Technological and Economic Indicators on Software Piracy in OECD Countries

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Abstract Taking countries of the Organization for Economic Co-operation and Development (OECD), this paper analyzes factors affecting their software piracy rate (SPR) by taking into account several economic and technological variables. The empirical results show that per capita GDP (PerGDP), inflation, consumer prices (ICP), unemployment rate (UR), and high-technology exports (HTE) have positive correlations with piracy rate; level of patent and copyright protection (PCP), personal computer (PC) ownership, and scientific and technical journal articles (STA) have negative correlations with software piracy rate.

Keywords: Software piracy, technology indicators, OECD countries

JEL classification: D23, O34, O53

1. Introduction

The research report of the International Data Corporation (IDC) shows that the contribution made by the decline in SPR to economic growth should not be underestimated. It is estimated that the *SPR* in Taiwan will drop to 31% in 2012, which may make a contribution of $ 414 million (approximately equal to TWD 13.4 billion) to the gross domestic product (GDP), offering many more job opportunities and helping to establish new enterprises. The reason why reducing pirated software has such a considerable influence is that the economy covers such service items as the application and installation of software. Therefore, even though prepackaged software only makes up 14% of the Taiwanese information technology (IT) industry's expenditure, it stimulates 22% of the employment in the whole IT industry, exerting significant influence on the job market.

In December 2005, IDC concluded that decreasing piracy by 10 percentage points over four years would add more than 2.4 million new jobs and almost $70 billion in tax revenues to local government worldwide. Most of that new employment and most of an additional $400 billion in GDP would be added to local economies. Considering that the influence of SPR on a country's economy is not negligible, this paper assumes economic indicators to be an important variable affecting SPR.

In 2008 global piracy rate survey, the Business Software Alliance (BSA)[2] pointed out that the rate of PC software piracy dropped in about half (52 percent) of the 110 countries studied and remained stable in another 39 countries (35 percent); however, the worldwide piracy rate went up from 38% in 2007 to 41% in 2008, and the monetary value of unlicensed software grew by more than $5.1 billion (11 percent) to $53 billion from 2007 to 2008. This phenomenon is the result of the dramatic increase in computer users in emerging economies. Whereas emerging economies account for 45 percent of the global PC market, they account for less than 20 percent of the PC software market. If the emerging economies' PC software share were the same as that of PC hardware, the software market would grow by $40 billion a year, which would be very impressive.

With advanced modern science and technology, many instruments can be used to duplicate an artist's work, such as photocopiers, answering machines, DVD recorders, computer CD writers, flash disks, and MP3. If the price of purchasing a work is much higher than the cost of reproduction, incentives for reproduction or piracy naturally appear. Software can be duplicated or pirated through web download or online transmission and this coupled with the ever-decreasing cost of pirate software means piracy is becoming more and more significant. As regards software users, the more advanced the science and technology a state has, the higher level of convenience users enjoy when they utilize software. Software vendors, however, find that scientific and technological progress promotes rapid change in software piracy techniques, which therefore causes them serious losses.

Furthermore, both Haruvy (2004) and Moores & Dhillon (2000) stated that increase in piracy would indirectly influence the profitability of software developers and the development of intellectual property, and reduce software designers' willingness to engage in software research and development; they also stated that the advancement of science and technology would facilitate the emergence of piracy and an increase in the piracy rate. Consequently, a country's higher level of science and technology means a stronger probability of software piracy and greater financial losses incurred by software vendors. Conversely, however, a higher level of science and technology means better techniques to prevent privacy from happening. For that reason, whether a nation's scientific and technological indicators are sufficient to become significant factors affecting SPR constitutes another key point of this study.

In previous research, there is substantial literature related to software piracy which includes extensive analytical perspectives, including economic, culture, education, and law issues.[3] Given that the instruments and techniques of piracy are critical factors influencing the ease with which software can be pirated, however, the scientific and technological level of a country serves as an important indicator. In the past, there was less literature which included scientific and technological indicators in its analyses. Apart from adding economic indicators, this study particularly discusses scientific and technological indicators, in the hope that when software vendors conduct cross-border trade they will understand the causes of piracy in the relevant state and be able to implement measures in advance to prevent piracy and reduce losses.

2. Data Analysis

This study selects 23 OECD countries[4] as sample objects for analysis to explore the influence of such variables as scientific and technological indicators and economic indicators on the SPR during the period from 1997 to 2005.[5] The explanatory variables include economic indicators as well as scientific and technological indicators. Whereas the former include Patent & Copyright protection(PCP), GDP per capita (PerGDP), Inflation, consumer prices (ICP), official exchange rate (OER), and Unemployment rate (UR), the latter included High-technology exports (HTE), internet users (IU), Personal computers (PC), and Scientific and technical journal articles (STA).

According to the research results in Table 1, as a nation's PCP level increases, its SPR will decrease and meanwhile the amount of software piracy losses will decline as well; on the other hand, as a nation's PCP level decreases, its SPR will go up and subsequently losses will increase correspondingly.

In addition, a nation with higher ICP means consumers of that country are confronted with higher price levels, which may lower their incentives to purchase licensed software. For that reason, consumers tend to use pirated software more and more frequently, causing and the SPR will to increase. However, as a country's per GDP increases, incentives for people to purchase authorized software will increase; conversely, as per GDP declines, people do not have enough money to buy licensed products, so they may tend to purchase counterfeit ones instead, which increases the piracy rate.

Official exchange rate (OER) refers to the level of a nation's exchange rate. When the exchange rate of a country that mainly depends on software import/export is devaluated, its import/export costs will increase/decrease due to the devaluation. Accordingly, the price of authorized software may rise/drop, and the proportion of consumers using pirated software will increase/decrease. Conversely, when a nation's OER appreciates, its import/export costs will decrease/increase; accordingly, consumers are/are not able to enjoy much cheaper licensed software, and thus piracy is likely to decline/go up. For this reason, as regards the influence of exchange rate factors on SPR, a nation must be analyzed in terms of whether it is a software import or export country. As a nation's UR increases, people's income will decrease correspondingly, and then they will not have enough purchasing capability for authorized software; hence, they tend to purchase pirated software. Consequently, pirated products will increase, and so will the expected piracy rate.

In terms of scientific and technological indicators higher HTE and IU percentages mean that a nation's science and technology as well as its network techniques are advancing increasingly, and consumers may take advantage of the internet as a medium for transmission to pirate software; consequently, piracy will be increasingly rampant and expected piracy rates will increase. Moreover, a nation's penetration rate of PC may also have an indirect influence on piracy rates. As a result of the internet, increasingly advanced information techniques, and increasing network sharing platforms, people are likely to pirate and use software through computer networks. Accordingly, they are reluctant to spend money on authorized software and thus the piracy rate increases correspondingly.

The increase of a nation's published STA means the nation's innovation level in terms of science and technology, in terms of either the anti-piracy technique or the piracy technique, changes rapidly. Accordingly, the prediction of this variable's influence on piracy rate is dependent on the degree of these two forces.

In addition, the analytical results of descriptive statistics of samples in Table 2 shows that the average piracy rate of the 23 OECD countries studied was about 41% during the period from 1997 to 2005, little different from the global piracy rate of 36%. According to the analytical data, Greece had the most serious piracy problem with a rate up to 74% in 1998, whereas the United States had the lowest piracy rate, which was 21% in 2005.

Furthermore, according to the descriptive statistics analysis of the samples in terms of economic indicator variables, in terms of PCP, Germany had the greatest PCP and Poland the lowest. Owing to PCP's negative correlation with SPR, the SPR in Germany was compared with that in Poland and a gap of about 28% was identified, showing that the higher the PCP a nation enjoyed, the lower SPR it had. Also, the situations of Per GDP were similar to that of PCP. In terms of Per GDP, Norway had the highest and Mexico, the lowest again. In terms of OER, Italy had the highest and Ireland, the lowest. As regards UR, Spain had the highest rate, which was 20.6% in 1997, and Mexico, the lowest, which was 2.10 % in both 1999 and 2001.

Finally, in the descriptive statistics analysis of scientific and technological indicators Ireland had the largest HTE, Poland, the smallest. As Poland is a country with relatively lower GDP among OECD countries, its budgets, whether in terms of level of scientific and technological development or in terms of the research and development of innovative technology, are lower than those in a nation with higher GDP; therefore, it exports less high technology.

In addition, in terms of IU, Sweden had the largest number of internet users, with an average of about 76 in every 100 people using networks in 2005; Mexico had the smallest number, with an average of only 0.63 in every 100 people using networks in 1997. In terms of PC, Canada was at the top of the list with an average of about 87.57 in every 100 people using computers; Mexico was still at the bottom of the list with an average of only 3.41 in every 100. Finally, the United States had the largest number of STA, Portugal the smallest. STA, however, had a negative correlation with the expected SPR. The SPR in the States was the lowest among unclassified countries by only 21%.

3. Empirical Results

This study utilized panel data analysis to analyze the relationship between SPR and scientific, technological, and economic indicators. Following Depken and Simmons (2004), the empirical model can be shown as follows:

$$\begin{aligned}\text{Piracyrate}_{it} &= a + b_1 \text{PCP}_{it} + b_2 \text{PerGDP}_{it} + b_3 \text{ICP}_{it} + b_4 \text{OER}_{it} + b_5 \text{UR}_{it} + b_6 \text{HTE}_{it} \\ &+ b_7 \text{IU}_{it} + b_8 \text{PC}_{it} + b_9 \text{STA}_{it} + \varepsilon_{it} \quad , \quad \varepsilon_{it} = \mu_i + \nu_{it}\end{aligned} \tag{1}$$

where b_s represents explanatory variable and the residual term, ε_{it}, consists of two components: the unobservable country-specific effects, μ_i, and the remaining disturbance, ν_{it}. The explanatory variables consisted of such economic indicators as PCP, CPI, PerGDP, ICP, OER[6], and UR. Furthermore, this paper also applied scientific and technological indicators like HTE, IU, PC, and STA to explain how they affected software piracy. Through these two elements, the determinants affecting software piracy were explored.

Owing to panel data, fixed effects model and random effects model have to be taken into consideration. For the choice of fixed effects model (FE) and ordinary least squares method (OLS)[7], the F-test can be applied to test whether various countries have equal intercepts. If the results fail to reject null hypothesis, there will be no individual effects, and it is better to adopt OLS rather than FE. In addition, when selecting the random effects model (RE) and OLS, the LM test can be utilized to examine whether intercepts have the features of RE. If the results reject null hypothesis, there will be random individual effects between nations, at the moment it is better to apply RE as the evaluation method. Finally, the comparison between RE and FE is conducted by means of the Hausman test. If the results do not reject null hypothesis, RE is superior to FE.

Table 3 shows the results of regression analysis from three models: model 1 is the OLS model, model 2 is the FE model, and model 3 is the RE model. The result of the F-test showed that the FE model was appropriate than the OLS model at 5% significance levels. The result of the LM test shows that the OLS model is suitable than the RE model at 5% significance levels. Finally, the Hausman test shows that the FE model is best choice to estimate the empirical model at 10% significance levels. Moreover, the R-squares of three models were very high, showing great explanatory ability. Hence, we estimate the equation 1 by using FE model and the results were discussed as follows. The results of the FE model shows that PerGDP, ICP, UR, and HTE had significantly positive relationships with software piracy rates, whereas PCP, PC, and STA have significantly negative relationships with piracy rates.

PerGDP's positive relationship with piracy rates is unexpected. Intuitively, as a nation's PerGDP goes up, the situation of buying authorized software to use is supposed to increase as well. Chen et al. (2010) found that as the PerGDP in leading Asian countries rose, SPR would drop. Utilizing OECD countries to analyze piracy rates, however, we find that as PerGDP increases, the piracy rate will increase too. Since many OECD countries have high PerGDP, the development of science and technology occurs earlier in these countries, and people of these nations therefore have access to products related to computers much earlier, so that they are probably more familiar with the utilization of such products. Also, the pirated techniques in these nations change rapidly; hence, software is more likely to be pirated. According to Furman et al. (2002), PerGDP could also be applied to measure a nation's market size. In a country with a large-scale market, there are more incentives for businessmen and businesswomen to engage in piracy and make a profit. All other things being equal, it is assumed that large market size helps to increase a nation's piracy rate.

ICP's positive relationship with piracy rates is expected. As ICP increases, consumers' real purchasing power will decrease, and the price of commercial software will rise, which in turn causes consumers' desire for products to decline, finally resulting in the increase of piracy rates. Also, UR has positive relationships with software piracy rates. Currently, the rise of UR helps to increase the number of people without any income, thus leading to increased piracy rates.

As for scientific and technological indicators, HTE has positive relationships with software piracy rates. With increasingly advanced science and technology, the increase of HTE means a nation's high technology has reached a certain level, causing increasingly serious piracy.

Moreover, the popularity of the internet makes piracy quick, easy, convenient and cheap. Therefore, as HTE increases, the piracy rate will rise, too.[8] Furthermore, PCP's negative relationship with piracy rates is the same as what was expected. The results show that among OECD countries, people have high awareness of patent protection. The increasingly widespread publicity about patent rights stops consumers rashly counterfeiting or copying products. Accordingly, high PCP will facilitate the dwindling of piracy rates.

PC has negative relationships with piracy rate. If PC is high, consumers will have more opportunities to share data through the computer. Thus network marketing immediately becomes a good tool for software vendors. Owing to the network's convenience and fixed rule for consumption, if consumers want to use online products, they must pay for them. For that reason, piracy rates will decline. This result is similar to that of Peitz and Waelbroeck's (2004) study, which suggested that the download of P2P freeware was able to keep software vendors' marketing costs to a minimum.

Finally, STA has negative relationships with piracy rates. As the publication of STA increases, a nation will have a good chance of success in terms of research and development in science and technology. Of course, piracy techniques improve along with anti-piracy ones; therefore, to ascertain STA's influence on piracy rate, the degree of both forces must be recognized. This paper, however, through the analysis of OECD countries, found that the anti-piracy measures seemed to be stronger, which made piracy rates drop.

4. Conclusions

Through scientific and technological indicators as well as economic indicators this paper analyzed the determinants of software piracy rate in OECD countries. We find that PerGDP, ICP, UR, and HTE had positive relationships with piracy rates and that PCP, PC, and STA had negative relationships with piracy rates. Among OECD countries, those with advanced development of science and technology experienced less serious piracy, mainly because the rapid improvement of software vendors' anti-piracy techniques and patent protection make software piracy less serious in these countries.

In terms of economic indicators, there is a great difference between past and present in that PerGDP shows positive relationships with piracy rates. As many of the countries analyzed are developed countries, the development of science and technology in these nations started early, and people had earlier access to products related to computers; therefore they are probably trained in the utilization of such products, and along with the rapid development of piracy techniques, this suggests a high probability of software piracy.

Finally, this study only focuses on 23 OECD countries. If future study can take developing countries into account, the results should be more comprehensive. Furthermore, a nation's educational indicator is also one of the significant factors affecting SPR, suggesting that future study taking it into account is another interesting topic.

Endnotes

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2. BSA refers to Business Software Alliance.

3. For example, Bezmen & Deplen(2006), Marron & Steel(2000), Bryan(2000), Peitz & Waelbroeck(2004), Gopal *et al.* (2006), Banerjee (2003), King & Lampe(2003)..

4. OECD currently has 34 member countries. Because it is hard to obtain related data from some countries, this study only covers 23 countries: the United States, Canada, Japan, Germany, France, Italy, Australia, New Zealand, Belgium, the Netherlands, Sweden, Finland, Austria, Ireland, Greece, Spain, Portugal, Norway, the Czech Republic,Hungary, Poland, and Korea. The member countries that are not included in this study are the United Kingdom, Luxembourg, Denmark, Iceland, Switzerland, Turkey, and the Slovak Republic.

5. This research period is 1997 to 2005. In this period, OECD countries have good economic performance and technology improvement well. So we try to find that how economic and technology variable influence pirate rate. We try to extend the research period, but some OECD countries' data are incomplete. We find the data trend is stable. So this constraint is not influence our results.

6. What is official exchange rate (OER)? OER is also called statutory rate, because it is often the exchange rate set by the monetary financial institutions of that country(for example, Central Bank, State Administration of Foreign Exchange, and Ministry of Finance). OER stipulates that all foreign exchange transactions must comply with the officially publicized exchange rate.

7. In the following text, FE stands for the fixed effect model, OLS stands for the Ordinary Least Squares Method, and RE stands for the random effect model.

8. Under the supports of many scientific and technological and network techniques, a work can be almost freely used. Thus, the balance of between the private benefits protected by Copyright Law and public benefits is collapsing, and the copyright owners' private benefits are heavily destroyed by right infringement.

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Table 1. Predicted Effects of Explanatory Variables on SPR

Explanatory variables		Predicted effect
Economic indicators	PCP	—
	PerGDP	—
	ICP	+
	OER	?
	UR	+
Scientific and technological indicators	HTE	+
	IU	+
	PC	+
	STA	?

Table 2. Descriptive Statistics of All Variables

Variables	Mean	S.D.	Minimum	Maximum
Software piracy rates (SPR)	0.409	0.12	0.21	0.74
Patent and copyright protection (PCP)	6.936	1.39	2.92	9.15
Per capita GDP (PerGDP)	23884.348	7963.195	8070	47550
Inflation, consumer prices (ICP)	3.043	3.15	-0.9	20.63
Official exchange rate (OER)	95.926	293.25	0.66	1736.21
Unemployment rate (UR)	7.272	3.553	2.1	20.6
High technology exports (HTE)	17.833	9.793	2.55	47.52
Internet users (IU)	29.711	19.079	0.63	76.35
Personal computers (PC)	32.976	19.673	3.41	87.57
Scientific and technological journal articles (STA)	20602.34	39547.50	1255.00	205320.00

Table 3 Results of Panel Data Analysis (SPR as explained variable)

Variables	Model 1 (OLS)	Model 2 (FE)	Model 3 (RE)
PCP	-.045125[a]	-.05522[a]	-.04586[a]
	(<0.001)	(<0.001)	(<0.001)
PerGDP	.065516[a]	.08389[a]	.067132[a]
	(0.003)	(<0.001)	(0.002)
ICP	.07688[a]	.08422[a]	.07771[a]
	(<0.001)	(<0.001)	(<0.001)
OER	0.0002	0.00021	0.00019
	(0.246)	(0.238)	(0.230)
UR	.07871[a]	.08109[a]	.07887[a]
	(<0.001)	(<0.001)	(<0.001)
HTE	.03588[a]	.03345[a]	.03561[a]
	(<0.001)	(<0.001)	(<0.001)
IU	-0.00429	-0.005798	-0.00448
	(0.403)	(0.404)	(0.389)
PC	-.02014[a]	-.01577[a]	-.01985[a]
	(0.002)	(0.031)	(0.002)
STA	-.000006[a]	-.000005[a]	-.000006[a]
	(<0.001)	(<0.001)	(<0.001)
R-squares	0.75186	0.782856	0.751819
OLS vs FE		29.25 [a]	
		(<0.001)	
OLS vs RE			14.1346[a]
			(<0.001)
FE vs RE			17.212[b]
			(0.0455)
Number of Sample	207	207	207

Note: Notations [a] and [b] respectively represent the 5% and 10% significance levels.