Factor Analysis on Software Piracy

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Abstract

Many empirical researches of software piracy have focused on the domestic factors, such as corruption, democracy, economic freedom et al. However, this paper assesses the extent of the international factors contributing to software piracy. It is founded that Patent Cooperation Treaty (PCT) international applications have a significant impact on it. That means international intellectual protection is a good way to control the piracy. Additionally, corruption is not a significant factor on piracy as previously believed.

Keywords

software piracy, corruption, PCT International application.

(1) Introduction

It is well known that the issue of software piracy has been growing more severe worldwide in recent years. "software piracy" can be defined as the unauthorized use of computer software or the unauthorized distribution of copies of software without permission being given by the owner [1] ." According to the Software Alliance's Ninth Annual BSA (The Business Software Alliance) Global Software 2011 Piracy Study[2], in 2011 damages caused by piracy totaled USD63.456 billion worldwide and both piracy and the amount of related damages were in an increasing trend.

Software piracy affects economic growth. Greater piracy of computer software lowers economic growth. However, the relationship between piracy and growth is nonlinear the decrease in economic growth diminishes with piracy (Andrés and Goel, 2012).

While numerous previous studies have looked at the issue of software piracy, since it is a complex issue (Goel and Nelson, 2009; Lau, 2003; Reinig and Plice, 2011). It has not been elucidated fully. Studies that empirically analyze factors in software piracy from a macroeconomic approach do so using models based on one or more of the five following factors: economic factors, cultural factors, technological factors, legal factors, and educational factors (Gomes, Cerqueira and Almeida, 2014).

Gross Domestic Product (GDP) per-capita often is used as an economic factor. Harbi, Grolleau and Bekir (2012) and Panas and Ninni (2011) find a relationship

[1] See Lau (2003).

[2] http://www.bsa.or.jp/

resembling a Kuznets curve between the two. If there is a Kuznets curve relationship between piracy rate and GDP per-capita, then protection of intellectual property (IP) rights should be conducted in accordance with the stage of economic development, but over the long term there would be a negative correlation between piracy rate and GDP per-capita.

Other studies such as Gomes, Cerqueira and Almeida (2014) have employed Hofstede's index[3], developed to serve as an indicator of national character, as a cultural factor, indicating that national character do affect the piracy rate. Such as Rafee and Rouibah (2010) found that awareness treatment was significant factor in reducing intention toward digital piracy.

Of course, the level of technology is likely to impact the piracy rate. It is conceivable that strong protection of authorized software would increase the costs of piracy, and as the costs of piracy rise, the piracy rate would decrease. However, since protection of authorized software would decrease the number of users of the software, in some cases it would not be desirable to producers of authorized software[4]. The number of Internet users is used as a technological factor. Bagchi, Kirs and Cerveny (2006) show that Internet users had partial influence on software piracy. Market size is another technology factor often be used in empirical analysis (Andrés and Goel, 2011; Goel and Nelson, 2009).

In analysis of legal or systemic factors, economic freedom and freedom of the press are used frequently. The concept is socially accepted that the higher the degrees of economic freedom and freedom of the press the lower the piracy rate. In addition, many empirical analyses use corruption as a systemic factor (Andrés and Goel, 2011; Bagchi, Kirs and Cerveny, 2006; Banerjee and Williams, 2013; Goel and Nelson, 2009; Reinig and Plice, 2011). Analysis of data on the piracy rate and indices of corruption shows a very high correlation between the two.

Regarding educational factors, a negative correlation has been identified between the literacy rate of people aged 15 and above and the piracy rate (Goel and Nelson, 2009). However, it also be argued that this result is unclear (Andrés and Goel, 2011).

Thus, each of the papers discussed above focuses solely on domestic factors when examining piracy. Certainly, a strong correlation has been demonstrated between domestic factors and the piracy rate, suggesting that improvement of domestic factors would be an effective way to reduce piracy. However, since the issue of software piracy is complex, it is conceivable that it cannot be resolved fully through domestic factors alone. The global age is characterized by all countries advancing in cooperation

[3] Hofstede's index was developed in 1980 by the Dutch social scientist Geert Hofstede in order to measure quantitatively and index the national character of multiple countries. It consists of the following six indices: (1) Power distance index, (2) Individualism, (3) Uncertainty avoidance index, (4) Masculinity, (5) Long-term orientation, and (6) Indulgence versus restraint.

[4] Since in general software involves network externalities, the more the number of users increases the more the value of the software rises. For this reason, producers of authorized software aim to increase the number of users of their software.

with others. When advancing in cooperation with other countries, it is possible to protect one's own country's rights through mutual recognition by countries of each others' rights. In general, Patent Cooperation Treaty (PCT) international applications play an important role in getting other countries to protect one's own country's science and technology. A producer can secure exclusive interests on a global basis through the exclusivity of PCT international applications. For this reason, the increase in the number of applications for PCT international applications by producers in a country can be considered to relate to strengthening that country's government's motivation to crack down on patent-related piracy. It is conceivable that recognizing each other's patents would have the effect of protecting IP rights. Accordingly, it can be considered important and meaningful to study the impact on the piracy rate of numbers of applications for PCT international applications.

Based on the above perspective, this paper analyzes the piracy rate through a regression model in which the explanatory power of technological factors in particular is strengthened, as one attempt at examining factors such as those above. In addition to independent variables related to the four factors used in Andrés and Goel (2011): systemic, economic, social, and technological factors, the model employs number of applications for PCT international applications as a new independent variable related to technological factors, developing a regression model to explain the piracy rate based on these and using it with real-world data to seek out variables with explanatory power. The reason this paper uses in its analysis the four factors other than cultural factors is because such analysis has been common traditionally (Andrés and Goel, 2011; Goel and Nelson, 2009), and because it is not easy to control the cultural factor of national character (Hofstede's index) through policy. The results show that our new variable of the number of applications for PCT international applications does have explanatory power with regard to the piracy rate. This can be considered to suggest the possibility that countries' recognition of each others' PCT international applications could be an effective way to reduce piracy.

The paper employs the following structure. Section (2) presents a literature review. Section (3) illustrates research data on software piracy. Section (4) describes the analytical method and models. Section (5) illustrates the results of empirical analysis. Section (6) provides some considerations. Section (7) concludes.

(2) Literature review

The issue of software piracy is a complex one to begin with, one impacted by numerous factors. Previous studies argue that it would not be possible to resolve piracy issues without improvements on all the factors of economic, systemic, social, and technological factors.

The following is a description of the specific indices impacting the piracy rate used as independent variables in the following regression analysis, along with the reasons for using them, for each of the above four factors and in accordance with a previous study (Andrés and Goel, 2011). Differences from Andrés and Goel (2011) are

the facts that this study uses number of applications for PCT international applications, which it did not use, and that this study does not use the size of the software market, which had little impact on the piracy rate.

As systemic factors, this study uses the corruption index, freedom of the press, and economic freedom. It is likely that in a country with a high corruption index pirates would be able to secure a degree of toleration for their acts or piracy through means such as bribery of government officials, increasing the piracy rate at a result. That is, it is conceivable that there is a positive correlation between the corruption index and the piracy rate. On the other hand, there is likely to be a negative correlation between freedom of the press (Andrés and Goel, 2011; Salahodjaev Odilova and Andrés, 2016) and economic freedom (Bezmen and Depken, 2006; Fraj, 2015) on one hand and the piracy rate on the other. It is conceivable that improving these would increase social transparency, making it easier to uncover illegal acts by government and pirates and increasing the risks of piracy as a result, so that the piracy rate would decrease.

This study, like numerous previous studies, uses GDP per-capita as an indicator of economic factors. This is considered to have a negative correlation to piracy (Andrés and Goel, 2011; Chen, Chen and Yeh, 2010; Goel and Nelson, 2009). In fact, piracy is unlikely to decrease if authorized software and pirate software are identical in value and consumers expect the same benefits from both authorized software and piracy. On the other hand, if producers of authorized software were to adopt the strategy of adding to authorized software high-quality value capable of differentiating it from pirate software then consumers would be likely to demand high-quality authorized software as they enjoy greater returns from its use. This is thought to be the grounds for the above negative correlation.

As a social factor, this study uses the national literacy rate. Gomes, Cerqueira and Almeida (2013) show that more schooling years have the opposite effect to piracy. But Depken and Simmons (2004) have not identified a significant relationship between literacy rate and piracy rate. It is conceivable that the national literacy rate could have some impact on the piracy rate since as literacy increases the number of users of software (both pirate and authorized software) would increase. However, it is not necessarily possible to determine clearly whether this correlation would be positive or negative. Accordingly, this paper will determine the sign of the correlation based on the results of individual data analysis.

As a technological factor, this study uses number of Internet users. Goel and Nelson (2009) showed that internet users will mitigate the software piracy. It is conceivable that as this number increases the piracy rate would decrease because it would become easier to detect acts of piracy. In other words, there could be a negative correlation between the number of Internet users and the piracy rate.

The independent variables used in the regression model, reflecting consideration of previous studies, are as described above. This paper also uses the number of applications for PCT international

applications as an independent variable related to technological factors. By taking out PCT international applications, a producer can secure exclusive interests on a global basis through the exclusivity secured by patents. For this reason, an increase in the number of applications for PCT international applications by producers in a country can be considered to relate to a strengthening of that country's government's motivation to crack down on patent-related piracy. At the same time, it also can be considered to raise awareness concerning elimination of piracy as the producers who apply for the PCT international applications attempt to protect the value of the technologies that they have developed themselves. For the above reasons, the number of applications for PCT international applications is expected to have a negative correlation to the piracy rate.

This paper considers the final variable of number of applications for PCT international applications to be of particular importance. This is because since the number of applications for PCT international applications is related to technological progress, an increase in the number of applications for PCT international applications also involves aspects that make it possible to maintain sustained innovation. In fact, it is conceivable that if this independent variable does affect piracy then encouraging producers to increase the number of applications for PCT international applications would serve to make them more conscious of the need to demand an environment in which protection of IP rights strengthens, improving the piracy rate as a result. Accordingly, in the following analysis as well this paper focuses on this independent variable in particular.

(3) Research data

As described above, the regression analysis used in this paper employs the piracy rate as the dependent variable and variables included in four categories as seen in Andrés and Goel (2011) as the independent variables: systemic factors (indicators of corruption, freedom of the press, and economic freedom), economic factors (GDP per-capita), social factors (national literacy rate), and technological factors (number of Internet users, number of applications for PCT international applications). The sources and meanings of the data used in this analysis are outlined below.

1. Piracy rate (Piracy, abbreviated pir)

For piracy rate, data published by the Software Alliance (BSA)[5] is used. This organization is considered highly credible, and the results of its studies on piracy and protection of IP rights have been cited in numerous papers. The piracy rate is calculated as shown below:

[5] http://www.bsa.or.jp/index.html. The BSA measures the piracy of commercial software. These estimates are some of the most reliable ones and have been used largely in empirical papers (for instance Andrés, 2006; Andrés and Goel, 2011; Goel and Nelson, 2009; Harbi, Grolleau and Bekir, 2012; Lau, 2003; Reinig and Plice, 2011), in spite of criticism that the data are unreliable.

$$\text{piracy rate} = \frac{\text{Quanitity of pirated PC software}}{\text{Total quanitity of PC software installed}}$$

The denominator above is derived by multiplying the number of PCs on which software is installed by the quantity of PC software per computer, while the numerator is derived by subtracting the quantity of authentic PC software from the denominator, or the denominator minus total units of PC software sold divided by the average price of PC software.

2. Corruption index (Corruption, adbreviated cor)

As an index of corruption, this study uses the estimated value of Control of Corruption[6] published on the Web by the World Bank. This is an indicator of the governance ability of government, ranging in value from −2.5 to 2.5 points. This range corresponds to a 90% confidence interval for the trustworthiness of government, and the higher the score the lower the degree of corruption. These data are collected from interviews with numerous companies, citizens, and experts concerning their views on governance, based on data collected through research organizations, think tanks, nongovernmental organizations, international agencies, and private-sector organizations, among other sources.

3. Freedom of the press (Democracy, abbreviated dec)

This study uses data published by Freedom House[7] concerning freedom of the press. The data range in value from 0 to 100 points, with a higher figure indicating a lower degree of media freedom. For this reason, this figure can be described as an indicator of lack of freedom of the press. This figure is made up of three elements: (i) influence of laws and regulations on the media (ranging from 0 to 30 points), (ii) political pressure and media internal control (ranging from 0 to 40 points), and (iii) economic impact of media (ranging from 0 to 30 points). A total score in the range of 0-30 is considered to indicate a state of freedom, while one in the range 31–60 indicates the presence of freedom to some degree and one in the range 61–100 indicates a lack of freedom.

4. Economic freedom (Freedom of Economic, abbreviated ef)

Data published by the Heritage Foundation[8] are used to indicate economic freedom. Economic freedom is made up of 10 elements from the following four categories: (i) politics (property rights, freedom from corruption), (ii) constitutional politics (political freedom, government expenditure), (iii) regulatory efficiency (business freedom, labor freedom, currency freedom), and (iv) free markets (freedom of trade, freedom of investment, financial freedom). Each of these elements is graded as a score in the range 0–100, and the average of these scores is used as the value of economic freedom. The higher this value, the higher the assessed degree of economic freedom.

5. GDP Per-capita (GDP Per-capita, abbreviated gdp)

6 http://www.worldbank.org/

7 http://www.freedomhouse.org/report-types/freedom-press

8 http://www.heritage.org/index/download

For GDP per-capita, this study uses the data published on the Web by the Center for International Comparisons at the University of Pennsylvania[9]. These data are considered the most trusted and most widely used data on GDP per-capita in macroeconomic analysis.

6. National literacy rate (Literacy, abbreviated lit)

Many previous papers on empirical analysis have used national literacy rate as an independent variable, and this paper follows their precedent. The data used are the latest data published on Wikipedia[10]. While for most countries these data cover ages 15 and older, for a few countries different ages are used.

7. Number of Internet users (Internet user, abbreviated net)

For number of Internet users, data published on the Web by the International Telecommunication Union[11] are used. These data indicate the number of Internet users in a country per 100 citizens.

8. Number of applications for PCT international applications (Patent, abbreviated pat)

Another independent variable used in this model is the number of applications for PCT international applications. While there are various methods of totaling patent applications by companies, since the number of applications for PCT international applications is considered to reflect the level of R&D in each country the higher this number the greater the incentive to protect its own IP rights is likely to be. For this reason, this paper focuses on the number of applications for PCT international applications. Furthermore, to eliminate the effects of population, for all countries the number of applications for PCT international applications are converted to the number per million population. The source for data on numbers of applications for PCT international applications is the World Intellectual Property Organization[12], while data published by the World Health Organization (WHO) were referred to for each nation's population[13].

Data adjustments

Actually, the countries for which data on the above dependent variable (piracy rate) and seven independent variables are published vary by variable. For this reason,

Table 1. Meaning of each variable

Variable	Meaning
pir	Piracy rate
cor	Corruption index
dec	Freedom of the press
ef	Economic freedom
gdp	GDP Per-capita
lit	Literacy rate of population aged 15 and older
net	Number of Internet users per 100 population
pat	Number of PCT international applications applied for per million population

9 https://pwt.sas.upenn.edu/

10 http://en.wikipedia.org/wiki/List_of_countries_by_literacy_rate

11 http://www.itu.int/en/Pages/default.aspx

12 http://www.wipo.int/pressroom/en/articles/2012/article_0001.html

13 http://memorva.jp/ranking/unfpa/who_2010_population_total.php

the analysis in this paper is limited to the 86 countries for which data are available for all eight variables (see Appendix). Lastly, the table below reviews the variables used:

(4) Analytical method and models

This section will use the independent variables described at the end of the previous section in a regression analysis with piracy rate as the dependent variable. Table 2 shows the variation in size and other information for each variable.

Table 2. Range of variation in size of each variable

Variable	Mean	Max.	Min.
pir	0.58	0.93	0.20
cor	0.30	2.38	−1.27
dec	43.56	94.00	10.00
gdp	19250	136248	1247
ef	64.42	86.10	37.10
net	49.71	93.39	3.70
lit	0.92	1.00	0.56
pat	53.17	521.83	0.01

Notes: net is Number of Internet users per 100 population, pat is number of applications for PCT international applications per million population.

Regression analysis with the simplest model (All the coefficients in this paper are non-standardized coefficients).

$$\text{pir} = c_1 + b_1\,\text{cor} + b_2\text{dec} + b_3\text{ef} + b_4\text{gdp} + b_5\text{lit} + b_6\text{net} + b_7\text{pat} + u_1$$

The result will be as shown in Table 3 when remove the no significant independent variable by t-test (the absolute value of t test is less than 1.96).

The result shows that corruption is significant to piracy as many previously studies. But the correlation coefficient of independent variable and logarithmic value of independent variable to piracy is as shown in Table 4.

Table 3. The result of simplest model

Variables	Estimated result
constant	0.897 (13.19)
cor	-0.090 (-4.67*)
dec	0.002 (2.62*)
net	-0.003 (-4.41*)
$\bar{R}^2$	0.770

Note: t-values are in parentheses. t- values aligned to the right* above are those for which estimates are statistically significant at the 1% significance level.

Table 4. The correlation coefficient of independent variable and logarithmic value of independent variable to piracy

	pir		pir
cor	-0.836	lcor	-0.836
dec	0.708	ldec	0.761
ef	-0.711	lef	-0.697
gdp	-0.639	lgdp	-0.788
lit	-0.425	llit	-0.412
net	-0.792	lnet	-0.698
pat	-0.663	lpat	-0.885

Note: Variables with l at the beginning denote the logarithmic value of variable.

The table indicate that the logarithmic value especially GDP and patent has a higher correlation than original data. Regression analysis with changing variable and logarithmic value of variable, three result of model with the best $\bar{R}^2$ value is the following.

$$pir = a_1 + a_2 lcor + a_3 dec + a_4 lgdp + a_5 ef + a_6 lit + a_7 net + a_8 lpat + u_1 \quad (1a)$$

$$pir = b_1 + b_2 lcor + b_3 dec + b_4 lgdp + b_5 ef + b_6 lit + b_7 lnet + b_8 lpat + u_2$$

(1b)

$$pir = c_1 + c_2 lcor + c_3 dec + c_4 lgdp + c_5 lef + c_6 lit + c_7 lnet + c_8 lpat + u_3 \quad (1c)$$

Each of the coefficients a_1~a_8, b_1~b_8, c_1~$c_8$will be estimated using this model. The terms $lcor$, $lgdp$ etc are abbreviations for the logarithms of the variables defined at the end of the preceding section, $\ln(cor)$, $\ln(gdp)$ etc, while u_1, u_2 and u_3 are error terms. Estimation is conducted using the ordinary least squares (OLS) method. Since the values of the corruption index range from −2.5 to 2.5, this paper uses a revised corruption index in which 2.55 has been added to that value. All of the data used are for the year 2011.

(5) Results of empirical analysis

Table 5 shows the results of estimation using regression model (1a), model (1b) and model (1c). A look at the results of VIF for each independent variable in Table 5 shows that each is substantially below 10, so that there is nothing similar to multicollinearity between any of the independent variables, and for this reason the results for the regression coefficients can be surmised to be relatively robust to variations in data values. Next, judgment of the statistical significance of the explanatory power of each regression coefficient and each independent variable using t values shows that even at a significance level of 10% the explanatory po-

Table 5. Results of estimation using regression model (1a), model (1b) and model (1c)

Variable	Model (1a)		Model (1b)		Model (1c)	
	Result	VIF	Result	VIF	Result	VIF
constant	0.752 (4.284)		0.754 (4.422)		0.883 (2.084)	
dec	0.002 (3.983*)	2.433	0.002 (4.123*)	2.381	0.002 (4.113*)	2.385
ef	-0.001 (-0.601)	3.189	4.123 (-0.543)	3.181		
net	-2.87 E-04 (-0.417)	3.915				
lit	0.520 (4.755*)	1.790	0.543 (4.855*)	1.882	0.542 (4.843*)	1.882
lcor	-0.007 (-0.110)	6.764	-0.009 (-0.152)	6.766	-0.013 (-0.220)	6.707
lgdp	-0.065 (-3.385*)	4.593	-0.062 (-3.329*)	4.426	-0.062 (-3.322*)	4.481
lef					-0.043 (-0.431)	3.056
lnet			-0.018 (-0.904)	2.898	-0.018 (-0.903)	2.922
lpat	-0.043 (-5.788*)	5.627	-0.042 (-5.946*)	5.237	-0.042 (-5.935*)	5.234
$\bar{R}^2$	0.865		0.866		0.866	

Notes: t-values are in parentheses, and t-values aligned to the right* above are those for which estimates are statistically significant at the 1% significance level.

wer of the three variables corruption, economic freedom, and Internet users could not be considered statistically significant.

By eliminating the lowest t value of variables, the result is as the following in Table 6 (the result is the same by eliminating a variable at a time).

Table 6. Results of regression analysis after eliminating the lowest t values from model (1a), model (1b) and model (1c)

Variables	Estimated result	VIF
Constant	0.710 (4.748)	
dec	0.003 (5.354*)	1.727
lgdp	–0.071 (–4.518*)	3.344
lit	0.536 (5.226*)	1.675
lpat	–0.045 (–7.050*)	4.505
$\bar{R}^2$	0.869	

Note: t-values are in parentheses, and t values aligned to the right* above are those for which estimates are statistically significant at the 1% significance level.

Comparison of Table 5 and Table 6 shows that the adjusted coefficient of determination ($\bar{R}^2$) remains largely unchanged and there was no difference in the fact that the explanatory power of corruption, economic freedom and Internet users. These variables are not statistically significant. Accordingly, a regression model analysis was conducted after eliminating the variables corruption, economic freedom and Internet users as well. The results are shown in Table 6 (There was no change in the results of the F test and the χ^2 test between the case of eliminating economic freedom alone and that of eliminating both variables at the same time).

A look at the results in Table 6 shows that the values of all regression coefficients are statistically significant at the 1% significance level and that the corresponding independent variables have explanatory power vis-à-vis the dependent variable. Comparing with the results ahead, $\bar{R}^2$ has been greatly improved, so the latter model is a superior model. Additionally, the common explanatory variable is democracy only. Other variable will be shuffled all. Notably, corruption is not remained as independence variable. As a result, this model combines the original data and replaced logarithmic data. In this model, corruption index will be deleted by using $lgdp$ and $lpat$. That means $lgdp$ and $lpat$ are better independence variables than corruption.

Incidentally, it is known that in the case of regression analysis using cross - sectional data as used in this study, the t value often does not necessarily function correctly as an indicator of statistical significance due to a lack of uniformity in distribution (Matsuura and McKenzie, 2012). Accordingly, a check for such lack of uniformity in distribution in this case was conducted.

A White χ^2 test with a null hypothesis of uniformity of distribution yields a χ^2 statistic of 11.352, for which the p value is 0.658, so that the null hypothesis of uniformity of distribution is not rejected.

(6) Consideration of results

The results above can be summarized as follows: First, the statistical significance of each independent variable's explanatory power will be verified. A look a Table 6 shows

that all four of the independent variables of index of freedom of the press, GDP per-capita, national literacy rate, and number of applications for PCT international applications had statistically significant explanatory power with regard to the piracy rate, indicating that all did affect piracy. While this finding is consistent with those of previous studies, it should be noted that consideration based on t value in particular shows that the independent variable of number of applications for PCT international applications, introduced for the first time in this paper, had the highest degree of statistical significance.

First of all, with regard to the national literacy rate, it should be clear that reducing this rate even below its current level in order to reduce the piracy rate would not be appropriate from economic considerations, because it would lead to a decrease in the number of users of software—not to mention ethical reasons. It is conceivable that the reason the piracy rate increases with an increase in the literacy rate is because of the resulting increase in the number of consumers using pirate software, as individuals gain access to methods of evading the regulatory net. Realistically, the national literacy rate is high in most countries, so that the national literacy rate's impact is not likely to be very pronounced.

The index of freedom of the press and GDP per-capita used in this paper both have been used as variables explaining the piracy rate in previous studies as well, and such studies have identified them as having statistically significant explanatory power. However, it must be said that realistically speaking it would in fact be difficult to control piracy through improving these variables, since they involve large-scale issues.

This paper showed that the number of applications for PCT international applications, which was not addressed in previous studies, is an important explanatory factor with regard to the piracy rate. What's more, controlling this variable does not involve unnatural issues with social ethics like those above and is effectively correlated with social innovation, so that it can be considered extremely significant. In fact, it is conceivable that as economic globalization advances incentives will act on countries and companies that have few patents, encouraging them to obtain PCT international applications, and the resulting increase in awareness of protection of patents (and copyright) could lead to stronger crackdowns on piracy. Accordingly, progress on creating an environment that would encourage companies to apply for PCT international applications can be considered as an effective means of decreasing the piracy rate.

On the other hand, this study showed that corruption, economic freedom, and number of Internet users had little influence on the piracy rate. While there is no problem with this finding with regard to the latter two because previous studies also showed that they had no influence, it does conflict with the results of most previous studies that showed that corruption had a strong influence. Some previous studies on corruption itself show that it can be explained by factors such as freedom of the press, GDP per-capita, and economic freedom (with coefficients of determination

of 82% or above). While correlation between indices of corruption and the piracy rate are very high, and as a result an index of corruption alone can show a high degree of explanatory power regarding piracy rate, the addition of numerous independent variables as in this study results in the elimination of the explanatory power of the index of corruption. In light of these considerations, indices of corruption, considered important in many previous studies, like piracy rate, be dependent variables explained by variables such as freedom of the press and GDP per-capita rather than causes of piracy rate.

(7) Conclusion

The main purpose of this paper is to verify the effect of the number of applications for PCT international applications on the piracy rate. Using data from 2011, it analyzed the factors impacting piracy while adding the number of applications for PCT international applications as a variable for the first time. The results showed that GDP per-capita, index of freedom of the press, national literacy rate, and number of applications for PCT international applications affect the piracy rate. These findings are summarized below:

1. The piracy rate decreases with an increase in GDP per-capita.

2. The piracy rate decreases with a decrease in the index of lack of freedom of the press (i.e., an increase in freedom of the press).

3. The piracy rate increases with an increase in the national literacy rate. It is conceivable that this is because an increase in the literacy rate increases the number of consumers using pirate software, as individuals gain access to methods of evading the regulatory net.

4. The number of PCT international applications applied for per million population also affects piracy. An increase in the number of patent applications leads to a decrease in the piracy rate. It is conceivable that this is because governments and producers become more conscious of protecting IP rights and more strongly motivated to protect their own property. Results of each of the analyses in this study showed that the number of applications for PCT international applications had a strong degree of explanatory power vis-à-vis the piracy rate, and it is conceivable that increasing the number of applications for PCT international applications would be meaningful in both economic and policy terms because it enables a country to carry out sustainable innovation.

5. This paper showed clearly that corruption, considered an important factor in many previous studies, is not a factor.

Consideration of the number of applications for PCT international applications, introduced for the first time in this study, showed that if countries with low numbers of applications for PCT international applications put effort into such factors related to technological progress they would be able to address piracy more efficiently, and such efforts also would facilitate the long-term technological progress of such countries. Accordingly, putting effort into the number of applications for PCT international applications would be recommended for such countries. It is hoped that these findings will

prove useful in policymaking.

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Appendix: Countries for which data were used in this paper

Albania	Algeria	Argentina	Armenia	Australia
Austria	Azerbaijan	Bahrain	Bangladesh	Belarus
Belgium	Bosnia	Botswana	Brazil	Bulgaria
Cameroon	Chile	China	Colombia	Costa Rica
Croatia	Cyprus	Czech Republic	Denmark	Dominican
Ecuador	Egypt	Estonia	Finland	France
Georgia	Germany	Greece	Guatemala	Hungary
Iceland	India	Indonesia	Ireland	Israel
Italy	J apan	Kazakhstan	Kenya	Korea
Latvia	Lebanon	Libya	Lithuania	Luxembourg
Malaysia	Malta	Mauritius	Morocco	Nicaragua
Nigeria	Norway	Oman	Pakistan	Panama
Peru	Poland	Portugal	Qatar	Romania
Russia	Saudi Arabia	Serbia	Singapore	Slovakia
Slovenia	South Africa	Spain	Sri Lanka	Sweden
S witzerland	Thailand	Tunisia	Turkey	UAE
United Kingdom	United States	Uruguay	Venezuela	Vietnam
Zambia				

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