한국경제학보 제19권 제2호
The Korean Journal of Economics Vol. 19, No. 2(Autumn 2012)

Nonlinear Income Inequality Effect on Software Piracy*

Seoung Joun Won** · Jongick Jang***

Abstracts

We examine the relationship between income inequality and software piracy rates in the presence of network effects. By the constructions of a theoretical framework, we are able to explain the relationship between income distributions and software piracy rates. Our research suggests that the proportion of the population having the positive net benefit of using pirated software increases with income inequality at a diminishing rate, and then eventually decreases. We provide empirical evidence for this inverted U-shaped relationship between income inequality and software piracy rates, while controlling for country-level income, judicial efficiency, individualism and the proportion of fixed broadband subscribers. Our theoretical and empirical results imply that lax anti-piracy policies would make software producers better off (i.e., higher software sales because of network effects) in countries whose income inequality is moderate, but worse off in countries whose income inequality is severe. Therefore, the anti-piracy government's policy and software company's strategy should be deliberately designed considering the non-linear effects of income inequality.

KRF Classification : B030702
Keywords : Software Piracy, Income Inequality, Network Effects

* This work was supported partly by the National Research Foundation of Korea Grant funded by the Korean Government (NRF 2010 330 B00065).

** First Author, Regulatory Economist, Missouri Public Service Commission, e-mail: wons@missouri.edu

** Corresponding Author, Assistant Professor, College of Global Cooperation, Hanshin University, e-mail: jijang5@hs.ac.kr

Ⅰ. Introduction

Software piracy has received growing attention from stake holders, national and international government authorities, and scholars. According to the Business Software Alliance (BSA), the losses from piracy in 2008 amount to 53 billion dollars, which is more than 60 percent of the 88 billion dollars made by the legitimate software market (BSA, 2009). Although some countries' piracy rates have been decreasing in recent years, the total losses from software piracy keep increasing as the industry expands.

More importantly, piracy rates vary across nations and over time (Marron and Steel, 2000). A growing body of literature has been devoted to explaining these variations, serving to identify factors that help control piracy behavior. According to the extant empirical literature, national factors that significantly influence software piracy include: national income per capita, a legal framework to protect intellectual property rights, judicial efficiency or law enforcement, and individualism (Banerjee, Khalid and Sturm, 2005; Holm, 2003; Husted, 2000; Maskus and Penubarti, 1995; Ostergard, 2000; Park and Ginarte, 1997; Rapp and Rozek, 1990; Shadlen, Schrank, and Kurtz, 2005). These empirical studies assume that piracy is a serious crime and are mainly concerned with the social costs of piracy.

However, some software producers seem to disregard losses from piracy. In many cases, software producers distribute their popular software without employing any anti-piracy technology, even if they possess sufficient technologies to do so (Katz, 2005; Slive and Bernhardt, 1998). In fact, a strand of theoretical literature on piracy suggests that a suitable rate of piracy may help increase the profit of software producers due to network effects (Conner and Rumelt, 1991; Gayer and Shy, 2003; Shy and Thisse, 1999; Takeyama, 1994). Given the lack of technology-based protection and software firms' allowance of *de facto* free use, the literature suggests that social net benefits from piracy may vary depending upon the value of network effects of piracy and that individual users' net benefits from piracy may vary depending upon the private and social constraints they face (Banerjee, et al., 2005).

Nonetheless, this beneficial side of software piracy has gained little attention from empirical studies. In this article, we examine income constraints that influence individual software users' net benefits from piracy. In particular, we consider income thresholds that determine individual users' positive net benefits from piracy and investigate the accumulated effects of a nation's income distribution on its piracy rate. We show that, among the computer users in a nation, the proportion of the population having positive net benefits of using pirated software increases with income inequality at a diminishing rate, and then eventually decreases. We provide empirical evidence for this inverted U-shaped relationship between software piracy rate and income inequality.

Our analytical and empirical results contrast with the existing literature on income inequality effects on piracy rates (Banerjee, et al., 2005; Husted, 2000; Rodriguez, 2006). In particular, Husted (2000) and Rodriguez (2006) offer empirical evidence for a negative linear relationship even though which is not statistically significant. Furthermore, there is no theoretical derivation of this relationship. We have found two main issues in the assumption of exiting research. One is that they assumed a linear relationship between software piracy rate and income inequality. The other is related to the assumption that piracy behavior is committed by the middle class. This assumption can be accepted with more clear definition of the middle class. However, more critical problem is that their studies have assumed that the piracy rate of a country is proportional to the proportion of the middle class out of the entire population of the country. However, as we explain in section 2, our research suggests the piracy rate of a country is proportional to the middle class out of the sum of the upper and middle classes, not the total population.

This paper is structured as follows: Section 2 discusses net benefits from piracy for individual software users and analyzes income inequality effects on piracy rate in the presence of network effects, to derive a testable hypothesis. Section 3 offers descriptions of the country level panel data and presents pooled ordinary least square (POLS) analysis results and discussions. Finally, concluding remarks follow.

Ⅱ. Theoretical Framework

An analysis of economic agents' piracy behavior involves costs and benefits. From an economics perspective, economic agents' commitments to an unauthorized use of software are realized when the benefits from piracy are equal to or greater than the costs of piracy. An obvious benefit that an economic agent obtains from piracy is saving the cost of purchasing software. Piracy costs that are incurred by the economic agent include the loss of service and support provided by software firms to officially authorized users, the risk of prosecution from the use of pirated software, and ethical costs (Bae and Choi, 2006; Chen and Png, 2003; Shy and Tissue, 1999).

The net benefits incurred by economic agents pirating software vary among individuals depending on the personal and social constraints[1] that they face (Banerjee, et al., 2005; Conner and

1) One may consider the social constraints such as intellectual property rights (IPR) protection laws and a third-party enforcement system. The efficiency of IPR protection laws and judicial systems would increase the costs of piracy incurred by consumers (Marron and Steel, 2000). Marron and Steel define

Rumelt, 1991). Based on the net benefits from piracy, we classify a nation's entire population into three groups of consumers.

Consumers in the first group cannot afford to purchase a brand new or used computer because their income level is too low. The expected benefits from piracy of the consumers in the first group are nothing, but the costs of piracy are positive. As a result, they have little incentive to commit software piracy.

Consumers in the second group have enough income to purchase computers, but they do not have enough income to purchase all software what they want to use. In addition, these consumers socio-economic status is not so high to take risk using pirated software. In summary, their net benefit from piracy is greater than zero. Thus, consumers in the second group have great incentives to commit software piracy.

Finally, the income level of consumers in the third group is high enough that they can pay for both hardware and software. There consumers have a higher cost from the risk using pirated software because of their socio-economic status. In other word, these consumers pay higher reservation prices for genuine software rather than using unauthorized software. For analytical convenience, we call the three consumer groups lower, middle, and upper class, respectively.

Based on the classification of consumer groups just described, we analyze the relationship between income inequality and piracy rate. We examine how a nation's piracy rate is related to the distribution ratio of the three classes and then analyze the relationship between the distribution ratio and income inequality. BSA (2009) defines piracy rate as the total number of units of pirated software divided

---

the efficiency of IPR protection laws as the estimated arrest rate of piracy, i.e., the number of arrest warrant related piracy to the estimated number of the piracy.

by the total units of software installed. The quantity of pirated software is indirectly estimated with the difference between the quantity installed and the quantity legitimately acquired. The quantity installed is estimated from the number of computers in use multiplied by norms[2] for the software load.

Therefore, the piracy rate is closely related to the ratio of the number of users buying software to the number of total software users. The number of users pirating software is equal to the total number of software users less the number of users buying software. Therefore, we have the following relationship:

$$\text{Piracy Rate} \approx \frac{\text{Number of Pirating Software Users}}{\text{Number of Total Software Users}} \qquad (1)$$

It is clear that the decision whether or not to use pirated software only made by a consumer who has at least a computer. Using the classification of consumer groups described before and removing the effects of other country characteristics such as income, judicial efficiency, etc, we can extend the equation (1) into the following:

$$\text{Piracy Rate} \approx \frac{\text{Population of Middle Class}}{\text{Population of Upper and Middle Class}} \qquad (2)$$

Equation (2) implies that a nation's piracy rate is influenced by income distribution as well as absolute income level. More specifically, the effect of income inequality on a piracy rate is

2) Norms are estimated by the Business Software Alliance (BSA) consultant International Data Corporation (IDC). IDC calculated the software loads per new computer and per existing computer from surveys of consumers and business users in 15 countries. Norms for other countries are estimated from these results. However, the computation methods of norms are not disclosed. See the BSA report (2004) for more details of the procedure of estimating norms.

determined by the ratio of the middle class population to the middle and upper class population. This analytical approach is dissimilar to the existing literature that assumes the effect of income inequality on piracy rate is influenced by the proportion of the middle class out of a nation's total population and that the relationship between the middle class portion and piracy rate is linear and negative (Husted, 2000; Rodriguez, 2006; Traphagan and Griffith, 1998).[3] In contrast, we maintain that the ratio of the middle class population over the middle and upper class population is more relevant to the analysis of income inequality effects on piracy rates and that the ratio changes nonlinearly with an increase in income inequality.

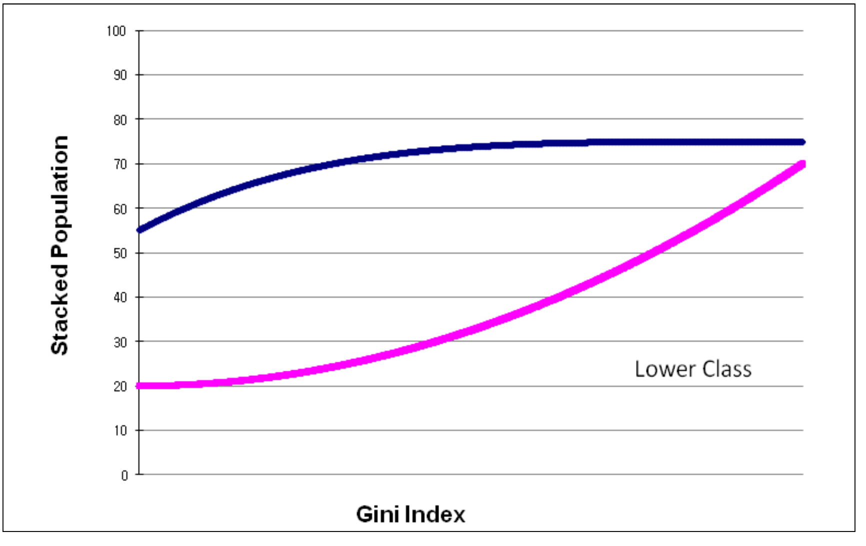
In our model, the effect of income inequality on piracy rate is determined by the relationship between the ratio of the middle class population to the middle and upper class population. If the ratio is decreasing monotonically, we may obtain a significantly negative

3) Husted (2000) and Rodriguez (2006) derive the argument from two implicit assumptions. First, most piracy behaviors are conducted by the middle class. Second, the portion of the middle class linearly decreases with a greater degree of income inequality (GINI index). Based on these assumptions, they argue that the piracy rate is proportional to the portion of the middle class. The contained supposition of Husted and Rodriguez's first assumption is that the upper class has a higher piracy cost compared to the middle class, and the lower class has little use for computers. The previous studies also indicate that net benefit from piracy is heterogeneous and upper class may have a negative net benefit from piracy (Bae and Choi, 2006; Chen and Png, 2003; Shy and Thisse, 1999). Furthermore, the difference of computer accessibility between the lower class and the other classes is widely reported (Becker, 2000; Rockman, 1995).
The second assumption seems obvious. However, the portion of middle income class is not decided by the Gini index alone. In addition, the validity of the assumption depends on the definition of the middle class which is another big question. Ritzen, Easterly, and Woolcock (2000) report that the correlation between the Gini coefficient and the percentage of the population of the middle class is 0.88, even though there are some outliers. For instance, the U.S. has a large middle class, but a large "Gini" inequality. Hungary has the reverse of low "Gini"-inequality and a small middle class, and the Netherlands has a large middle class and low "Gini"-inequality. Although further investigation for these assumptions is needed, we leave it for future research.

effect of the Gini index on piracy rates. On the other hand, if the ratio is increasing first and then decreasing, we may obtain a significantly positive effect of the Gini index and a significantly negative effect of the squared Gini index on piracy rates. Based on the discussion concerning the relationship between income equality and the network effects of piracy, we anticipate an inverted U-shaped relationship between piracy rates and income inequality.

Figure 1 illustrates a plausible relationship between the Gini index and the proportion of the three classes, Figure 2 illustrates the relationship between the Gini index and the piracy rate obtained by calculating the ratio of the population of the middle class to the population of the middle and upper classes, which is derived from Figure 1.

【Figure 1】 Hypothetical Relationship between Gini Index and Stacked Population



Ritzen, Easterly, and Woolcock (2000) suggest that the proportions of the upper class and the middle class are decreasing with income inequality. We build on this and maintain that the proportion of the middle class and the proportion of the upper class have different rates of decrease with income equality after controlling for other country characteristics such as income. Recalling what equation (2) specified above, we are interested in the change in the ratio of the middle class population to the middle and upper class population, which would take place with an increase in income inequality. We propose that a mild rise in income inequality diminishes the proportions of middle and upper class, but the rate of diminishment of the middle class proportion is smaller than that of the upper class proportion (see the left side of figure 1). In contrast, a high increase in income inequality makes the rate of diminishment of the middle class proportion greater than that of the upper class proportion (see the right side of figure 1). This relationship between population distributions by class and income inequalities is supported by both existing literature and the simulation of theoretical model.

【Figure 2】 Hypothetical Relationship between Gini Index and Piracy Rate

First, this relationship is supported by previous research. According to Kuttner (1983), observations in the middle class move from the middle of the income distribution to both tails when inequality increases. Levy and Murnane (1992) use the Gini index as the measure of the polarization caused by the vanishing the middle class, even though they note that standard inequality measures cannot exactly measure the polarization. Although we do not accept the idea that the upper class increases with a rise in income inequality, it is a reasonable assumption that the decreasing rate of the upper class is lower than the decreasing rate of the middle class, according to existing studies.

Second, the relationship can be verified a simulation of the theoretical model. For ease of simulation, we assume that the functional form of the Lorenz curve is given by x^n. From its definition, the Gini index is calculated as

$$2\int_0^1 x - x^n dx = \frac{n-1}{n+1}.$$

Therefore, the corresponding degree n of the Lorenz curve x^n of the given Gini index a is

$$n = \frac{1+a}{1-a}.$$

When the Gini index is 0, that means perfect equality, that is, everyone has the same income 1. For this income, we assume all consumers buy the genuine network good because of enough income. By simple calculation, we can prove that the income of a consumer θ on the unit interval is the value of the first derivative of the Lorenz curve at $x = \theta$,

$$n\theta^{n-1}.$$ [4]

With the Gini index increases, there are consumers whose income is less than 0.2, and we assume that they belong to the low class. In other words, those consumers do not have computers. Consequently, consumers whose income is between 0.2 and 1 are in the middle class. Let us assume that $x=\theta_H$ and $x=\theta_L$ satisfy the following

$$nx^{n-1}=1 \text{ and } nx^{n-1}=0.2,$$

respectively. Then the piracy rate can be written as the following,

$$\text{Piracy Rate}=\frac{\theta_H-\theta_L}{1-\theta_L}.$$

In other word,

$$\text{Piracy Rate}=\frac{n^{-\frac{1}{n-1}}-(5n)^{-\frac{1}{n-1}}}{1-(5n)^{-\frac{1}{n-1}}}.$$

Therefore, the piracy rate can be written as the function of the Gini index a

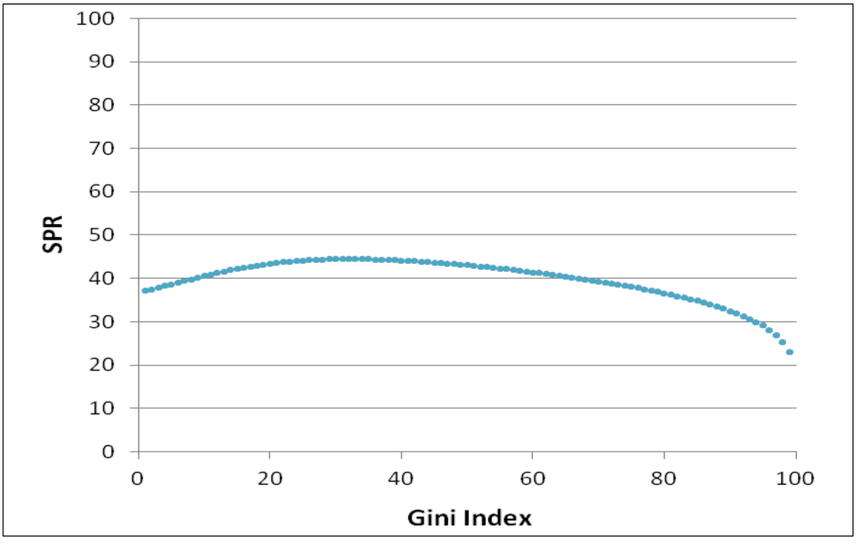
$$\text{Piracy Rate}(a)=\frac{\left(\frac{1+a}{1-a}\right)^{-\frac{1-a}{2a}}-\left(5\frac{1+a}{1-a}\right)^{-\frac{1-a}{2a}}}{1-\left(5\frac{1+a}{1-a}\right)^{-\frac{1-a}{2a}}}.$$

Because of the complexity of the function, we conduct simulation to calculate the value of the piracy rate for each $a \in \{0.01, 0.02, 0.03,$

4) One can ease to get this result while considering the relationship between the average income and individual's income.

…, 0.98, 0.99}. The Figure 3 is the simulation of this result.

【Figure 3】 Simulation Result for Relationship between Gini Index and Piracy Rate



In addition, we claim that replacing the ratio of the middle class population to the middle and upper class population with piracy rates does not drastically change the inverted U-shape made by the relationship between Gini index and the ratio. To substantiate the claim, we incorporate software firms' strategic policy against piracy into the relationship. Software producers strategically set a policy against piracy considering network effects. More specifically, we consider two dynamics which have the opposite influence of income inequality on piracy rates: network effect enhancement and network effect diminution. Network effect enhancement occurs when a rise in income inequality diminishes the number of software purchasers. When income inequality is moderate, the benefits from intensifying piracy protection would be declining since the positive network effects would be reduced. Thus, it would be more profitable for firms to allow piracy behavior since the network effect from piracy is increasing.[5)] In contrast, network effect diminution takes place when a rise in income inequality lessens the number of computer users as well as software users. When income inequality is severe, positive network effects would shrink, and as a result, piracy rates would decrease.

In our model, the network effect enhancement dominates the network effect diminution when income inequality is moderate (see the left side of figure 2). Considering the net network effect enhancement, software producers would be unlikely to spend resources to protect from piracy. As a result, the piracy rate would be decreasing until the network effect enhancement is overshadowed by the network effect diminution. The dominance of network effect diminution begins to appear when the ratio of the middle class population to the middle and upper class population begins to fall. As a result, the piracy rate is decreasing. To put those two sides together, an inverted U-shaped relationship between piracy rate and income inequality is derived (see figure 2).

Ⅲ. Data

We build a data set covering 40 countries from 2003 to 2006 with 106 observations. We regard the software piracy rate (SPR) as a dependent variable. Software piracy rate is the percentage of software acquired illegally. The number of software acquired illegally is obtained by the difference between software programs installed and software applications legally licensed. We employ the piracy rate reported by the Business Software Alliance (BSA)

5) This dynamic is closely related to the software purchase decision of the marginal consumer between the upper class and the middle class. For the marginal consumer with income constraints, pirating software is more rational than stealing a computer.

consultants International Data Corporation (IDC) from 2003 to 2006, which has been widely used in public policy and academic research (Banerjee et al., 2005; BSA, 2009; Holm, 2003; Husted, 2000; Png, 2008; Rodriguez, 2006; Shadlen et al., 2003).

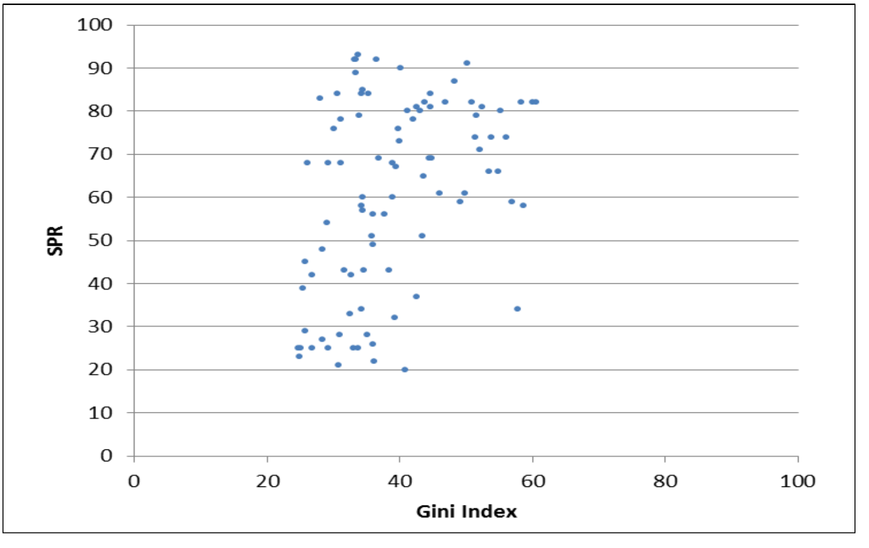
However, there are limitations to the accuracy of this data. First of all, the piracy rate data have been produced based on the estimation of IDC. The estimation may be downward biased since many cases of the software applications are sold without the computer hardware however, the reported piracy rates are calculated based on the number of hardware sold (Rodriguez, 2006). In addition, IDC has not disclosed the method of projecting the number of computers in the fifteen sample countries to that in other countries IDC projected the number of computers in each country with a norm calculated from an observed sample of fifteen countries. However, as we previously note, IDC has not disclosed the detailed calculation method (BSA, 2004). Notwithstanding, the BSA piracy report is the most transparent in terms of methodology, data sources, and implementation (Png, 2008). Piracy rates range from 0 percent, no piracy, to 100 percent, all installed software being pirated.

The explanatory variables include the degree of economic inequality and four control variables which are: national income, judicial efficiency, individualism, and internet broadband subscribers. We employ the Gini index as a measure for the degree of economic inequality. The Gini index measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. In this study, we use the World Income Inequality Database V2.0c (WIID2) established by the World Institute for Development Economics Research of the United Nations University (UNU-WIDER).[6] The

6) WIID2 consists of the Deininger and Squire database from the World Bank and new estimates from the Luxembourg Income Study and the

existing data on income distribution is compiled from a highly unbalanced and irregularly spaced panel of observations (Dollar and Kraay, 2000). In addition, the quality of the data sources can be problematic (Rodriguez, 2006). We only consider observations with a quality rating better than four, thus excluding the "unreliable" data. The following Figure 4 is the scatter plot of software piracy rate versus the Gini index.

【Figure 4】 Piracy Rate and Gini Index

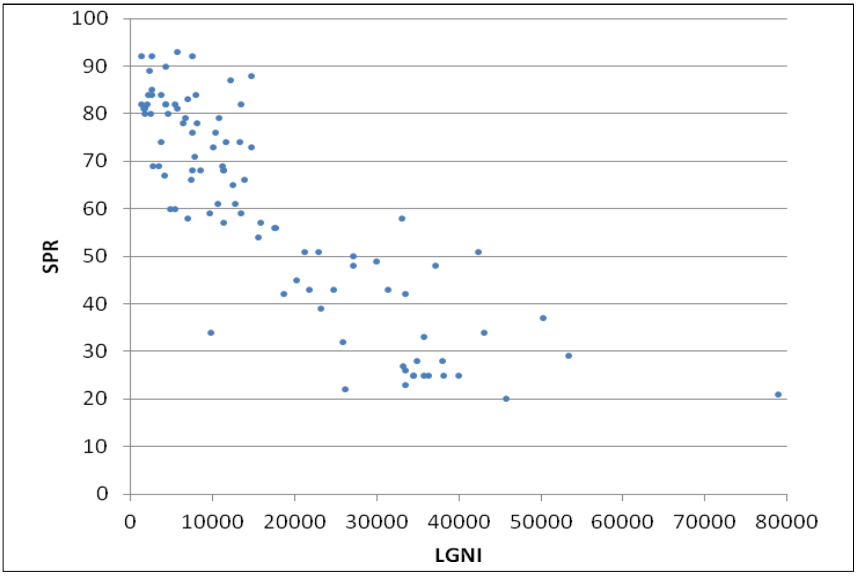


The measure of national income used in this paper is the natural logarithm of the Gross Net Income (GNI) per capita, measured in constant dollars, and adjusted via purchasing power parities. Of our national factors, the relationship between GNI and piracy has been the most rigorously studied by previous research (Husted, 2000). Similar to the study, we extracted data on GNI per capita from the World Bank's World Development Indicators (WDI) database from 2003 to 2006 (World Bank, 2008a). Per capita values were obtained

TransMONEE Database (Shorrocks and Wan, 2005).

by dividing the Purchasing Power Parity (PPP) GNI data by the Population data. The following Figure 5 is the scatter plot of software piracy rate versus the PPP GNI per capita.

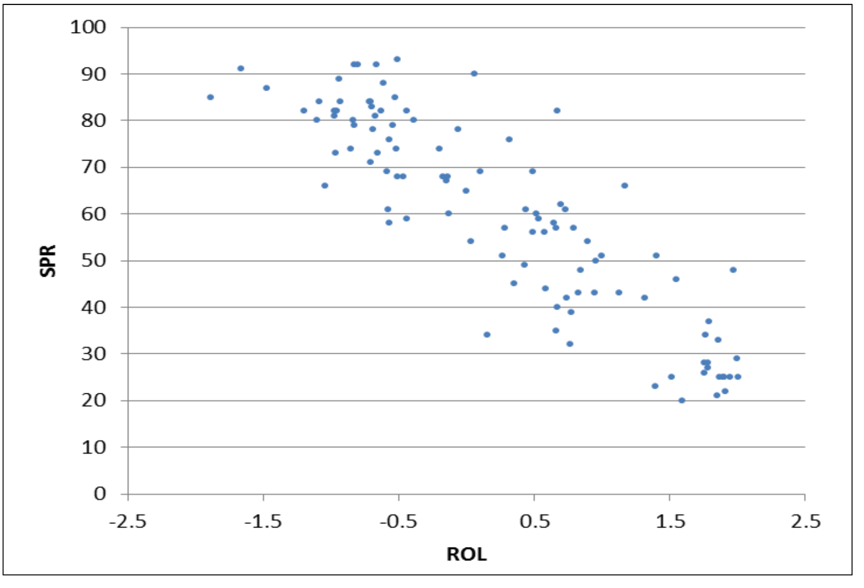
【Figure 5】 Piracy Rate and the Logarithm of PPP GNI per capita



The Rule of Law (ROL) is used as a proxy for judicial efficiency. Following previous studies, we emphasize the efficiency of third-party enforcement rather than the legal framework regarding piracy activities (Holm, 2003; Marron and Steel, 2000; Rodriguez, 2006). The cost of obtaining a copy of software often involves illegal actions. The costs of piracy should be higher in countries that have efficient institutions to enforce the Rule of Law than in countries where this is not the case, since individuals that undertake illegal actions require compensation for the expected cost of being caught (Becker, 1968). We employ the indicator of the Rule of Law from the World Governance Indicator Project developed by the Word Bank (2008b). This indicator aims to measure the efficiency of the judicial system in a country (Kaufmann, Kraay, and Mastruzzi, 2008). The

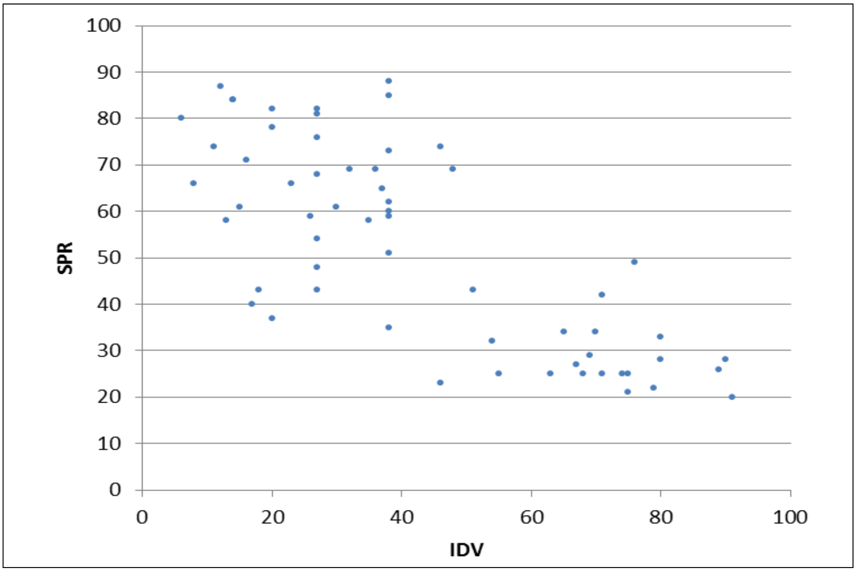
Rule of Law indicator for a country is measured in units ranging from -2.5 to 2.5, where a higher value represents a more efficient judicial system. Holm (2003) and Rodriguez (2006) have found a strong negative relationship between the Rule of Law and the piracy rate. The following Figure 6 is the scatter plot of software piracy rate versus the Rule of Law.

【Figure 6】 Piracy Rate and Rule of Law



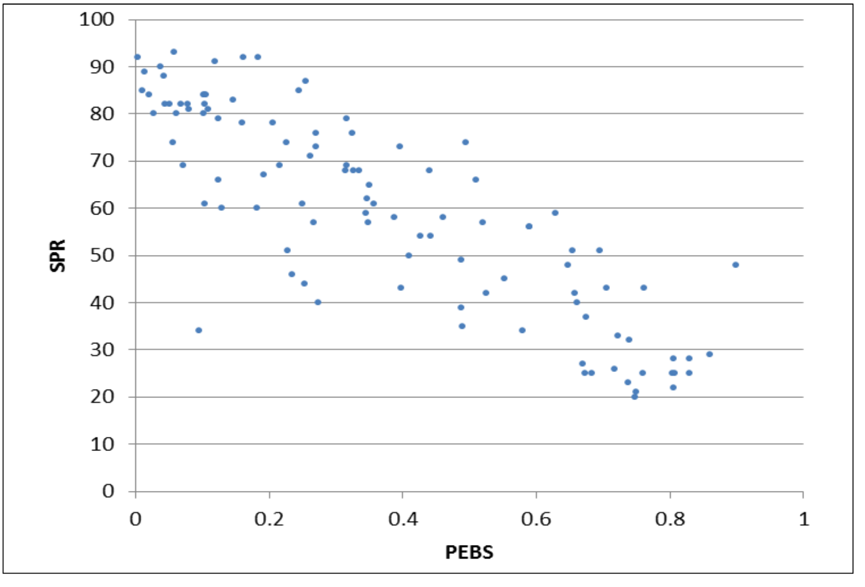
To measure individualism, we adopt the index of individualism developed by social psychologist Geert Hofstede (2001) who gathered data from paper-and-pencil surveys on IBM employees covering 72 countries. The index is concerned with how each country or region is rated on a scale from 0 to 100, from the least individualistic to the most individualistic. The opposite side of individualism is collectivism which measures the degree to which individuals are integrated into groups. On the individualist side, one finds societies in which the ties between individuals are loose. On the collectivist side, one finds societies where people from birth onwards are integrated into strong, cohesive in-groups, often extended families, which continue protecting them in exchange for unquestioning loyalty. The word "collectivism" in this sense has cultural rather than political meaning: it refers to the group, not to the state. According to Husted (2000), individualism was related to software piracy in a cultural dimension only. The following Figure 7 is the scatter plot of software piracy rate versus the individualism index.

【Figure 7】 Piracy Rate and Individualism



As a measure of the percentage population of Fixed Broadband Subscribers (FBS), we use the data of the World Telecommunication/ Information and Communication Technologies (ICT) Indicators (WTII) which are established by International Telecommunication Union (ITU). Existing literature has predicted a positive sign of the coefficient of FBS since the internet is considered a piracy enhancing tool (Hinduja, 2001, 2003; Peitz and Waelbroeck, 2006), FBS refers to the sum of the Digital Subscriber Line (DSL), cable modem, and other fixed broadband subscribers. Although various definitions of broadband exist, it is here defined as sufficient bandwidth to permit combined provision of voice, data, and video. Speed should be greater than 256 kbps, as the sum of capacity in both directions. The percentage population of FBS is calculated by dividing the number of fixed broadband subscribers by the population of the country and by multiplying by 100. The following Figure 8 is the scatter plot of software piracy rate versus the percentage population of Fixed Broadband Subscribers.

【Figure 8】 Piracy Rate and Fixed Broadband Subscribers



Ⅳ. Empirical Model and Results

In order to empirically test the prediction of an inverted U-shaped relationship between piracy rate and income inequality which is derived from our theoretical analysis developed in section 2, we establish a reduced form of an econometric model, including the

【Table 1】 The number of observations

Nation	2003	2004	2005	2006	Total
ARGENTINA	1		1	1	3
AUSTRALIA		1			1
AUSTRIA	1	1	1	1	4
BELGIUM	1	1	1	1	4
BRAZIL	1	1	1		3
CHILE	1				1
COLOMBIA		1			1
COSTA RICA	1	1	1	1	4
CROATIA	1		1		2
DENMARK	1	1	1	1	4
ECUADOR	1	1	1	1	4
EGYPT		1			1
FINLAND	1	1	1	1	4
FRANCE	1	1	1	1	4
GERMANY	1	1	1	1	4
GREECE	1	1	1	1	4
INDIA		1			1
INDONESIA			1		1
IRELAND	1	1	1	1	4
ITALY		1	1	1	3
LUXEMBOURG	1	1	1	1	4
MALAYSIA		1			1
MEXICO		1	1		2
NETHERLANDS	1		1	1	3
NEW ZEALAND		1			1
NORWAY	1	1	1	1	4
PAKISTAN		1			1
PANAMA	1	1			2
PERU	1	1	1		3
PHILIPPINES	1				1
PORTUGAL		1	1	1	3
SERBIA				1	1
SLOVENIA	1	1	1	1	4
SPAIN	1	1	1	1	4
SWEDEN	1	1	1	1	4
TURKEY	1				1
UNITED KINGDOM	1		1	1	3
UNITED STATES	1	1			2
URUGUAY		1	1		2
VENEZUELA	1	1	1		3
Total	27	31	27	21	106

【Table 2】 Variable definitions, summary statistics and data sources

Variable	Definition	Mean	SD	MIN	MAX	Source
SPR	Software piracy rate (%)	47.22	19.31	21	87	Business Software Alliance International Data Corporation
GINI	Gini index	35.89	10.97	22.1	62.83	United Nations World Income Inequality Database V2.0c
SGINI	Square of Gini	1407.57	881.87	488.41	3948.12	United Nations World Income Inequality Database V2.0c
LGNI	GNI per capita, PPP (Natural Logs)	9.73	0.96	7.14	11.24	World Bank World Development Indicators
ROL	Rule of Law	0.86	1.01	-1.26	2.01	World Bank World Governance Indicator
IDV	Individualism	49.88	25.35	8	91	Geert Hofstede Individualism Index
PEBS	Fixed broadband subscribers (%)	41.24	25.03	3.14	85.59	International Telecommunication Union World Telecommunication/ICT indicator

Gini index and the squared Gini index and a set of control variables. We construct an unbalanced panel data set of the four-year period from 2003 to 2006, which may help enhance the degrees of freedom. The reduced form of econometric model is as follows:

$$SPR_{it} = \beta_0 + \beta_1 \cdot GINI_{it} + \beta_2 \cdot SGNI_{it} + \beta_3 \cdot LGNI_{it}$$
$$+ \beta_4 \cdot ROL_{it} + \beta_5 \cdot PFBS_{it} + \beta_6 \cdot IDV_i + \varepsilon_i$$

where SPR_{it} is the software piracy rate of country i in year t, $GINI_{it}$ is the Gini index of country i in year t, $SGINI_{it}$ is the square of the Gini index in country i in year t, $NGNI_{it}$is the natural logarithm of the GNI per capita PPP of country i in year t, ROL_{it} is the Rule of Law index of country i in year t, $PFBS_{it}$ is the percent population of fixed broadband subscribers in country i in year t, and IDV_i is the Hofstede's individualism index of country i. The β_j is an unknown parameter to be estimated using pooled ordinary least squares (POLS), and ε_i is random error. Because of the unbalanced and irregularly time spaced nature of the Gini index, we only obtain 106 observations. After conducting Breusch-Pagan test and the Poolability test, we employ POLS instead of panel data models. The definition of variables, descriptive statistics, and sources are summarized in Table 1.

Table 3 displays the results of POLS heteroskedasticity-robust estimations using the model of 106 observations without missing values in the sample. We consider two sets of models, and each set has four models. The first four models, from column (1) to column (4), include ROL, IDV, and PFBS with different combinations, and GINI and LGNI as default variables. The last four models, from column (5) to column (8), are made based on the first four models, including SGINI. All regression models passed a RESET test for a

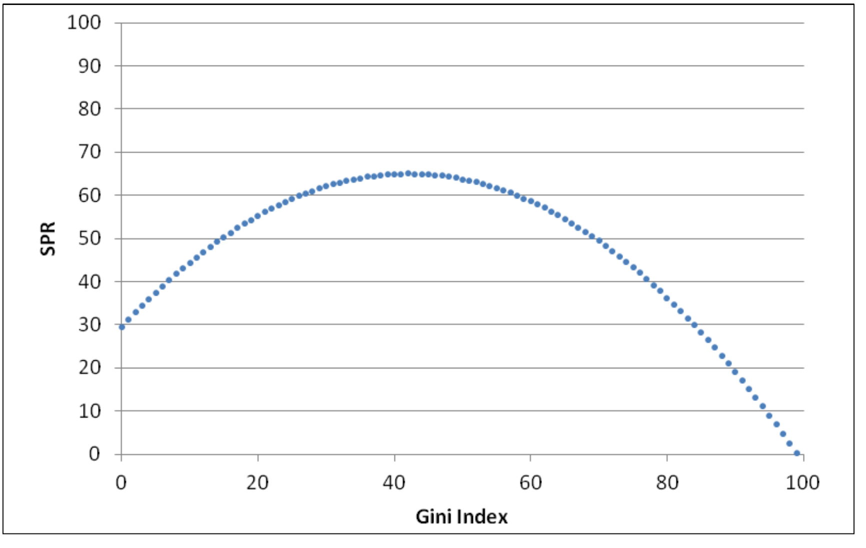
【Table 3】 Empirical result for POLS heteroskedasticity-robust estimations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gini	−0.091	−0.141	0.063	−0.140	1.962***	1.345*	2.210***	1.684**
	(0.10)	(0.11)	(0.09)	(0.10)	(0.49)	(0.53)	(0.61)	(0.50)
Sgini					−0.03***	−0.02**	−0.03***	−0.02***
					(0.01)	(0.01)	(0.01)	(0.01)
LGNI	-5.762**	-6.104**	-11.654***	-4.411*	-5.100**	-6.380***	-11.215***	-4.379*
	(1.86)	(1.77)	(1.49)	(1.93)	(1.65)	(1.65)	(1.45)	(1.72)
ROL	-10.606***	-11.545***		-10.679***	-10.070***	-11.291***		-10.178***
	(1.93)	(1.96)		(1.93)	(1.89)	(1.95)		(1.90)
IDV	−0.141**		−0.185**	−0.126**	−0.165**		−0.215***	−0.154**
	(0.05)		(0.05)	(0.05)	(0.05)		(0.06)	(0.05)
PEBS		−0.341**	−0.288*	−0.302**		−0.248*	−0.144	−0.179
		(0.12)	(0.13)	(0.11)		(0.12)	(0.13)	(0.11)
Constants	122.712***	124.602***	116.190***	113.273***	78.721***	98.257***	125.822***	78.477***
	(16.33)	(15.39)	(10.84)	(16.86)	(18.02)	(18.03)	(19.77)	(17.33)
N	106	106	106	106	106	106	106	106
R2	0.887	0.887	0.848	0.895	0.903	0.894	0.864	0.906
F	220.89	241.93	201.68	190.12	238.44	238.44	204.13	192.60
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Root MSE	6.605	6.631	7.667	6.426	6.148	6.435	7.294	6.107

Note: ***, **, and * indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively.

model specification error. In addition, the hypothesis of normality of residuals was not rejected based on the Jarque-Bera test statistics. We address the heteroskedasticity issue, estimating robust standard errors using the Huber-White Sandwich estimator. The estimations are carried out using STAT 10. The set of explanatory variables, including the constant term, explains more than 85% of the variation in the reported national piracy rates. Interestingly enough, explanatory powers are improved when adding the square term of the Gini index.

【Figure 9】 Net Income Inequality Effect on Software Piracy Rate



In the first four models, the coefficients of the Gini index are not statistically significant and the signs of the coefficient for the Gini index vary across models. These results are consistent with the results of Banerjee et al. (2005) but inconsistent with the results of Husted (2000) and Rodriguez (2006). In the last four models, however, the signs of the coefficient for the Gini index are positive, the signs of the coefficient for squared Gini index are negative, and the coefficients of both variables are statistically significant. These results support the prediction of the inverted U-shaped relationship between income inequality and piracy rates. More precisely, the software piracy rate increases with the Gini index at a diminishing rate and then turns down at the Gini index of about 40. The following Figure 9 presents the net income inequality effect on software piracy rate using of the result of regression model [8] in Table 8. For calculating the constant value of the equation for Figure 9, we used mean values for other variables in Table 2.

The regression results reveal that the coefficients of most control variables are statistically significant with expected signs. National income has a negative and statistically significant effect on piracy rates across eight regression models. These results are consistent with previous studies. Nations with higher income levels exhibit smaller piracy rates, after controlling for indirect income effects, judicial efficiency, individualism, and fixed broadband subscribers.

The coefficient of the Rule of Law has a negative and statistically significant effect on piracy rate. This is in accordance with previous studies that claim a negative relationship between judicial efficiency and piracy rate (Holm, 2003; Rodriguez, 2006). The coefficient of the individualism index is negative and statistically significant across eight models. This is consistent with previous studies (Holm, 2003; Rodriguez, 2006; Shadlen et al., 2003).

The percent of the population of fixed broadband subscribers is negatively associated with piracy rate across all models, but the coefficients are only statistically significant in some models. These results are not consistent with the expectations of some previous studies. Online file sharing using high-speed internet is the most technologically convenient tool for pirating software (Hinduja, 2001). Therefore, it is conjectured that the coefficient of the percentage of the population using internet is positive only if we consider internet as a piracy tool. This issue deserves to be examined further.

Ⅴ. Conclusion

We have examined the relationship between income inequality and piracy rates in the presence of network effects. Further, we have built a theoretical framework which accounts for how income inequality difference among countries affects different software piracy rates. Based on our theoretical framework, we predict an inverted U-shaped relationship between income inequality and piracy rates. We have conducted an empirical test for the hypothesis and obtained statistically significant evidence supporting the non-linear relationship between income inequality and piracy rate after controlling for income, judicial efficiency, individualism, and fixed broadband subscribers.

The findings provide some implications for policy concerning software piracy. Firms would be better off to allow a certain level of piracy in countries that have moderate income inequality since harsh policies against piracy may unduly shrink a potential network growth. In contrast, in countries which have severe income inequality, allowing piracy gives little benefit to software publishers because most computer users are in the upper class. Therefore, lax anti-piracy policy may reduce the cost of pirated software use without increasing the total software users. This suggests that preventive policies against piracy need to be strategically established considering the level of income inequality of each nation.

Although our theoretical and empirical results indicate new findings for accounting for piracy behavior, we acknowledge that this study is subject to some limitations. The data of software piracy rates used in our regressions are only estimated values while the data reported by BSA are the most reliable among existing data (Png, 2008). In addition, the data of the Gini index is compiled from a highly unbalanced and irregularly spaced panel of observations which prevents us from controlling for unobserved effects other than a country-specific degree of individualism.

Finally, we conclude this study with suggestions for future research. The relationship between the high-speed internet users and piracy rates has received little attention in existing literature. Our empirical results indicate that the percentage of the population of fixed broadband subscribers has a negative effect on piracy rate and this result is significant in several models. However, this result is inconsistent with the existing studies which consider the internet as a piracy enhancing tool. Hence, it would be interesting to build a model which can explain these phenomena in the presence of network effects.

Received: March 8, 2012. Revised: August 5, 2012. Accepted: September 29, 2012.

◈ *References* ◈

Bae, S. H. and J. P. Choi (2006), "A Model of Piracy," *Information Economics and Policy*, 18 (3), pp. 303-20.

Banerjee, D., A. Khalid and J. Sturm (2005), "Socio-economic Development and Software Piracy: An Empirical Assessment," *Applied Economics*, 37 (18), pp. 2091-98.

Becker, G. S. (1968), "Crime and Punishment: An Economic Approach," *Journal of Political Economy*, 76, pp. 169-217.

Becker, H. J. (2000), "Who's Wired and Who's Not: Children's Access to and Use of Computer Technology," *The Future of Children*, 10 (2), pp. 44-75.

Business Software Alliance (BSA) (2004), *First Annual BSA-IDC Global Software 03 Piracy Study*, Washington, DC: BSA.

________________ (2009), *Sixth Annual BSA-IDC Global Software 08 Piracy Study*, Washington, DC: BSA.

Chen, Y. and Png, I. (2003), "Information Goods Pricing and Copyright Enforcement: Welfare Analysis," *Information Systems Research*, 14, pp. 107-23.

Conner, K.R. and R.P. Rumelt (1991), "Software Piracy: An Analysis of Protection Strategies," *Management Science*, 37, pp. 125-39.

Dollar, D. and A. Kraay (2002), "Growth is Good for the Poor," *Journal of Economic Growth*, 7(3), pp. 195-225.

Gayer, A. and O. Shy (2003), "Internet and Peer-to-peer Distributions in Markets for Digital Products," *Economics Letters*, 81(2), pp. 197-203.

Hinduja, S. (2003), "Trends and Patterns Among Online Software Pirates," *Ethics and Information Technology*, 5, pp. 49-61.

__________ (2001), "Correlates of Internet Software Piracy," *Journal of Contemporary Criminal Justice*, 17, pp. 369-82.

Hofstede, G. (2001), *Culture's Consequences: Comparing, Values, Behaviors, Institutions, and Organizations Across Nations*, 2d ed. Thousand Oaks, CA: Sage Publications.

Holm, H.J. (2003), "Can Economic Theory Explain Piracy Behavior?," *Topics in Economic Analysis and Policy*, 3, pp. 1-15.

Husted, W.H. (2000), "The Impact of National Culture on Software Piracy," *Journal of Business Ethics*, 26, pp. 197-211.

International Telecommunication Union (ITU) (2008), World telecommunication indicators, Available at http://www.itu.int/ITU-D/ict/statistics/at glance/KeyTelecom99.html [Accessed 22 June 2009].

Katz, A. (2005), "A Network Effects Perspective on Software Piracy," *University of Toronto Law Journal*, 55, pp. 155-216.

Kaufmann, D., A. Kraay and M. Mastruzzi (2008), "Governance Matters VII: Aggregate and Individual Governance Indicators, 1996-2007," *World Bank Policy Research Working Paper* No. 4654, Washington, DC: World Bank.

Kuttner, B. (1983), "The Declining Middle," *Atlantic Monthly*, 252(1), 60-71.

Levy, F. and R.J. Murnane (1992), "The U.S. Earnings Levels and

Earnings Inequality: A Review of Recent Trends and Proposed Explanations," *Journal of Economic Literature*, 30(3), pp. 1333-1381.

Marron, D. B. and D. G. Steel (2000), "Which Countries Protect Intellectual Property?: The Case of Software Piracy," *Economic Inquiry*, 38, pp. 159-74.

Maskus, K. E. and M. Penubarti (1995), "How Trade-related are Intellectual Property Rights?," *Journal of International Economics*, 39, pp. 227-48.

Ostergard, R. L. (2000), "The Measurement of Intellectual Property Rights Protection," *Journal of International Business Studies*, 31, pp. 349-60.

Park, W. and J. C. Ginarte (1997), "Intellectual Property Rights and Economic Growth," *Contemporary Economic Policy*, 15, pp. 51-61.

Peitz, M. and P. Waelbroeck (2006), "Piracy of Digital Products: A Critical Review of the Theoretical Literature," *Information Economics and Policy*, 18(4), pp. 449-76.

Png, I. P. L. (2008), *On the Reliability of Software Piracy Statistics*, Available at SSRN: http://ssrn.com/abstract=1099325 〔Accessed 12 August 2009〕.

Rapp, R. T. and R. P. Rozek (1990), "Benefits and Costs of Intellectual Property Protection in Developing Countries," *Journal of World Trade*, 24, pp. 75-102.

Ritzen, J., W. Easterly and M. Woolcock (2000), *On Good Politicians and Bad Policies: Social Cohesion, Institutions, and Growth*, Washington, DC: World Bank.

Rockman, S. (1995), "In School or Out: Technology, Equity, and the Future of Our Kids," *Communications of the ACM*, 38(6), pp. 25-29.

Rodriguez, A. (2006), "Software Piracy and Income Inequality," *Applied Economics Letters*, 13(2), pp. 101-05.

Shadlen, K., A. Schrank and M. Kurtz (2005), "The Political Economy of Intellectual Property Protection: The Case of Software," *International Studies Quarterly*, 49, pp. 45-71.

Shorrocks, T. and G. H. Wan (2005), "Spatial Decomposition of Inequality," *Journal of Economic Geography*, 5(1), pp. 59-81.

Shy, O. and J-F. Thisse (1999), "A Strategic Approach to Software Protection," *Journal of Economics and Management Strategy*. 8(2), pp. 163-90.

Slive, J. and D. Bernhardt (1998), "Pirated for Profit," *Canadian Journal of Economics*, 31, pp. 886-99.

Takeyama, L. N. (1994), "The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Network Externalities," *Journal of Industrial Economics*, 62, pp. 155-66.

Traphagan, M. and A. Griffith (1998), "Software Piracy and Global Competitiveness: Report on Global Software Piracy," *International Review of Law, Computers and Technology*, 12(3), pp. 431-47.

World Bank (2008a), *World Development Indicators*, Washington, DC: World Bank.

__________ (2008b), *Worldwide Governance Indicators*, Washington, DC: World Bank.

소프트웨어 불법복제행위에 대한 소득불평등의 비선형효과

원 승 전* · 장 종 익**

논문초록

본 논문은 네트워크 효과가 존재하는 경우에 소득불평등과 소프트웨어 불법복제행위의 관계를 분석하는 것을 목적으로 한다. 소득배분과 소프트웨어 불법복제행위의 관계를 설명하기 위하여 이론적인 틀을 제시하고 실증분석을 시도한다. 분석결과, 불법 복제된 소프트웨어를 사용함으로 인하여 얻게 되는 순편익이 영보다 크게 되는 인구의 비율은 소득불평등도가 높아짐에 따라 증가하지만 그 증가율은 체감하여 일정 수준이상으로 높아지면 결국 감소하게 된다는 점이 제시되었다. 이러한 분석결과는 소프트웨어 불법복제행위에 대한 관대한 규제정책이 소득불평등정도가 심하지 않은 나라에서는 소프트웨어 생산기업들의 후생을 증가시키지만 소득불평등정도가 매우 심한 나라에서는 그 반대의 결과를 초래한다는 점을 암시한다. 그러므로 소프트웨어 불법복제행위에 대한 정부의 정책이나 기업들의 전략을 수립할 경우에 이러한 소득불평등의 비선형 효과를 고려할 필요가 있다.

주제분류 : B030702
핵심 주제어 : 소프트웨어 불법복제행위, 소득불평등, 네트워크 효과

* 이코노미스트 미조리 공공 서비스 위원회, e-mail: wons@missouri.edu
** 한신대학교 글로벌 비즈니스 학부 조교수, e-mail: jijang5@hs.ac.kr