2B07 高度情報化社会における社会経済体質とその技術政策への影響

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1. Introduction

Telecommunication technology has undoubtedly attracted much attention and penetrated into this world overwhelmingly during these twenty years. With the global telecommunication deregulation, numerous telecom monopolies were broken, thus enabling new players to emerge in the market place. Continuing technological innovations in computing and telecommunications have made the Internet and associated Web services available worldwide (Joe Z. Cheng, 2003 [1]). Among ICT technologies, mobile phone could be considered as a prominent sector when it comes to diffusion issues. As illustrated in **Fig. 1**, number of mobile phone user has surged up rapidly since 1980. Moreover, according to ITU (International Telecommunication Union), the figure has gone over one billion in the middle of 2002 and it declared a new era that mobile phone subscribers have outnumbered fixed-line phone users.

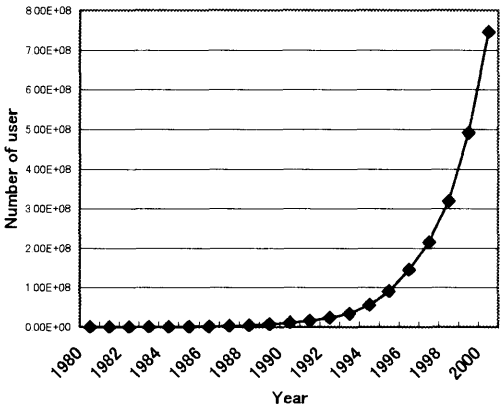


Fig. 1. Number of Mobile Phone User Worldwide (1980-2000).

Source: World Development Indicators (World Bank, 2002)

While research interest focuses on the economics of new information and communication technology in the global economy and limits on specific countries, not much work has been undertaken on a multi-country scale. However, certain research has displayed that ICT density is proportional to GDP per capita (Sampsa Kiiski et al., 2002 [3]). Kondo et al. analyzed the diffusion trajectory of Internet in Japan and the U.S. with diffusion models and related the result with the mechanism of IT functionality development (Kondo, 2003 [4], Watanabe et al., 2003 [13]). In this paper, diffusion trajectory and its governing factors of mobile phone in selected high-income countries are analyzed. In section 2, diffusion models and data resources are explained. Section 3 provides the result of empirical analyses. Section 4 briefly summarizes the conclusion.

2. Methodology

2.1 Diffusion model

There are a variety of efforts in modeling the diffusion of innovations (Mahajan et al., 1990 [5]) including the Bass model, the epidemic function (logistic growth function), the Gompertz curve, the Weibull curve, and Lotka-Volterra model for competitive innovations. An epidemic function approach was used in this paper (Meyer, 1994 [9], Meyer and Ausbel, 1999 [10]) in order to identify IT's self-propagation behavior. The following two epidemic functions were used for a comparative analysis of epidemic behaviors of mobile phone diffusion in the selected countries.

(1) Simple Logistic growth function (SLF)

This diffusion process is actually quite similar to the contagion process of an epidemic disease (Grilliches, 1957 [2]) and exhibits S-shaped growth. This process is well modeled by the simple logistic growth function, an epidemic function that was first introduced by Verhulst in 1845 (Meyer, 1994 [9]). Since the logistic growth function has proved useful in modeling a wide range of innovation processes, a number of studies applied this function in analyzing the diffusion process of innovations as well (e.g. Griliches, 1957 [2], Mansfield, 1963 [6], 1969 [7], Metcalfe, 1970 [8], Norris and Vaizey, 1973 [11]).

The Logistic function of diffusion is

$$f(t) = \frac{K}{1 + a\exp(-bt)} \tag{1}$$

where $f(t)$: number of adopters; a and b: coefficients; K: carrying capacity (ceiling of the adoptions of innovative goods); and t : time trend.

As t increases, the number of adopters will converge to the capacity K.

(2) Logistic growth function within a dynamic carrying capacity (LFDCC):

The epidemic function expressed by equation (1) assumes that the level of carrying capacity (K in equation (1)) is constant through the dissemination process of innovation. However, in particular innovations, the correlation of the interaction between innovation and institutions displays a systematic change in the process of growth and maturity. This leads to the creation of a new carrying capacity in the process of its diffusion. In these innovations, the level of carrying capacity will be enhanced as their diffusion proceeds, and carrying capacity K in equation (1) should be treated as the following function:

$$\frac{df(t)}{dt} = bf(t)\left(1 - \frac{f(t)}{K(t)}\right) \tag{2}$$

where $K(t)$ is also an epidemic function enumerated by equation (2-3).

$$K(t) = \frac{K_K}{1 + a_K \exp(-b_K t)} \tag{3}$$

where K_K indicates carrying capacity (the ultimate upper limit).

The solution of a differential equation (2) under the condition (3) can be obtained as an equation (4).

$$f(t) = \frac{K_K}{1 + a\exp(-bt) + \dfrac{b \cdot a_K}{b - b_K}\exp(-b_K t)} \tag{4}$$

where a, b, a_K and b_K: coefficients; K_K: carrying capacity; and t: time trend.

2.2 Data and software

The data used in this analysis, including whole population, population of ages 14-65, population density and mobile phone user per 1000, is retrieved from World Development Indicators (World Bank, 2002[14]). Diffusion function simulation is done with SHAZAM software. Statistical analysis and correlation analysis are done with Excel Statistical Features.

3. Result of analysis and discussion

(1) Diffusion function analysis and ages 15-64 population proportion (% of total)

First, by means of equation (1), mobile penetration rate (number of subscriber per 1000) with the logistic function is analyzed. Next, with the coefficient a, b and K of all the countries, an correlation analysis to investigate if ages 15-64 population proportion and mobile diffusion is carried out. The result is illustrated in **Fig. 2**.

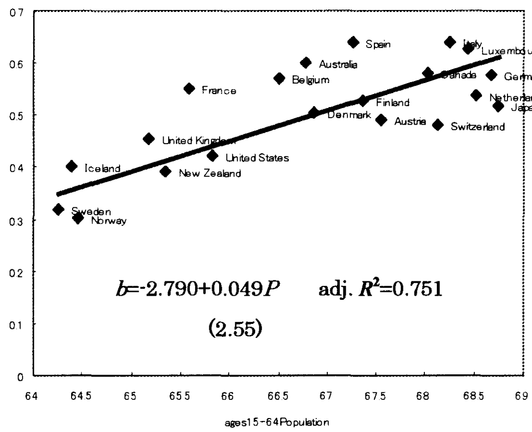


Fig. 2. Correlation between 15-64 ages population and diffusion speed of mobile phone technology.

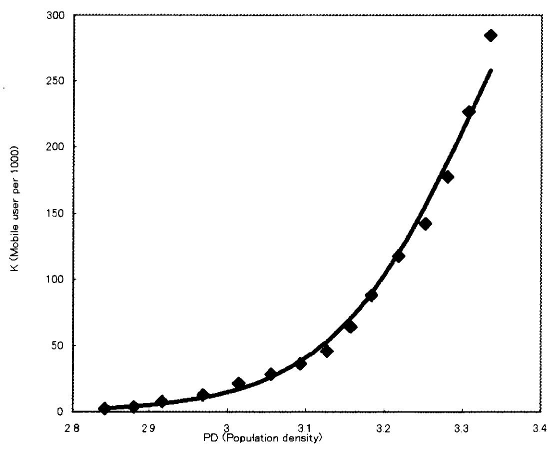
From this result, it is shown that the higher the proportion of ages 15-64 is, the higher the coefficient b is. Since coefficient b affects the speed of technology diffusion, ages 15-64 population seems to be a positive factor to spread out mobile phone technology. Since the process of technology diffusion is similar to the process of epidemic diffusion, it is understandable that people of ages 15-64 are more capable of carrying new technology to those who have not adopted yet.

Recently more and more mobile companies started to re-consider the direction of R&D and divide the products into two groups, one of which focuses on fashionable style for young generation and the other for older users. Especially in high-income countries, the problem of aging trend might hamper technology to get matured. Therefore, it is essential for mobile phone companies to take careful consideration of the effect brought by population structure change into their core strategies.

(2) Diffusion model considering population growth

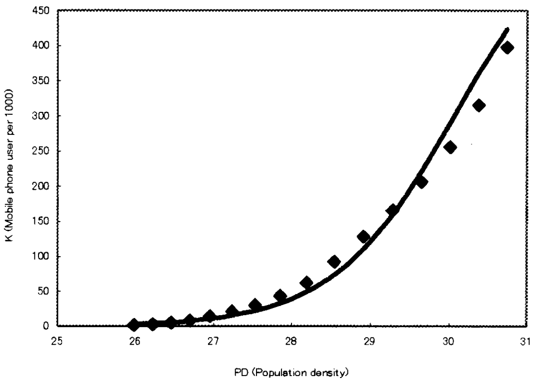
Since the total population restricts the diffusion ceiling, a novel analysis is attempted by considering population as a factor affecting the diffusion ceiling. Instead of taking time variable t into a logistic function, population density is taken as a substitution of time t. With the data of population density (per square km) of the same selected countries, an empirical result demonstrates that diffusion equation of mobile phone can also be depicted by logistic growth function with population density.

The empirical results of the example of Canada and the US are shown in **Figs. 3** and **4**.



K=476.08/(1+(3.1E+15)*EXP^(-10.75PD)) R^2=0.992

Fig. 3. Population density and mobile phone user per 1000 (Canada).



K= 603.63/(1+(7E+16)*EXP^(- 1.28PD)) R^2=0.975

Fig. 4. Population density and mobile phone user per 1000 (US).

If we consider population growth function as a logistic function of time t, this equation would be $K = f(P) = f(P(t))$, which will become logistic growth function within a dynamic carrying capacity. On the one hand, due to technology innovation and ITs subsequent self-propagating behavior, diffusion mode can be taken as logistic growth function within a dynamic carrying capacity; on the other hand, when taking population into account, we can come up with the same result.

The reason why population density is a positive factor is that the epidemic power grows stronger when people contact others more. It deepens the need for people to connect themselves with others in the most efficient way. This can also be considered as a reason why people in the city tend to adopt new technology product earlier and the diffusion speed is usually faster compared with the rural area. Increasing population density usually comes with busier lifestyle, more frequent contact with friends and strangers, larger amount of information, and less time to spend communicating with people, etc.. All these changes will bring faster information communication technology diffusion and adoption. Since the need for ICT of the consumer's side increases, the producer's side will definitely react with the consumer's need. They provide better products with more functions to fulfill different needs, thus create new need in the market. Adopters will be the central source of the technology epidemic process, bringing new innovations to non-adopters.

4. Conclusion

4.1 New Findings

Noteworthy, findings obtained through the empirical analysis include:

(i) Since all the countries chosen in this research are high-income countries, the effect of economic factors could be minimized although careful attention should be done in applying to non-high-income countries with significant effects of economic factors. It is shown that the ages 15-64 population (% of total) is related with the mobile phone diffusion positively.

(ii) When taking population density into consideration, the technology growth function can be explained as a logistic growth function within a dynamic carrying capacity.

4.2 Points of further development

These results lead to the following important points of further development:

(i) It is hard to say which generation is the main central source of the ICT spread-out process. Since the data of World Bank (World Bank, 2002 [14]) does not offer population structure in detail, collecting population data of each country is an important approach for analyzing how each generation affect ICT diffusion. The older generation owns economic power to consume and adopt new technology while the young tend to take new technology as a symbol of fashion, which prompts them to consume more. Therefore, it would be interesting to analyze in detail which roles these generations play in the diffusion process.

(ii) When taking population density as a simple Logistic function, it is possible to tract the Logistic growth function within a dynamic carrying capacity with two steps. The first step is to determine the population growth function of each country, and the second step is to facilitate this population function as the carrying capacity in the technological growth model.

4.3 Conclusion

Mobile phone is still new since communication standard and the functions are being upgraded all the time. Recently 3G standard has started to penetrate the market quietly but quickly. Multi-functioned mobile phone technology also brought up a new stage of mobile phone development. There is definitely no limit of this self- propagating technology.

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