computers.

The predictions again highlight the marginalized groups of ICT users – the older, low-educated, and low-income individuals. On the other hand, gender is a category where inequality is found to be smallest. While the gender gap remains in various areas of ICT access and use, its magnitude is smaller in comparison to the other demographic categories examined here.

TABLE 7 ABOUT HERE

Changes in determinants of digital inequality over time

Our final analysis examines changes in the determinants of digital inequality over time. For all regressions reported in Tables 3 to 6, we reran the regressions by including an interaction effect with the survey year dummy for all variables. The coefficients for the interaction effects indicate whether the effects significantly differ in 2000 as opposed to 1997.[18] In the interest of space, we present a summary table of the findings in Table 8. Only

[18] For example, in the logit used to predict Internet use, we have:

$$\text{Logit}\,[P(\textit{Internet use} = 1)] = \alpha + \beta_1\,\textit{gender} + \beta_2\,\textit{gender*year} + \beta_3\,\textit{year} + \ldots$$

where the variable *year* is the dummy variable for the year 2000 (versus the baseline year of 1997). In this example, the coefficient β_2 shows whether the change in the effect of gender on Internet use was statistically significant or not in the year 2000 compared to 1997. In our analysis, interactions with survey year were included for all variables. In Japan, we examine the years 1997 and 2000 (and drop the sample for the other years) to allow consistent comparisons with the other two countries.

the variables which showed significant changes over time are reported here with their respective signs. To give one example, in the case of computer use at home in South Korea, we find that the interaction effect for age is positive. The interpretation here is that older persons were more likely to use computers in 2000 than they were in 1997.

TABLE 8 ABOUT HERE

In general, our analysis shows few changes in the determinants of digital inequality over the period 1997 to 2000. In Japan, older persons were less likely to use computers at home than they did in 2000. Aside from this, there were no changes in any of the variables examined here. In South Korea, there are some signs that digital inequality is narrowing. Compared to 1997, older persons are now more likely to use computers at home, women are more likely to use the Internet from home, and lower income individuals are less likely to respond that they can barely type. In contrast, the divide seems to be widening in Singapore. Compared to 1997, older persons are now less likely to use Internet from any location or from home, lower income individuals are less likely to use the Internet from any location, and older persons are more likely to report slower typing speed.

Summary and conclusions

This paper has examined the extent and causes of digital inequality in the three countries of East Asia – Japan, South Korea and Singapore. These countries were classified as "high-access countries" according to the ITU (2003). Despite their high overall rates of ICT diffusion, there remains a clear divide in access and use between various demographic groups. In general, we find that inequality in ICT access, use and skills reflects pre-existing inequality in other areas of economy and society in the three countries.

Our analysis confirms that the main determinants of digital inequality within countries are age, gender, education and income, but there is considerable variation in their magnitudes. In Japan and South Korea, women are less likely to use the computers and the Internet than men. In Singapore, gender inequality is less pronounced, but the separation between the users and the non-users by education and income is considerably larger than in the other two countries.

We also confirm that there remains a noticeable gap between access and use in each of the three countries. While a majority of the households now own computers in all three countries, we find a clear divide across demographic groups when it comes to its actual usage. Access therefore does not translate into usage at least in the three countries that we have examined here.

The countries that we have examined in our research are the economically advanced countries of Asia. However, as noted by Wong (2002) and others, there remains a deep divide in ICT access and use within the Asia region. Future research could therefore benefit from the inclusion of developing economies, which would allow us to draw broader implications concerning the state of digital inequality in Asia.

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Table 1 Computer ownership and Internet use in Japan, South Korea and Singapore

	Japan		South Korea		Singapore	
	PC ownership	Internet use	PC ownership	Internet use	PC ownership	Internet use
1997	-	9.2	43.2	-	41.0	-
1998	25.2	13.4	44.5	-	-	-
1999	-	21.4	51.8	22.4	58.9	24.4
2000	38.6	37.1	68.7	44.7	61.0	43.4
2001	50.1	44.0	76.6	56.6	63.9	-
2002	57.2	54.5	78.6	59.4	68.4	50.3

SOURCE: Japan: Economic and Social Research Institute (ESRI). Korea: National Internet Development Agency of Korea (NIDA). Singapore: Computer ownership data taken from Infocomm Development Authority (IDA), Internet use data taken from ITU.

Table 2 Selected indicators of inequality in Japan, South Korea and Singapore

	Japan	South Korea	Singapore
GDP per capita (PPP USD)	26,940	16,950	24,040
Gini index of inequality	24.9	31.6	42.5
Ratio of richest 10% to poorest 10%	4.5	7.8	17.7
Adult literacy	99.5	97.9	92.5
Enrolment in tertiary education	47.7	52.0	33.7
Advancement rate to university	41.0	49.0	22.3
Gender Empowerment Measure (GEM) rank	44	63	26

Enrolment in tertiary education from UNESCO (2002); Advancement rate to university from OECD (2003). All other data from UNDP (2003).

Table 3 Computer ownership and use at home

	(a) PC at home						(b) Use PC at home cond'l on PC at home					
	Japan		S. Korea		Singapore		Japan		S. Korea		Singapore	
Female	-0.007		0.099		0.126		-0.914	**	-1.100	**	-0.558	*
	(0.058)		(0.158)		(0.167)		(0.089)		(0.243)		(0.276)	
Age	-0.008	**	0.032	**	0.017		-0.044	**	-0.098	**	-0.098	**
	(0.003)		(0.009)		(0.010)		(0.005)		(0.014)		(0.017)	
High school	0.501	**	0.146		0.376		0.926	**	0.845	**	2.680	**
	(0.118)		(0.201)		(0.208)		(0.224)		(0.282)		(0.545)	
Some college	0.959	**			1.460	**	1.350	**			3.882	**
	(0.141)				(0.298)		(0.248)				(0.606)	
College +	1.373	**	1.041	**	2.553	**	1.881	**	1.903	**	4.232	**
	(0.128)		(0.232)		(0.459)		(0.232)		(0.311)		(0.691)	
Logged income	0.702	**	0.881	**	0.997	**	0.020		0.247		0.633	*
	(0.051)		(0.129)		(0.127)		(0.079)		(0.194)		(0.269)	
Married	0.074		-0.859	**	0.044		0.226		-0.423		-0.214	
	(0.071)		(0.203)		(0.226)		(0.120)		(0.323)		(0.430)	
Working	-0.099		-0.238		-0.619	**	0.570	**	0.037		0.364	
	(0.063)		(0.163)		(0.177)		(0.099)		(0.259)		(0.298)	
Year 1998	0.189	*					0.051					
	(0.084)						(0.142)					
Year 1999	0.406	**					0.246					
	(0.084)						(0.142)					
Year 2000	0.978	**	1.263	**	0.449	**	0.414	**	0.768	**	0.219	
	(0.083)		(0.151)		(0.154)		(0.136)		(0.239)		(0.263)	
Year 2001	1.299	**					0.748	**				
	(0.084)						(0.134)					
Constant	-12.090	**	-15.846	**	-11.086	**	0.078		-1.075		-5.045	
	(0.788)		(2.192)		(1.305)		(1.230)		(3.291)		(2.709)	
Log-likelihood	-4,281		-595		-515		-1,834		-266		-205	
N	6,902		996		941		3,153		582		592	

* $p < 0.05$, ** $p < 0.01$. Standard errors are in parentheses and are White-corrected for individual-specific heteroscedasticity.

Table 4 Internet use by location

	(a) Use Internet from any location						(b) Use Internet from home cond'l on PC at home					
	Japan		S. Korea		Singapore		Japan		S. Korea		Singapore	
Female	-0.657	**	-0.660	**	-0.097		-0.575	**	-0.445	*	-0.296	
	(0.080)		(0.188)		(0.189)		(0.091)		(0.219)		(0.226)	
Age	-0.044	**	-0.049	**	-0.059	**	-0.043	**	-0.052	**	-0.048	**
	(0.004)		(0.011)		(0.011)		(0.005)		(0.013)		(0.014)	
High school	1.060	**	0.555	*	4.162	**	0.687	*	0.392		3.611	**
	(0.228)		(0.275)		(0.981)		(0.273)		(0.304)		(0.982)	
Some college	1.711	**			5.447	**	1.105	**			4.504	**
	(0.250)				(1.003)		(0.294)				(1.021)	
College +	2.473	**	2.187	**	6.646	**	1.556	**	1.326	**	5.540	**
	(0.231)		(0.295)		(1.054)		(0.276)		(0.318)		(1.053)	
Logged income	0.468	**	0.552	**	0.807	**	0.028		0.191		0.545	**
	(0.067)		(0.152)		(0.157)		(0.080)		(0.171)		(0.197)	
Married	-0.005		-1.254	**	-0.240		0.183		-0.632	*	-0.528	
	(0.095)		(0.223)		(0.238)		(0.124)		(0.280)		(0.312)	
Working	0.565	**	-0.011		0.284		0.530	**	0.156		0.271	
	(0.088)		(0.197)		(0.203)		(0.104)		(0.232)		(0.262)	
Year 1998	0.552	**					0.265					
	(0.115)						(0.167)					
Year 1999	1.115	**					0.890	**				
	(0.113)						(0.160)					
Year 2000			2.368	**	1.175	**	1.303	**	1.455	**	1.516	**
			(0.215)		(0.190)		(0.153)		(0.231)		(0.239)	
Year 2001	1.987	**					1.914	**				
	(0.111)						(0.150)					
Constant	-9.412	**	-9.812	**	-11.779	**	-1.716		-3.193		-8.593	**
	(1.053)		(2.598)		(1.602)		(1.264)		(2.947)		(1.920)	
Log-likelihood	-2,450		-412		-384		-1,778		-307		-271	
N	5,544		996		941		3,153		582		592	

* $p < 0.05$, ** $p < 0.01$. Standard errors are in parentheses and are White-corrected for individual-specific heteroscedasticity. Question concerning Internet use from anywhere not available in the year 2000 survey in Japan.

Table 5 Computer skills

	(a) Can barely type						(b) Typing speed					
	Japan		S. Korea		Singapore		Japan		S. Korea		Singapore	
Female	0.218	**	0.028		-0.052		0.022		-0.021		0.410	**
	(0.065)		(0.182)		(0.217)		(0.052)		(0.142)		(0.141)	
Age	0.062	**	0.085	**	0.069	**	-0.059	**	-0.086	**	-0.049	**
	(0.003)		(0.010)		(0.012)		(0.003)		(0.009)		(0.009)	
High school	-1.228	**	-1.061	**	-2.526	**	1.252	**	0.771	**	2.803	**
	(0.115)		(0.236)		(0.309)		(0.109)		(0.205)		(0.287)	
Some college	-1.944	**			-4.297	**	1.988	**			3.779	**
	(0.146)				(0.470)		(0.129)				(0.307)	
College +	-2.563	**	-2.720	**	-4.921	**	2.493	**	2.221	**	4.242	**
	(0.139)		(0.287)		(0.764)		(0.117)		(0.213)		(0.331)	
Logged income	-0.477	**	-0.585	**	-0.889	**	0.407	**	0.161		0.605	**
	(0.055)		(0.149)		(0.173)		(0.043)		(0.110)		(0.118)	
Married	-0.133		0.932	**	0.611		0.112		-0.672	**	-0.088	
	(0.081)		(0.248)		(0.324)		(0.065)		(0.175)		(0.176)	
Working	-0.340	**	-0.107		-0.397		0.630	**	-0.029		0.535	**
	(0.073)		(0.193)		(0.232)		(0.057)		(0.148)		(0.159)	
Year 1998	-0.011						0.064					
	(0.089)						(0.073)					
Year 1999	-0.192	*					0.228	**				
	(0.090)						(0.073)					
Year 2000	-0.389	**	-0.643	**	0.270		0.349	**	0.561	**	0.181	
	(0.093)		(0.176)		(0.202)		(0.073)		(0.134)		(0.133)	
Year 2001	-0.611	**					0.569	**				
	(0.095)						(0.073)					
Constant	6.105	**	7.239	**	8.153	**						
	(0.836)		(2.486)		(1.751)							
Log-likelihood	-3,542		-431		-327		-7,714		-1,041		-973	
N	6,906		996		941		6,906		996		941	

* $p < 0.05$, ** $p < 0.01$. Standard errors are in parentheses and are White-corrected for individual-specific heteroscedasticity.

Table 6 Experience with computers

	(a) No prior experience with PC						(b) PC history					
	Japan		S. Korea		Singapore		Japan		S. Korea		Singapore	
Female	0.393	**	0.201		0.013		-0.400	**	-0.370	**	0.027	
	(0.062)		(0.175)		(0.204)		(0.049)		(0.129)		(0.133)	
Age	0.064	**	0.072	**	0.066	**	-0.051	**	-0.070	**	-0.038	**
	(0.003)		(0.010)		(0.012)		(0.003)		(0.009)		(0.009)	
High school	-1.116	**	-1.017	**	-2.623	**	1.219	**	0.843	**	2.915	**
	(0.126)		(0.233)		(0.336)		(0.115)		(0.189)		(0.329)	
Some college	-1.707	**			-3.920	**	1.793	**			4.010	**
	(0.149)				(0.419)		(0.132)				(0.350)	
College +	-2.446	**	-2.505	**	-4.934	**	2.269	**	2.207	**	4.726	**
	(0.140)		(0.270)		(0.679)		(0.120)		(0.201)		(0.375)	
Logged income	-0.558	**	-0.615	**	-0.792	**	0.436	**	0.492	**	0.777	**
	(0.054)		(0.144)		(0.158)		(0.042)		(0.111)		(0.103)	
Married	0.147		0.850	**	0.549		0.203	**	-0.238		0.235	
	(0.078)		(0.227)		(0.307)		(0.066)		(0.172)		(0.181)	
Working	-0.473	**	-0.023		-0.407		0.667	**	0.152		0.550	**
	(0.069)		(0.184)		(0.215)		(0.052)		(0.134)		(0.151)	
Year 1998	-0.023						0.085					
	(0.088)						(0.077)					
Year 1999	-0.221	*					0.274	**				
	(0.087)						(0.076)					
Year 2000	-0.541	**	-0.834	**	-0.110		0.409	**	0.815	**	0.358	**
	(0.089)		(0.168)		(0.192)		(0.072)		(0.129)		(0.130)	
Year 2001	-0.943	**					0.733	**				
	(0.091)						(0.072)					
Constant	7.747	**	8.515	**	7.850	**						
	(0.827)		(2.403)		(1.567)							
Log-likelihood	-3,783		-471		-357		-11,287		-1,473		-1424	
N	6,902		996		941		6,902		996		941	

* $p < 0.05$, ** $p < 0.01$. Standard errors are in parentheses and are White-corrected for individual-specific heteroscedasticity.

Table 7 Predictions by gender, age, income and education categories

		Japan	S. Korea	Singapore
PC at home	Men	0.47	0.60	0.62
	Women	0.44	0.57	0.63
	Age less than 25	0.48	0.58	0.64
	Age greater than 50	0.41	0.59	0.62
	Less than HS	0.24	0.50	0.47
	College +	0.65	0.73	0.94
	HH income bottom 10%	0.20	0.23	0.28
	HH income top 10%	0.61	0.73	0.89
Use PC at home cond'l on PC at home	Men	0.72	0.68	0.76
	Women	0.46	0.47	0.58
	Age less than 25	0.69	0.84	0.95
	Age greater than 50	0.44	0.14	0.23
	Less than HS	0.26	0.27	0.04
	College +	0.78	0.80	0.94
	HH income bottom 10%	0.61	0.28	0.26
	HH income top 10%	0.59	0.62	0.83
Use Internet from any location	Men	0.34	0.40	0.48
	Women	0.18	0.23	0.37
	Age less than 25	0.34	0.47	0.67
	Age greater than 50	0.15	0.08	0.14
	Less than HS	0.06	0.11	0.01
	College +	0.53	0.56	0.90
	HH income bottom 10%	0.16	0.05	0.09
	HH income top 10%	0.35	0.37	0.73
Use Internet from home cond'l on PC at home	Men	0.46	0.42	0.58
	Women	0.29	0.30	0.42
	Age less than 25	0.46	0.49	0.74
	Age greater than 50	0.24	0.12	0.20
	Less than HS	0.15	0.18	0.01
	College +	0.54	0.52	0.83
	HH income bottom 10%	0.42	0.13	0.20
	HH income top 10%	0.36	0.37	0.70
Can barely type	Men	0.27	0.35	0.30
	Women	0.36	0.43	0.40
	Age less than 25	0.16	0.11	0.08
	Age greater than 50	0.54	0.86	0.74
	Less than HS	0.74	0.76	0.92
	College +	0.11	0.11	0.02
	HH income bottom 10%	0.50	0.73	0.84
	HH income top 10%	0.23	0.30	0.11
PC history zero	Men	0.36	0.39	0.34
	Women	0.51	0.50	0.44
	Age less than 25	0.23	0.18	0.11
	Age greater than 50	0.68	0.86	0.76
	Less than HS	0.81	0.79	0.94
	College +	0.18	0.16	0.03
	HH income bottom 10%	0.62	0.79	0.84
	HH income top 10%	0.33	0.34	0.14

Dotted boxes indicate areas where inequality is greater than a factor of 5.
Solid boxes indicate areas where inequality is greater than a factor of 10.

Table 8 Changes in ICT inequality over time

	Japan	S. Korea	Singapore
Own PC at home	None	None	None
Use PC at home cond'l on PC at home	Age (-)	Age (+)	None
Use Internet from any location	None	None	Age (-) HH income (+)
Use Internet from home cond'l on PC at home	None	Female (+)	Age (-)
Type speed zero	None	HH income (+)	None
PC history zero	None	None	None
Type speed	None	None	Age (-)
PC history	None	None	None

Table A.1 Sample size by country and survey year

	Japan	South Korea	Singapore
1997	1,409	500	505
1998	1,431	-	-
1999	1,410	-	-
2000	1,402	510	507
2001	1,414	-	-
Total	7,066	1,010	1,012

Table A.2 Summary statistics

	Japan		South Korea		Singapore	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Female	0.495	(0.500)	0.491	(0.500)	0.493	(0.500)
Age	37.947	(12.543)	34.802	(11.845)	35.695	(11.869)
Married	0.665	(0.472)	0.650	(0.477)	0.655	(0.476)
Working	0.714	(0.452)	0.546	(0.498)	0.595	(0.491)
High school	0.596	(0.491)	0.508	(0.500)	0.473	(0.500)
Some college	0.104	(0.305)	-	-	0.208	(0.406)
College +	0.229	(0.420)	0.289	(0.454)	0.117	(0.321)
Logged household income	15.596	(0.591)	16.753	(0.613)	10.491	(0.716)

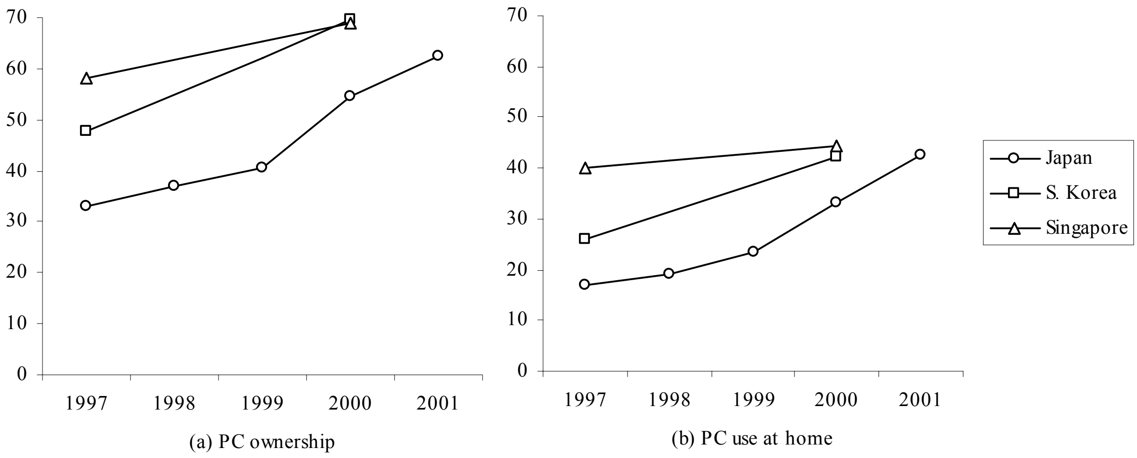

Figure 1 Computer ownership and computer use at home (%)

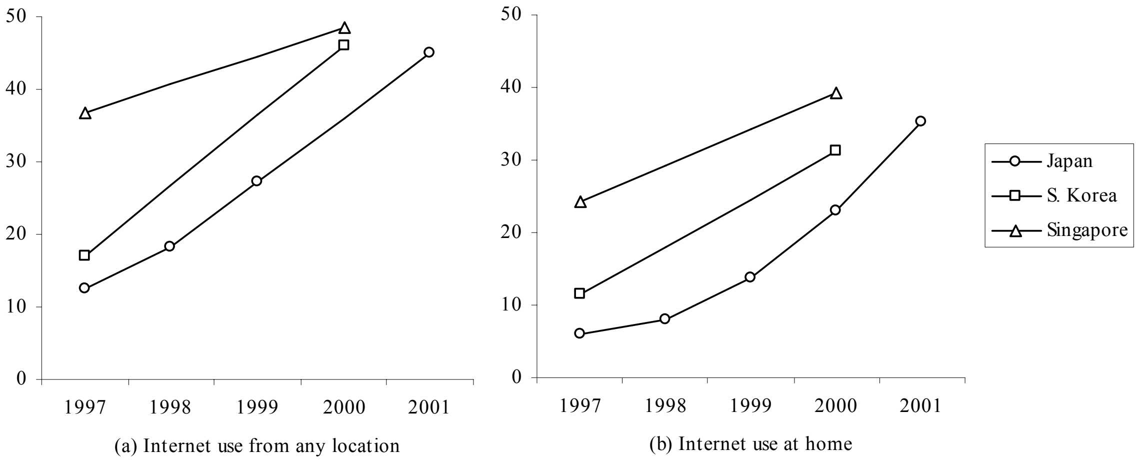

Figure 2 Internet use by location (%)

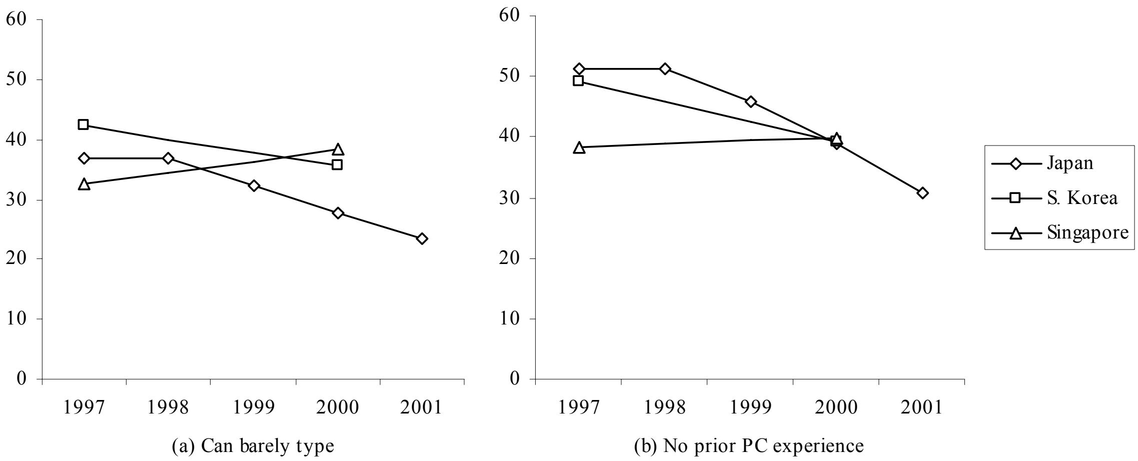

Figure 3 Computer skills and prior experience with computers (%)