The Relationship between Software Protection and Piracy: Evidence from Europe

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Abstract

In this paper, we empirically examine the relationship between software protection and piracy rates using a panel data set for 24 European countries. In addition, a new measure of software protection is constructed. We find evidence that software protection has a significant negative effect on piracy rates. We also find that per capita income has a significant negative effect on piracy rates. Additionally, the above findings are robust to the inclusion of other descriptors suggested by the empirical literature on piracy.

Key Words: Piracy, Enforcement, Software protection, Panel data, Copyright.
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1 Introduction

The increase of piracy is a phenomenon that in recent years has greatly affected markets for information goods such as business and entertainment software applications, sound recordings, movies, and books. Without doubt, the emergence of digital technologies has provided the opportunity for copyright violations on a much larger scale than it ever was and has raised serious concerns on actual intellectual property rights (IPRs) system. Nowadays, there is an intensive debate over how IPR should be adapted and structured. At this respect, for instance, the EU software developers have expressed serious concerns over the prospective EU enlargement because thousands of illegal copies may be brought into the European market. Obviously, cross border regulations will be of critical importance within the EU Antipiracy policy. Third, new legal criteria, as Part III of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs), have assumed a crucial position to fight against piracy[1].

Since piracy affect mostly business software application and since legal rules such as enforcement measures are considered as vital for the prospective development of software industry, the relationship is of great importance.

To date, no empirical paper has examined the impact of software protection on piracy levels in European countries[2]. The majority of empirical studies on piracy has adopted a cross–section estimation method and therefore has the weaknesses of not being able to account for changes over time and unobserved heterogeneity. In the current paper, we estimate a panel data model using data for 24 European countries over a period of three years: 1994, 1997 and 2000. Panel data methods allow control for omitted variables bias and improving the accuracy of parameter

[1] Arts 41–61 provide explicitly enforcement measures.

[2] Another related branch of the empirical literature has examined the impact of IPR protection on economic growth, trade flows and technology licensing using IPR scores. Mansfield (1994), Seyoum (1996), Maskus and Penubarti (1995), Maskus (2001), and Yang and Maskus (2001), among others.

estimates. Furthermore, we also contributes to the existing empirical literature on cross national IP measures by developing one of the first software protection indexes that takes explicitly into account statutory law as well as their enforcement.

The rest of the paper is organized as follows. The next section briefly reviews the existing literature on measures of IPRs protection. Section 3 describes the index of software protection. The variables used in the empirical analysis are presented in Section 4. Section 5 addresses the econometric specification. In Section 6, the estimation results are presented. Section 7 contains a conclusion and suggestions for future research.

2 Measures of IPRs

A number of researchers have attempted to quantify cross–nationally IP protection measures. A study by Rapp and Rozek (1990) was the first to construct a IP measure. The RR index considered 159 countries and focused on patent laws rather than other forms of IP protection. Their measure ranged from zero to five. Its main disadvantage is that belongs to the transition period.

The RR index was considerably extended by Ginarte and Park (GP) (1997). The GP index covers 110 countries for the period 1960–1990 and focuses on the strength of patent rights. Their index accounts for five categories of patent laws: (1) extent of coverage, (2) duration of protection, (3) membership in international patent conventions, (4) provisions of loss of protection and (5) enforcement mechanisms. Each of the categories is codified between 0 and 1. In their index, each of the categories are given equal weights. Like in RR, their index varies from zero to five where zero represents a country with no patent protection and five represents a country with the highest level of protection. For the purpose of this study, however, the GP measure is not appropriate because it assess the strength of patent laws rather than copyright laws and measures the laws on the books but not their actual enforcement.

As Ostergard (2000) noted, enforcement aspects might have a crucial impact on the level of protection enjoyed in a particular country. The Ostergard's measure includes 20 countries for the years 1988, 1991 and 1994. His copyright index ranges from zero to 10 while the enforcement component ranges from zero to four where a higher value corresponds to a higher level of enforcement. The advantages of the Ostergard index are quantifying several forms of IP protection (patents, copyrights and trademarks) and accounting and accounting for enforcement issues as well as law on the books. However, his measure is only available for only 12 countries of the 24 countries for which we have piracy data and we only observe it in 1994.

In summary, patent rights indexes has been widely used in empirical studies. Furthermore, none of these studies has attempted to quantify the level of software protection across European countries. Specifically, in the next section, I build a software protection index used in this empirical investigation.

3 Measuring Software Protection in Europe

As mentioned, one of the objectives of this study is the construction of a software protection measure across European countries. This is complicated by the fact that many national copyright laws are not available in English and any IP protection measure might be subject to subjectivity and criticism itself.

As regards as software protection concerned, computer programs may qualify for several methods of IP protection (patents, copyright and trade secrets). The EU law protects computer software as "literary works" (Art. 1, Council Directive 91/250/EEC). This in line with other international agreements[3]. What is really protected is the expression of a computer program[4] against unauthorized duplication. Ideas do not enjoy copyright protection (Art. 2, Council Directive 91/250/EEC). Thus, our analysis focused on this mechanism of IP protection[5].

In the spirit of Ginarte and Park (1997), our index of software protection is composed of two dimensions: statutory law and enforcement. In the subsequent subsections, a brief description of each of these components and reasoning for use them are provided.

3.1 Law component

The law component contains information on two categories: membership in international copyright treaties and statutory enforcement measures.

- International Copyright Conventions

The protection of software across national borders relies on several international agreements on intellectual property. The main international copyright conventions are: the Berne Convention for the protection of artistic and literary works (1886)[6], the WIPO copyright Treaty (1996) and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS, 1994).

Many scholars have also used country's membership in international conventions as crude indicator of the strength of a country's IP law (Ferrantino, 1993;

[3]See, Art. 11 of the TRIPS agreement (1995), Art. 4 of the WIPO Copyright Treaty (1996) and the Berne Convention (1971).

[4]The expression of a computer program encompasses: operating systems, application programs, programming language and manuals.

[5]Over the last ten years, an intense debate has emerged in relation to whether and to what extent should be patentable. By contrast, computer programs are patentable in the US.

[6]Although, the Berne Convention does not explicitly include computer programs to qualify for protection. However, the definition of literary and artistic works" is extremely broad and thus can encompass computer software. It has been revised and amended various times: revised at Berlin (1908), revised at Rome (1928), at Brussels (1948), at Stockholm (1967), and at Paris (1971), and amended in 1979 (Berne Union).

Burke, 1996; Rapp and Rozek, 1990; Hogenbirk and Van Kranenburg, 2003). It is argued that country's membership any convention may be a signal that its national law recognizes the principle of national treatment and certain period of protection. In addition, we have explicitly incorporated the 1994 TRIPS agreement administered by the WIPO because it establishes certain minimum standards in matter of enforcement for WTO members. We believe that it is essential that our index reflect how WTO members are making adjustments in their enforcement practices to bring them in compliance with TRIPS.

- Judicial measures

Obviously, international membership is a poor software protection indicator. Enforcement measures take enormous relevance due to the emphasis placed on them by recent international copyright conventions. Most European countries stand in line with TRIPs recommendations in matter of enforcement efforts but in some cases, there is a urgent need to reform legal system and its administration in light of the latest reports conducted by several international organizations.

In line with Ginarte and Park (1997), this study considers the presence or absence of the following statutory enforcement measures but it focuses on statutory enforcement measures for computer programs. The judicial measures included are: ex–parte civil search, border measures and remedies. They are based on what is written down in national copyright laws. Even if they are changed, it is possible to compute exact values for each period of time, considering the current copyright law at present. This source of information was supplemented with Civil and Penal Codes.

- Ex–parte Civil Search Order

A legal procedure which has been regularly implemented against pirates of copyright material is the Anton Piller order[7]. This legal term describes a search conducted upon the application of the copyright holder without prior notice filed with a court, wherein the copyright–holder alleges an infringement of a right likely to cause harm and or where there is a enough risk of evidence of being destroyed. If granted, the court will allow the plaintiff to enter the workplace or residence of another in search for documents, software, etc for preserve it or to obtain evidence that may be improperly withheld.

- Border Measures

This legal term refers to acts where the copyright holder may file in an application to the custom authorities to suspend the entry of pirated goods (illegal software). In most European laws, there also exists a chance custom officials may act ex–officio (by surprise). As a general rule, the goods proved be pirated through a final decision of a court will be destroyed or rendered to the copyright holder[8].

- Remedies

Another usual enforcement measure is the availability of remedies such as seizure and destruction of infringing copies as well as materials and equipment used for their reproduction.

[7] This rules derives from the English case Anton Piller K.G.V. Manufacturing Process LTD in 1976.

[8] As regards to European customs action against infringements to intellectual property rights, the legal framework is the Council Regulation 3295/94 of 22 December 1994. Its effects extended to infringement of copyright and other similar rights and also to export and re–export. Lastly, the custom authorities were given greater scope for action and were allowed to act ex–officio. In 1999 Council Regulation No. 241/99 substantially amended the 1994 Regulation, broadening its scope to patents and supplementary certificates, as well as to the protection of Community trademarks at customs via an uniform system of protection in all Member States. Similarly, intervention was extended to infringing goods whatever their customs status.

The law component is quantified as the sum of two categories equally weighted and ranges from zero to two where higher values indicate a stronger software protection on the books[9].

3.2 Enforcement component

It should be noted that the legal procedures above mentioned reflect a potential assessment of the form and degree of a particular country to comply with general provisions of the IP law not as they are actually implemented.

In the current paper, we also quantify the enforcement aspect of IPRs regime. We use actual placements on the Special 301 Watch list in coding the enforcement component[10]. In the USTR's list countries are ranked from the lowest to strictest degree of IP enforcement. Thus, countries whose acts, policies or practices have the greatest adverse impact on relevant U.S. products are categorized as Priority Foreign Countries (PFC). The Priority Watch list (PWL) and Watch list (WL) identify those countries which have serious deficiencies in matter of IPRs. Countries which have minor deficiencies are placed on Other Observations (OO). The enforcement component ranges from 1 to 4 where higher values correspond to a higher levels of enforcement. Table 1 lists the coding criteria.

To get the overall score of index for each country and period of time, the law component was multiplied by the enforcement dimension (A complete list of components is presented in Appendix). Table 7 displays the index values over the periods of time 1994, 1997 and 2000 (see, Appendix). The reason of choosing only three periods of time is because one would not expect laws were to vary much

[9] One might argue that this assumption is very restrictive and that each category should be weighted according to their importance. One question arises, what is the most important treaty?. Subjective criteria should be introduce by the fact that no theoretical framework exists indicating the relative importance of each factor.

[10] For example, Smarzynska (2002) uses the same enforcement component to examine the impact of IPRs on foreign direct investment.

Table 1: **Enforcement coding**

Value	Description
1	Priority Watch List (PWL)
2	Watch List (WL)
3	Other observations (OO)
4	No reported problems

Source: IIPA Special 301 reports

annually and the earliest piracy data date back to the year 1994. On average, the highest scores were obtained by Austria, Belgium, Finland, France, Netherlands and Switzerland (7.11) while Russia had the lowest score (0.78). The average value of the index is 4.87.

Finally, as a check, the Pearson correlation coefficients between our index and similar indexes used in the literature are shown in Table 2. All correlations have a positive sign as expected. The highest correlation of our index was with Ginarte and Park's measure[11]. RR and Ostergard measures are moderately correlated with our index.

4 The variables

In this section, we describe the explanatory variables and endogenous variable. Sample statistics for all variables used in the empirical analysis are reported in Table 4.

[11] I would like to thank Walter Park for kindly providing the updated version of the index.

Table 2: **Correlation matrix of IP measures**

Year	RR (N=15)	GP (N=21)	OS (N=19)
2000	0.27	0.54	0.52
1997	0.30	0.48	0.37
1994	0.53	0.69	0.57

Note: RP = Rapp and Rozek (1990); GP = Ginarte and Park (1997) and Ostergard (2000). Correlation are computed for all years for which our software protection score is available. N= number of observations

4.1 Dependent variable

In this paper, the dependent variable is the piracy rate. Annual national software piracy rates are compiled by the Business Software Alliance (BSA) and the Software Information Industry Association (SIIA) for eighty countries since 1994. We have only considered observations from individual countries where we have the piracy rate. Thus, we net out merged observations corresponding to Croacia/Ukraine.

Piracy rates are computed as the difference between software programs installed (demand side) and software applications legally licensed (supply)[12]. Thus, piracy rates are defined as the volume of software pirated as a percent of total software installed in each country. Piracy rates range from 0 % to 100 % (all software installed is pirated). It is important to emphasize that piracy rates are only estimates. The BSA's piracy data suffers from the fact that a large part of software is sold without the computer hardware. This might introduce some sort of bias in the reported piracy rates. Despite of these shortcomings, they have been widely

[12] Further information on the methodology employed to construct piracy rates can be found in the recent report on Global Software Piracy elaborated by the BSA and SIIA (2000).

used in empirical models of piracy (Givon, Mahajan and Muller, 1995; Husted, 2000; Marron and Steel, 2000 ; Hogenbirk and Van Kranenburg, 2003;).

Table 3 presents data on estimated rates of piracy and the associated lost revenues for business software applications over the period of study. The mean piracy rate was 55.36 and the median was 51.5. Average piracy rates decreased substantially from 1994 to 2000 (30 %).

As regards as piracy ranking across European countries concerned, in some Eastern countries, all software installed is pirated. For instance, Russia, had a piracy rate of 88 % in 2000. Czech. Rep had the lowest piracy rate in this region at 43 %. In Western Europe, Greece was the country with the highest piracy rate at 66 %. Other countries, for instance, Denmark and United Kingdom, in contrast had piracy rates in business software applications of 26 %. Overall, the average software piracy rate is at a higher level in Eastern Europe than that in Western Europe. The average piracy level of countries included in this study was of 46 % in 2000 while Sweden, Norway, Switzerland, Belgium, Finland, Germany, Denmark and UK were the only countries with piracy rates below world average piracy rate at 37%.

Interestingly, it can be seen that countries are not affected in the same way for piracy. Richer nations register lower piracy rates but their total piracy loss is higher due to higher usage rates.

4.2 Explanatory variables

In the formal literature, the relationship between income and piracy is far from being clear. Some authors confirm a negative relationship between piracy rates and income (Burke, 1996; Husted, 2000; Marron and Steel, 2000; Ramello and Silva, 2000; Gopal and Sanders, 1998 and Cheng et al., 1997). It is argued that the higher the level of economic development, the less likely illegal activities replace

Table 3: **Estimated piracy rates and lost revenues**

Year	1994		1997		2000	
Country	piracy rate (%)	revenue ($ th.)	piracy rate (%)	revenue ($ th.)	piracy rate (%)	revenue ($ th.)
Austria	47	41,223	40	41,620	37	70,748
Belgium	53	41,223	36	51,485	33	53,767
Denmark	48	67,300	32	45,787	26	40,076
Finland	53	56,081	38	37,754	29	39,135
France	53	421,145	44	407,900	40	480,064
Germany	48	671,068	33	508,884	28	635,264
Greece	87	28,845	73	44,546	66	61,542
Ireland	74	30,590	65	46,847	41	77,399
Italy	69	288,490	43	271,714	46	421,942
Netherlands	64	206,706	48	195,098	40	227,595
Norway	53	80,092	46	104,337	35	64,292
Portugal	65	36,091	51	40,991	42	23,609
Spain	77	190,746	59	167,288	51	168,514
Sweden	54	151,993	43	127,051	35	92,889
Switzerland	38	65,842	39	92,898	34	91,093
UK	42	370,793	31	334,527	26	530,787
Bulgaria	94	19,269	93	13,171	78	10,019
Czech Republic	66	97,150	52	51,972	43	44,674
Hungary	76	101,902	58	25,488	51	41,252
Poland	77	208,176	61	107,625	54	103,531
Romania	93	19,025	84	15,297	77	20,918
Russia	95	516,254	89	251,837	88	108,983
Slovakia	66	23,683	58	17,018	45	6,866
Slovenia	96	19,082	76	9,198	61	11,743
Average	66.74	161,372	54.61	128,646	46.65	146,673

Source: Eighth Annual BSA Global Software Piracy Study. Trends in Software Piracy 1994–2002.

legal ones.

In contrast, in a study of 39 countries, Hogenbirk and Van Kranenburg (2003), found a significant negative association between the income and the piracy rates.

In a panel data study, Kurtz et al. (2002), found that per capita income was negatively associated with the piracy rates of nations.

Per capita income is employed to measure economic development. Data on GDP per capita come from the World Bank's World Development Indicator (WDI, 2003). Per capita GDP in 1995 US dollars is used. The income variable is introduced in natural log in the estimates since we expect a non–linear relationship between piracy and income as indicated in previous studies (Marron and Steel, 2000).

To understand piracy rates, information about IP law is crucial. Most empirical studies of piracy have relied on international copyright membership as a standard proxy of the strength of national IP systems assuming such measure is appropriate. It is believed that the stronger the IP protection the less likely is that piracy happens. To date, empirical evidence is mixed. Burke (1996) estimated a multinomial logit model to explore the determinants of audio piracy levels. He found that copyright membership was not really effective in lowering audio piracy levels. More recently, Hogenbirk and Van Kranenburg (2003) examined the relationship between copyright protection and piracy rates over countries. Software protection was negatively associated with piracy rates, indicating that strong copyright protection might result in lower piracy rates.

One alternative explanation comes from the literature on criminal behavior. Piracy can be seen as a criminal act, and thus, the existence of strong copyright systems might increase the opportunity costs of piracy and therefore decreases the likelihood of piracy (Ehrlich, 1973). Unfortunately, we do not have information on penalties which are expected to be an important predictor when discussing issues of piracy. In this study, we have included a measure of software protection (*SOFT*).

Data collection on legal rules of copyright were explicitly concerned with index of software protection. The principal sources of all legal data were: World Intellectual property Organization (WIPO), United Nations Educational, Scientific and Cultural Organization (UNESCO), and the World Trade Organization (WTO). This information was supplemented by the criminal and civil codes in force and the text of national copyright laws.

To assess the robustness of our empirical specification measures of educational attaintment, scientific infrastructure and political rights and civil liberties have been also included in cross–country piracy studies. In general, the empirical evidence supports the notion that higher stock of human capital leads to lower piracy rates. Data on average years of schooling for people above 25 years (*EDUC*) are taken from Barro–Lee's dataset (2000). Countries with missing values on $EDUC$ for the sample period are assigned the most recent observation available.

The question of whether R& D has a statistically significant effect on piracy has been investigated by a number of researchers, including Marron and Steel, 2000; Kurt et al., 2002. The general conclusions appears to be that the measures of scientific infrastructure are typically inversely related to piracy rates. Data on R&D expenditures as a share of real GDP are taken from the World Bank's World Development Indicator (WDI, 2003). For some countries, R & D data are missing. We linearly interpolated values of the *R& D* variable for those countries with no recent observations available.

The motivation to include the *FI* variable is to shed some light the extent to which piracy is connected to political systems. It seems to be reasonable to expect that capitalistic countries have lower piracy rates. Marron and Steel (2000) found that the freedom index was not significantly associated with the national piracy rates. The data source for freedom index is the Freedom of House (2001).

Table 4: **Descriptive Statistics (NT= 72)**

Variable	Definition	Mean	Std Dev	Min	Max
PR	piracy rate (%)	55.36	19.32	26	96
PCGDP	real per capita GDP (in 1995 US)	18,952.38	13,003.83	1,310	46,777
SOFT	software protection index	4.87	2.42	0.67	8
R & D	R & D expenditures (% GDP)	1.52	0.82	0.37	3.80
EDUC	average years of schooling in population $>$ 25 years	8.87	1.51	4.33	11.86
FI	freedom index	1.56	0.73	1	5

5 Economic modelling

In this section, we describe the estimation procedure. Using the subscripts i and t to denote the country and year, we estimate a fixed effects model to examine the effects of software protection on piracy rates using data for 23 countries for 1994, 1997 and 2000. The baseline model employed in this paper is the following

$$y_{it} = X'_{it}\,\beta + Z'_{it}\,\gamma\ + \alpha_i\ + \epsilon_{it} \tag{1}$$

where y_{it} is the natural log of the piracy rate, X_{it} is a vector of explanatory variables that vary over countries and over time and that includes income and software protection variables, Z_{it} is a vector of additional regressors that are expected to influence piracy rates as well. The time invariant effects α_i that appear in eq. (1) control for the unobserved country fixed effects. These country specific effects might reflect factors such as persistent differences in tastes for piracy in a given country and national culture which may not be captured by the set of regressors included in our specification and ϵ_{it} are the usual random disturbance terms, assumed to be i.i.d. with mean zero and constant variance.

We know that the OLS estimator is biased (inconsistent) if the individual effects α_i are correlated with the explanatory variables x_{it} and z_{it}. Between model estimates are unbiased only if the individual effects are uncorrelated with x_{it} and z_{it}.

One alternative is to consider the FE (covariance) estimator that wipes out the unobserved individual heterogeneity using the within transformation of eq. (1). The covariance estimator relies on enough within variation across countries and over time and assumes that α_i are correlated with the set of regressors included in the model. One disadvantage of this modelling approach is that the FE cannot estimate the effect of any time invariant variable.

Finally, there are some potential issues associated with the software protection variable. The level of protection enjoyed in a particular country might be endogeneously determined as well as subject to measurement error.

The use of instrumental variables techniques addresses these issues. We use variables correlated with the software protection but uncorrelated with the error term. As instruments, we use the measure of quality bureaucracy and rule of law provided by Kaufmann et al. (2003). These measures do not include a measure of property rights and therefore we do not expect a problem of endogeneity.

Given that the number of instruments exceeds the number of regressors to be instrumented, the model is overidentified. With an overidentified model, we can test whether our instruments are valid for the level of piracy.

6 Estimation Results

Before proceeding we run a pooled OLS regression where we restrict the intercept coefficient to be the same across countries. We then examine whether the intercepts vary over countries using a F–test (see, Baltagi, 2001). The F–test (*p-value* = 0.000) reveals the existence of heterogenous intercepts across countries and therefore pooled OLS is biased and inconsistent since it omits the country specific effects in the estimation. We conclude that the presence of unobserved heterogeneity is statistically important in our sample.

A Ramsey's (1969) regression specification error test (RESET) suggests that there might not be inconsistency due to omitted variables (*p–value*=0.32). Finally, the hypothesis of a normal distribution of residuals in each equation was tested using Jarque Bera's (1987) statistical test[13].

The empirical results of the baseline specification are presented in Table 5. Column (1) contains the fixed effects estimates after applying OLS to the data in levels. We observe that all variables included in our study are statistically significant and have the anticipated signs. Together with the set of fixed effects, these two variables capture 95% of the variation in piracy rates across countries, and thus indicating a good performance for the regression model.

We find that $PCGDP$ has a negative significant impact on piracy rates. The estimated coefficient for income (and its t statistic) is $-1.54(-9.20)$. Countries cannot afford laws if they are relatively poor. Since the is expressed in logarithms, we can interpret the coefficient in terms of elasticities. If the per capita income is increased by 1%, piracy rates fall by 1.54%.

As expected, the $SOFT$ coefficient is negative and statistically significant at conventional levels. The interpretation of the coefficient is that as the level of software protection increases, the piracy rates decrease. Apparently, individuals perceive higher levels of protection as more harmful and pirate less as a result.

Given that our estimates may be inconsistent due to the possibility of simultaneity bias introduced by using software protection (SOFT) as regressor. Column (2) presents the fixed effects 2SLS estimates[14]. We also report the F–test for the

[13] In all regressions, the JB accepts the null hypothesis of normality of residuals on conventional significance levels.

[14] A Durbin–Wu Hausman test does not reject the the null hypothesis that the variable SOFT is exogenous. I have chosen to employ IV techniques since it makes no difference to the results. In addition, a Pagan Hall test for homoskedasticity was performed. The null hypothesis of homoscedastic errors in the IV regressions cannot be rejected.

Table 5: Panel Regression Results

Variables	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)
PCGDP	-1.539^{***}	-1.537^{***}	-1.356^{***}	-1.335^{***}	-1.303^{***}	-1.242^{***}
	(-9.20)	(-9.61)	(-6.72)	(-8.59)	(-7.25)	(-8.69)
SOFT	-0.029^{***}	-0.036^{**}	-0.027^{***}	-0.037^{**}	-0.028^{***}	-0.035^{**}
	(-3.37)	(-2.35)	(-3.29)	(-2.47)	(-3.65)	(-2.21)
Additional variables						
EDUC	–	–	-0.093^{**}	-0.084^{**}	-0.088^{*}	-0.093^{**}
			(-2.09)	(-2.03)	(-1.82)	(-2.09)
FI	–	–	-0.013	-0.017	0.012	0.009
			(-0.33)	(-0.59)	(0.31)	(0.31)
R & D			–	–	-0.145	-0.142^{*}
					(-1.62)	(-1.91)
Observations	72	72	72	72	72	72
R^2–adjusted	0.95	0.95	0.95	0.76	0.95	0.95
Jarque Bera	1.75	2.88	7.09	5.34	6.44	7.96
(p–value)	(0.417)	(0.237)	(0.029)	(0.069)	(0.04)	(0.019)
Partial R^2		0.20		0.18		0.18
F–test (1st)		5.50		4.86		4.67
(p–value)		(0.007)		(0.013)		(0.015)
Hansen's J–statistic		2.57		3.51		3.94
(p–value)		(0.109)		(0.061)		(0.047)

Note: Dependent variable is the natural log of piracy rate. All estimations carried out using STATA 8.0. A constant term and country dummies variables were included in all regressions but are not reported. Robust t–statistics are reported in parentheses. *** Statistically significant at 1%, ** Statistically significant at 5% and * Statistically significant at 10 %.

joint significance of the instruments in the first stage regression. In all these regressions, our instruments were statistically significant at the 0.05 per cent level. In assessing the validity of 2SLS approach, in the final row, we report the result of Hansens's J–statistic of overidentifying restrictions and the corresponding probability associated with the null hypothesis that instruments are uncorrelated with the error term. In all specifications, we do not fail to accept the null hypothesis that our instruments are uncorrelated with the error term.

Turning on the regression coefficients, the results are quite similar to OLS estimation. The software coefficient is negative and its magnitude is larger in 2SLS as compared with OLS estimates.

We now assess the robustness of our baseline specification and focus on the fixed effects 2SLS estimates. Columns (4) and (6) report the regression results when additional controls are included. All regression have a high explanatory power. The regression results regarding both software protection index and income are not affected substantially and we find that the coefficient on $EDUC$ variable is negative and significant in the piracy equation confirming that education increases demand for intellectual property rights. We also find that the FI variable to have a negative effect on piracy rates complementing previous empirical findings (Marron and Steel, 2000). Indeed, this effect appears to be positive when R&D is added. Nevertheless, nones of these effects is significant. Finally, the R &D variable appears to be negatively correlated with piracy rates.

Summing up, the empirical results indicate that the level of software protection (law on the books and their enforcement) as well as per capita income have influence on piracy rates. They also suggest the robustness of previous empirical findings when additional controls are included in the baseline specification.

7 Conclusions

In this paper, we empirically investigate the relationship between software protection and piracy rates. For that purpose, a new measure of software protection for 24 European countries for the years 1994, 1997 and 2000 is constructed.

The regression results reveal that a weak protection of software might increase piracy. Per capita income appears to have a negative significant effect on piracy rates. They also suggest earlier empirical findings are quite robust.

This paper has also some policy implications. Given that software protection can have larger impact on piracy than previously estimated. Consequently, policy makers should pay more attention how enforcement of IP laws is effectively carried out.

Obviously, the current version of the software protection index has some limitations. One extension is to include data on penalties, damages, delays in courts, etc. Unfortunately, a major obstacle is that the majority of national laws indicates whether or not there will be civil or criminal sanctions but does not go into the details (the length of jail sentences). The sample may be expanded to include more countries and time periods. In spite of these shortcomings, this research not only quantifes but also empirically links software protection to piracy.

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Table 6: **Index of Software Protection**

Law Component		
(1) International Membership	Signatory	Not signatory
Berne Convention	$\frac{1}{3}$	0
WIPO Copyright Treaty	$\frac{1}{3}$	0
TRIPs Agreement	$\frac{1}{3}$	0
(2) Judicial Measures	Exists	Does not exist
Ex–parte search	$\frac{1}{3}$	0
Border Measures	$\frac{1}{3}$	0
Remedies	$\frac{1}{3}$	0
Enforcement Component		
(1) Special 301 reviews	Placed on	
Priority Watch List	1	
Watch List	2	
Other observations	3	
No reported problems	4	

Table 7: **Index of Software Protection**

Country	Year	Score	Country	Year	Score
Austria	1994	5.32	Netherlands	1994	5.32
	1997	6		1997	8
	2000	8		2000	8
Belgium	1994	5.32	Norway	1994	5.32
	1997	8		1997	6.68
	2000	8		2000	6.68
Bulgaria	1994	2.68	Poland	1994	2
	1997	2		1997	3.34
	2000	6.68		2000	1.67
Czech Republic	1994	2.68	Portugal	1994	4
	1997	3.99		1997	8
	2000	3.34		2000	8
Denmark	1994	4	Romania	1994	1.32
	1997	3.34		1997	3.99
	2000	3.34		2000	3.34
Finland	1994	5.32	Russia	1994	0.99
	1997	8		1997	0.67
	2000	8		2000	0.67
France	1994	5.32	Slovakia	1994	1.32
	1997	8		1997	4
	2000	8		2000	6.68
Germany	1994	3	Slovenia	1994	1.32
	1997	6		1997	8
	2000	8		2000	8
Greece	1994	1.33	Spain	1994	2.66
	1997	2		1997	8
	2000	2		2000	4
Hungary	1994	2.68	Sweden	1994	4
	1997	6		1997	3.34
	2000	4		2000	8
Ireland	1994	5.32	Switzerland	1994	5.32
	1997	4		1997	8
	2000	4		2000	8
Italy	1994	2.66	United Kingdom	1994	4
	1997	4		1997	8
	2000	2		2000	8

Source: Constructed by the author from various legal sources (WIPO, UNESCO, and national copyright laws