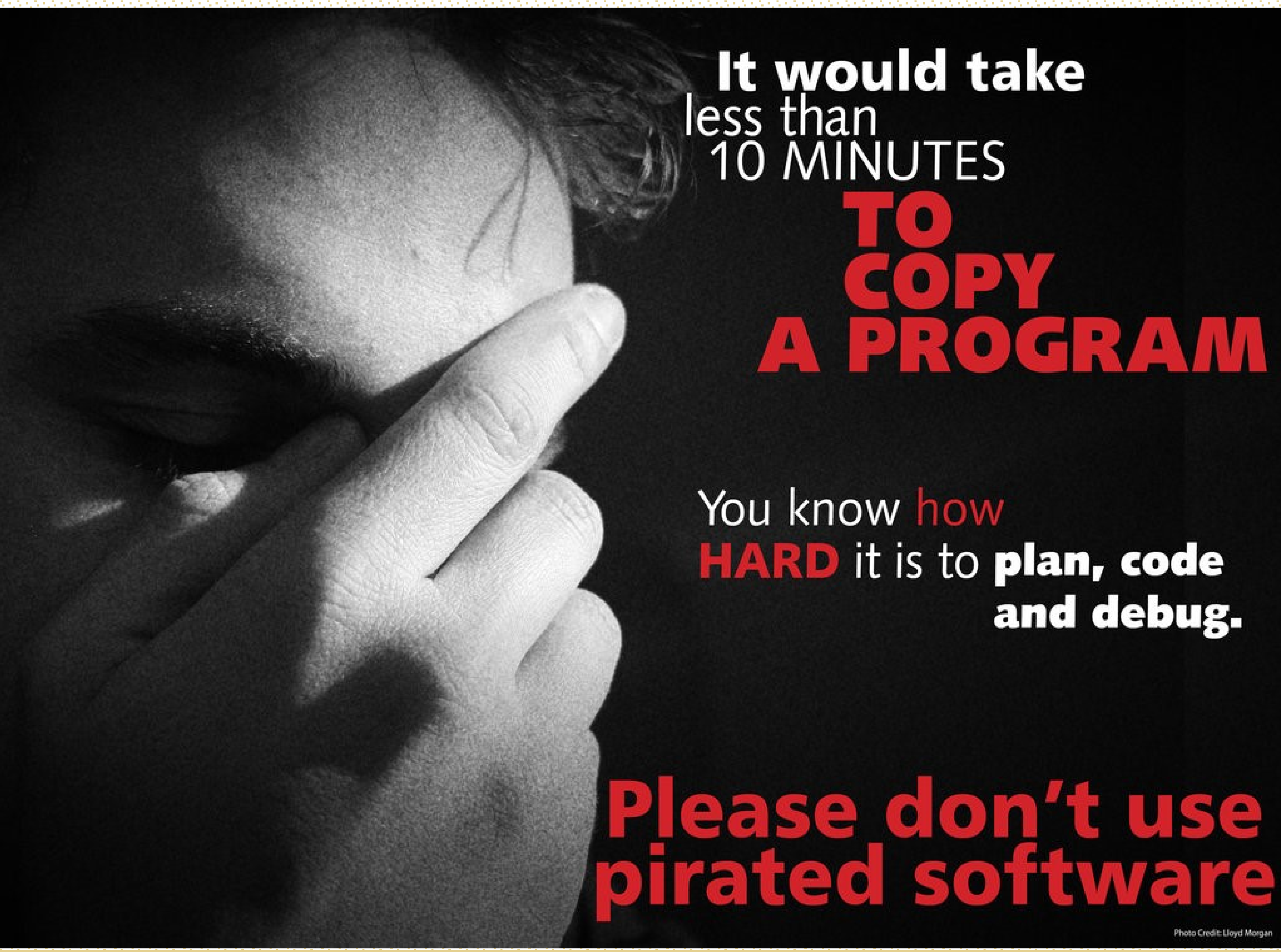

Nicolas Dias Gomes

Software Piracy: An Empirical Analysis

Tese de Doutoramento em Economia, Apresentada à Faculdade de Economia da Universidade de Coimbra
Orientada pelos Orientadores: Prof. Doutor Luís Miguel Alçada Tomás Almeida e
Prof. Doutor Pedro André Ribeiro Madeira da Cunha Cerqueira.

Setembro de 2014

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Coimbra, 2014

Acknowledgments

I would like to tank both my PhD advisors, Pedro Cerqueira and Luís Alçada for the support and continuous suggestions, critical feedback done and careful reading.

I would like to thank my brother, for correcting my work.

I would like to thank my mother for all the support done since the beginning.

Abstract

Chapter 2 summary

As the devices that used software became more available to the masses the problem of software piracy increases. Recent theoretical works have attempted to model the phenomenon of software piracy; others tried to describe empirically the determinants that may explain this phenomenon. The empirical literature in the latter case is still in its infancy. This chapter reviews the theoretical literature focusing on three major models: those dealing with diffusion models, with network externalities and with game theory. It also presents the empirical literature where we identify eight stylized results that reflect the main macroeconomic variables in five dimensions that explain software piracy: the Economic, Cultural, Educational, Technological and Legal and dimensions.

Chapter 3 summary

This chapter studies the determinants of software piracy losses along five major macroeconomic dimensions: Technological, Educational, Institutional, Access to Information and Labor force. The study was conducted based on a large dataset available from 1994 to 2010 and comprising 81 countries.

As for the Technological dimension, more patents by residents increases piracy losses while the effect of *R&D* is opposite (decreases piracy losses). In terms of the Educational dimension the results obtained show that more spending on education increase the piracy losses but, at the same time, more schooling years have the opposite effect. In the Institutional dimension, more corrupt free nations have low piracy levels. Regarding the Access to Information, it seems that access to Internet diminishes the losses while the share of Internet broadband subscriptions has no effect. The results show that, regarding the Labor dimension, employment in services has a deterrent effect while labor force with higher education and youth unemployment increases piracy losses.

Chapter 4 summary

This chapter explores the relation between the levels of taxation among different types of households and the levels of software piracy from 1996 to 2010, in the European Union (EU). It extends previous work by introducing large sets of panel data for the EU and its various regions. We estimate our model using the fixed effect, comparing results from the

Euro Area and the Countries that joined EU in 2004 and 2007. Results show that levels of taxation increase the levels of software piracy losses; moreover these results depend on marital status and number of children. The weight of taxation on GDP (e.g. the taxes on consumption) increases piracy losses while the impact of inflation is negative and marginal. Additional to this we also found that the relative importance of these taxes in relation to total taxation can affect this phenomenon. An increase in the weight of capital taxation would decrease software piracy while this effect was opposite when considering the relative importance of consumption taxes.

Chapter 5 summary

In this chapter we construct a panel data set from 2000 to 2011 for the EU 28, studying the impact of education on the levels of software piracy in a country.

When an aggregated analysis is made, e.g. considering all ISCED (International Standard Classification of Education) levels, expenditure on public educational institutions as well as public spending on education have a deterrent effect on piracy, being significant. However, the effect of financial aid to students is positive. When the analysis is made taking into account the ISCED 1997 disaggregation, expenditure on ISCED 5-6 has a negative and significant effect. Taking into account the type of educational institutions, more expenditure on ISCED 1 to 4 will lower piracy. We also found that more financial help to students on higher levels of education, e.g. ISCED 5-6, have a positive and significant effect. Finally, more years of schooling of both primary and secondary education will have a deterrent effect on software piracy.

Chapter 6 summary

This chapter analyses the interactions between software piracy and economic growth using a simultaneous equation approach to a panel of countries for which information on software piracy is available for 1995, 2000, 2005 and 2010. This allows us to establish the interactions between these variables, but also to measure the direct and indirect effects of other variables that have shown relevancy for both economic growth and software piracy. Results indicate that there exist a concave nonlinear relationship between software piracy and economic growth.

Keywords: Software Piracy, *Copyright, Intellectual Property Rights,* System GMM, Panel data, personal taxation, Education, ISCED classification, Economic Growth, 3SLS

JEL Classification: *C12, C23, C33, C50, C51, C70, D85, H20, I21, L86, O34, O40 O52*

Resumo

Resumo do Capítulo 2

Há medida que os computadores que usam software se disseminaram, o problema da pirataria informática surgiu. Estudos teóricos recentes modelaram o fenómeno da pirataria; outros tentaram explicar empiricamente os determinantes que podem explicar este fenómeno. A literatura empírica ainda está em sua infância. Este capítulo analisa a literatura teórica com foco em três grandes modelos: aqueles que lidam com modelos de difusão, as externalidades de rede e com a teoria dos jogos. Apresenta, também, a literatura empírica em que identificamos oito resultados estilizados que refletem as principais variáveis em cinco dimensões macroeconómicas que explicam a pirataria de software: económicas, culturais, educacionais, tecnológicas e dimensões legais.

Resumo do Capítulo 3

Este capítulo estuda os determinantes das perdas resultantes da pirataria de software ao longo de cinco dimensões macroeconômicas principais: tecnológica, dimensões educacionais, aspectos institucionais, força de trabalho e acesso à informação utilizando um conjunto grande de dados disponíveis de 1994-2010, composto por 81 países.

Quanto à dimensão tecnológica, mais patentes por residentes aumenta as perdas de pirataria enquanto o efeito do *I&D* é oposta (diminui as perdas de pirataria). Em termos da dimensão educacional, os resultados obtidos mostram que mais gastos em educação aumentam as perdas de pirataria, mas, ao mesmo tempo, mais anos de escolaridade têm o efeito oposto. Na dimensão institucional, as nações livres de corrupção, têm baixos níveis de pirataria. Em relação ao acesso à informação, parece que o acesso à Internet diminui as perdas, enquanto a quota de assinaturas de banda larga à Internet não tem efeito. Os resultados mostram que, em relação à Força de Trabalho, o emprego nos serviços tem um efeito dissuasor, enquanto força de trabalho com o ensino superior e o desemprego dos jovens aumenta as perdas de pirataria.

Resumo do Capítulo 4

Este capítulo explora a relação entre níveis de tributação entre os diferentes tipos de famílias na União Europeia e os níveis de pirataria de software entre 1996-2010. Melhora estudos anteriores na medida em que introduz dados em painel, estudando a União Europeia e as

diferentes regiões. Nós estimamos o nosso modelo utilizando o efeito fixo (FE), comparando os resultados a partir da zona do euro e os países que aderiram à UE em 2004 e 2007. Os resultados mostram que os níveis de tributação aumentam os níveis de pirataria de software. Além disso, estes resultados dependem do estado civil das famílias e do número de filhos. O peso da tributação sobre um PIB na Economia (Produto Interno Bruto), ou seja, os impostos sobre o consumo têm um efeito positivo sobre os prejuízos da pirataria, enquanto o impacto da inflação é negativa e marginal sobre a pirataria de software. Alem disto, a importância relativa desses impostos em relação ao peso total de impostos pode afetar este fenômeno. Um aumento no peso da tributação do capital diminuiria a pirataria de software, enquanto este efeito foi oposto ao considerar a importância relativa dos impostos sobre o consumo.

Resumo do Capítulo 5

Neste capítulo vamos construir um painel de dados entre 2000-2011 para a UE 28, estudando o impacto da educação sobre os níveis de pirataria de software.

Quando uma análise de agregados é feita, e.g. considerando todos os níveis de ISCED (Classificação Internacional Tipo da Educação), gastos com instituições educacionais públicas, bem como os gastos públicos com a educação tem um efeito dissuasor sobre a pirataria, sendo significativo. No entanto, o efeito de ajuda financeira aos estudantes é positivo. Quando a análise é feita tendo em conta a desagregação ISCED 1997, as despesas com ISCED 5-6 tem um efeito negativo e significativo. Tendo em conta o tipo de instituições de ensino, mais despesas com ISCED 1-4 irá reduzir a pirataria. Também encontramos que mais ajuda financeira aos estudantes nos níveis mais elevados do ensino, por exemplo, ISCED 5-6, tem um efeito positivo e significativo. Por fim, mais anos de escolaridade do ensino primário e secundário terá um efeito dissuasor sobre a pirataria de software.

Resumo do Capítulo 6

Este capítulo analisa as interações entre a pirataria de software e o crescimento económico através de uma abordagem de equações simultâneas, utilizando um painel de países para os quais informações sobre a pirataria está disponível para 1995, 2000, 2005 e 2010. O que nos permite estabelecer as interações entre essas variáveis, mas também para medir os efeitos diretos e indiretos de outras variáveis que mostraram relevância para o crescimento

económico e a pirataria de software. Os resultados indicam que existe uma relação não linear côncava entre a pirataria de software e crescimento económico.

Palavras-chave: Pirataria de Software, Direitos Autorais, Direitos de Propriedade Intelectual, Sistema GMM, dados em Painel, impostos sobre o rendimento do trabalho, Educação, classificação ISCED, Crescimento Económico, 3SLS

Classificação JEL: *C12, C23, C33, C50, C51, C70, D85, H20, I21, L86, O34, O40 O52*

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Chapter 1　Introduction

During the past decade, the information society witnessed a huge development across the globe. In 1994, the use of Internet was very small (less than 1 user per 100 habitants) while in 2010 this number increased to 52/100 Internet users[1]. Information is widely available and almost instantly accessible with a simple click on the mouse. This access to information was developed alongside to the new technologies, namely the Internet and Computers. But to be able to access this information operating systems that are installed on Computers are necessary. Some of these operating systems are free, based on Linux; on the other side we have proprietary systems such as Microsoft® Windows and the Apple® Mac OS X. Furthermore, in each of these operating systems, complementary software can be used to facilitate and take profit of this global access (communication tools, productivity and media suites, and games).

These developments also brought problems to the society; on one side we have programs such virus that could access private information. As an example of the extremely large number of treats, Kaspersky lab products neutralized 5 188 740 554 cyber-attacks, and almost 3 billion malwares attacks. Out of the 3 billion malwares, 1.8 million malicious and potentially unwanted programs were detected. We also have pirates that for the sake of visibility (or personal ideology of open access to software) will hack software; they will break its protection and distribute it to the general public for free. This is known as software piracy that can be defined as the unauthorized use of software that is copyright protected.

This phenomenon has been increasing over the years (see Figure 3.1) and can bring harmful consequences for countries and firms, because taxes are not collected and jobs are lost. Since 1994 the *Business Software Alliance* (BSA) provides estimates for this phenomenon across a large group of countries.

Due to the importance of the software piracy, with losses that represent more than 62.7$ billion in 2013 (BSA, 2014), this thesis will study this phenomenon trying to find the major macroeconomic determinants that may explain it. Software piracy is a relatively recent phenomenon and follows the technological development of a country; e.g., greater access to global digital content increases the ease of obtaining information and utilities to break the protection of the protected software and simultaneously increases the ease of finding and distribute this software after unprotected. Chapter 2 of this thesis has the main objective to

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[1] Data based on the World Development Indicators of the World Bank.

provide an introduction to the problem, and consist on a survey of the literature on software piracy in which we systematize previous findings in a series of stylized facts that may constitute the basis for future empirical literature. Chapter 3 gives a broad picture of the software piracy phenomenon across all the countries present in official publications. Chapter 4 and Chapter 5 focus on this phenomenon across the European Union to give a detailed analysis of previous findings. Finally in Chapter 6 we will try to find what are the effects of the software piracy on economic growth. We now provide a detailed summary of the main chapters; in each one we identify the main objectives, methodology, brief conclusions and also the relationships between the different chapters.

Chapter 2 presents a systematic review of the empirical literature on software piracy in which we identify several stylized facts across five major macroeconomic dimensions: economic, cultural, educational, technological and legal/institutional dimensions. Surveys on theory that can explain software piracy already exist, namely Peitz and Waelbroeck (2006a) and Belleflamme and Peitz (2010). We also provide some advantages of theoretical works. This work focuses essentially on economic theory (describing the different approaches, game theory, diffusion models and network externalities) and empirical results found that can be applied to the economy and will be the building blocks for the remaining thesis.

In Chapter 3 we investigate the major worldwide macroeconomic dimensions that can affect software piracy losses. This variable (piracy losses) is present in the official publications, but no empirical work has focused on its determinants. This variable provides different results (compared with piracy rates) as it measures different realities; for instance, United States has low piracy rates but represent huge losses, comparable to the European Union as a whole. This work tries to identify which of the macroeconomic dimensions, including the structure of the Labor force; Technological dimension; Access to Information, Educational dimension and the correct functioning of Institutions, that can explain this phenomenon. The majority of empirical studies used cross-sectional data or panel data for a short period of time. We contribute to the debate on this problem because we introduce a large dataset from 1994 to 2010 corresponding to 81 countries. It was found that the dataset was persistent and to take into account this, we implemented a dynamic panel data analysis using the System GMM proposed by Arellano and Bover (1995) and Blundell and Bond (1998).

After studying this phenomenon worldwide we investigate a relatively small group of countries; the European Union, in chapters four and five (fixed effect model will be used). Chapter 4 identifies what are the consequences of personal taxation on the disposable income that will be used to spend on digital goods. This chapter also uses software piracy losses as a dependent variable. The main question that we try to answer is how the level of taxation and the taxation structure will affect households. Data on different households are provided by the Eurostat (from 1996 to 2010), the effective level of taxation is available for thirteen households that are representative of the population.

European Union has several taxes, we consider those that are more representative, e.g. the personal income tax (PIT), corporate income tax (CIT) and value added tax (VAT). We provide a comprehensive analysis of these taxes as well as the effective taxation level of households that include social security contributions. We found that taxation positively affect software piracy, e.g., it increases piracy, although this depends of income and number of children. To assess the validity of our results we also split the sample into the different regions, only on countries outside the euro and the countries that recently entered in 2004 and 2007 significance was maintained. The final question that we tried to answer was the relative importance of these three taxes (PIT, CIT and VAT) as a share of total taxation. Results indicate that there is still room in reducing the impact of taxation on consumption.

On Chapter 5 we study the effects of education on software piracy, namely focusing on financial aspects. We introduce as a dependent variable the software piracy rates (from 2000 to 2011). The main contribution to the empirical literature is the introduction of educational dimension reflecting financial aspects as opposed to previous studies (Goel & Nelson, 2009) that only used non-financial variables such as literacy rate. Furthermore our analysis disaggregates this expenditure into the different levels of education (primary, secondary and tertiary education). Results show that spending on education will reduce software piracy but at the same time more financial aid to students will increase it.

In Chapter 6 we present a different perspective of this phenomenon; we extend the results found by Andrés and Goel (2012), which using a cross sectional analysis found that software piracy affected economic growth, although this relation was not robust. This chapter identifies what are the consequences of software piracy on economic growth. To take into account the effects of software piracy on economic growth and the effects of economic growth on software piracy we, implement a system of equations using the 3SLS

(3 stage least squares) for the years 1995, 2000, 2005 and 2010 for the 75 countries present in the official publications. To implement this analysis we introduced a full set of country dummies (fixed effects). Proceeding this way we obtained robust results. We found that piracy has a concave relationship on economic growth.

Finally, Chapter 7 concludes. We summarize the main findings and possible limitations, providing future paths for research.

Chapter 2 Software Piracy: A critical survey of the theoretical and empirical literature

2.1 Introduction

Technology has evolved over the years and is present in almost everything we use. Common examples of that fact are the computers and the Internet. Computers and the Internet play an important role in our lives; they increase the productivity of firms, make life easier for households allowing, for instance, home banking or online shopping. Other examples can be added; perhaps one of the tools that most significantly improved the productivity of enterprises was the replacement of the typewriter by the computer. That device has been used since the 19^{th} century when Christopher Sholes developed the first modern typewriter in 1866. Other devices have benefited from these developments and with miniaturization of components. Examples are the smartphones, tablets, laptops, etc.

The above-mentioned devices cannot run without the software; only with it can we exploit its full potential. An operating system will start and control these machines, but tools like Microsoft® Office to produce professional documents are also required, which can increase the initial price. Software and hardware are protected by Copyright laws. It is in the first case that these copyright laws must be better enforced, due to the nature of the software: i) it can be reproduced at almost no cost, with the same quality as the original , ii) it is easily modified by hackers that beat the protective barriers and iii) it is easily distributed.

Software piracy occurs when there is an unauthorized use duplication or sale of commercially available software (Moores & Dhillon, 2000) that is protected under national or international copyright laws. This piracy can come in many forms[2]. Software piracy affects profits of firms because potential software units are not sold. Additional to this it can affect levels of employment. Annually, *Business Software Alliance* (BSA) publishes estimates of piracy losses and rates for a large group of countries (Annex I provides a detailed summary of the Annual reports). At the moment these estimates are one of the most reliable ones. Nevertheless the full methodology is not publicly available as it uses

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[2] Softlifting: purchasing a single licensed copy of software and loading the same copy onto several computers, contrary to the license terms; Internet: making unauthorized copies of copyrighted software available to others electronically; Software counterfeiting: the illegal duplication and distribution of copyrighted software in a form designed to make it appear to be legitimate; OEM unbundling: selling stand-alone software that was intended to be bundled with specific accompanying hardware; Hard disk loading: installing unauthorized copies of software onto the hard disks of personal computers, often as an incentive for the end user to buy the hardware from that particular hardware dealer and Renting: unauthorized rental of software for temporary use, like you would a video.

confidential information provided by its members (Adobe®, AVG®, Intel®, Microsoft®, Symantec® are some of the members; they cover both the hardware and software industry). These estimates have been widely used in empirical works to analyze the underlining factors that affect software piracy. See, for instance, (Andrés, 2006a).

We must separate two types of piracy: the commercial type in which we buy a DVD from the black market - in this case the reseller has profits and compete with other firms (the competition is asymmetrical[3]); and the end-user piracy, when consumers use, at home software that is not sold. Commercial piracy is a form of counterfeiting; it can be used both in hardware and software industry. There are some actions that firms can implement to protect software. One is in the courts, enforcing anti-piracy laws. Other actions can involve updating programs, introducing mechanisms that can detect pirated products making them unusable to the user. Some piracy can be beneficial for the software developer (Lahiri & Dey, 2013; Lu & Poddar, 2012).

Due to the growing importance of software piracy, as a consequence of global digitalization of the economy, the main goal of this chapter is to provide a comprehensive survey of the theoretical and empirical literature that will serve as building blocks for future empirical studies that are still in their infancy. The main conclusions of the empirical works are summarized in a series of eight stylized results.

This work is built on recent works by Peitz and Waelbroeck (2006b), who made a critical review of the recent theoretical literature that addresses the economic consequences of end-user copying and, more recently, Belleflamme and Peitz (2010), who made a review of the theoretical developments made on the subject of digital piracy, in which software piracy is included.

The chapter is organized as follows: section 2.2 reviews the theoretical literature focusing the main strategies adopted by authors to model this problem which are diffusion models, network externalities and game theory models; in section 2.3 the empirical literature on software piracy is reviewed, describing the stylized facts; finally section 2.4 concludes.

[3] Some authors that model this phenomenon are Peitz and Waelbroeck (2004); Peitz and Waelbroeck (2006a); Duchêne and Waelbroeck (2005) and Zhang (2002).

2.2 Theoretical Literature

Different studies from different areas of knowledge present important conclusions for the firms, software developers, consumers and governments. These agents are important to prevent piracy; they can enforce *Intellectual Property Rights Protection,* can deter consumers from using illegal software through positive incentives (e.g. inclusion of printed manual with legal software) or negative incentives (e.g. increasing penalties from using illegal software - these penalties can range from fines to prison). This section focuses on three theoretical methodologies.

The first theoretical model considered will be the diffusion model (see Bass (1969)); we introduce this model because it can predict potential sales of software or potential software piracy.

Another type of models analyzed will be the ones that introduce network externalities. A network effect can be defined as the additional benefit that a consumer retrieves from a product as more consumers use it. For example, a small group of consumers of an operating system has little technical support. As other users start to use it, more technical support is introduced which beneficiate all users; this can be seen as an advantage.

As the use of a certain operating system increases it also increases the probability of virus attacks; this could represent a risky situation because when a person or a "team" develops a virus, their main objective may be to maximize damage. Other objectives may be less harmful, or even benefic, like a simple alert to a detected security hole in the system. Some pirated software downloaded from the Internet bring unwanted "presents" in the form of Trojans or Virus. After downloaded they attack computers that run, mainly, Windows® operating systems. Anti-virus software such as Kaspersky detect and neutralize millions of threats every year. As the number of consumers increases, some will purchase illicit software; nevertheless the majority will purchase licit software. Based on Givon, Mahajan, and Muller (1995), some of pirates will purchase or licentiate the software in a later period.

Models that use game theory can model the behavior of consumers or firms; it is defined as "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson, 1997). These models allow policymakers to optimize the degree of software protection. Two of the most common representations of game theory models are in the extensive form and in the normal form. In the first case the policymaker draws a tree where the different branches represent the different outcomes of the game, and moves of players are sequential in time. The normal form is represented by a matrix that shows the players, strategies and payoffs[4].

2.2.1 Diffusion Models

We start our analysis by describing the diffusion model first proposed by Bass (1969). This model describes the process of how new products get adopted as an interaction between users and potential users; it models the behavior of the innovator and imitators. Since its publication in 1969, many extensions were introduced; one example was the introduction of prices in the model. The Formula for this model is given by

$$N_t = N_{t-1} + p(m - N_{t-1}) + q\frac{N_{t-1}}{m}(m - N_{t-1}) \tag{2.1}$$

where m is the market potential, p is the coefficient of external influence, q is the coefficient of internal influence and N_t is the number of companies or consumers at time t. Mass media coverage of a certain software product affect p, while q is affected by "word-of-mouth" or other influence from those already using the product. Knowing the parameters of interest, we can use this model to forecast the potential use of products. Sultan, Farley, and Lehmann (1990) found that the average value of p is 0.03 and q is 0.38. With these results, this model could be implemented in many areas such as marketing or management.

With known parameters, this model could be applied to the problem of software piracy. Givon et al. (1995) used a diffusion model based on Bass (1969) that could track shadow diffusion (e.g. piracy) and legal diffusion over time. This model is applied to word processor and spreadsheet software in the United Kingdom; it is analyzed what are the effects of word-of-mouth and pirates. Results show that pirates were responsible for piracy (piracy rate was very high) but, at the same time, they generate an increase of more than 80% in software sales. Shadow diffusion (which is imitation) positively affects legal diffusion

[4] One example of this game is the prisoner's dilemma used in Economics. Other games that are more complex may have more players and many periods that must be implemented mathematically.

(which is innovation). A consumer that pirates today software can, in the future, purchase the software. Prasad and Mahajan (2003) also find evidences that the control of piracy and of software prices can be used to promote sales.

More recently Liu, Cheng, Tang, and Eryarsoy (2011) developed an analytical model that embodied recent empirical findings on software diffusion. The model is constituted by innovators that are influenced by external factors (e.g. reviews, parameter *p*) and imitators that buy the software because of word-to-mouth influence from previous owners of software (parameter *q*). Results show that depending on the pricing schemes, a lower demand of innovators implies a higher profit from implementing multiple price schemes[5].

Summary: Having the ability to control piracy led to several important results: i) the effect of piracy on legal sales (which was positive); ii) track piracy over time and iii) the ability to optimize how many different configurations and prices can a product have and still manage to obtain a high profit for the firm.

2.2.2 Network externalities

Network externality have been studied by some authors like Conner and Rumelt (1991), Slive and Bernhardt (1998), Shy and Thisse (1999) and D. S. Banerjee (2003). They argue that with the presence of network externalities it is profitable for software developers to allow some degree of piracy. Network externalities affect the valuation that consumers make of software, as the value of it is dependent on the number of users. An example of a productivity tool that beneficiate with this effect is the Microsoft® Office. Other examples are econometric tools that benefit with the increasing number of users (both legal and illegal); some of these users will develop modules that will permit to compute additional econometric models not initially available with the program.

Authors such as Poddar (2002) tries to show that the existence of externalities cannot be generalized as the only explanation for the existence of software piracy when there is commercial benefit in using illicit software. More access to information won't necessarily

[5] Windows 7 has various versions; Basic, Home Premium, Professional and Ultimate. Each of these versions has different prices (www.windows.com).

mean more sales of illicit software. A model is developed to show that, even with network externalities, it is preferable to protect software instead of allowing some level of piracy. It is assumed the existence of three types of consumer: one that buys, one that pirates and other that do not use any software. It is shown that having the option of protection and non-protection, it is always profitable to protect with or without network externalities. Others argue (see Rasmussen (2003)) that, with network externalities, some degree of piracy is beneficial for a software monopoly company (e.g. Microsoft® and Apple®). The level of network effects explains the degree of protection. With a high level of network externalities it is beneficial to have lower protection. In a monopoly, market competition induces firm to choose a low level of protection.

More recently Lu and Poddar (2012) found that piracy rates depend on three parameters: the consumers' willingness to pay the product, the quality of the pirated product and the strength of IPR protection that prevails in the economy.

Summary: When software piracy is for personal use, network externalities are beneficial but, when this illicit behavior has a commercial nature, even with network externalities software piracy is not efficient. One example is illustrative of the benefits of a network externality on software: as the number of consumers increase, valuation of each one increases because more technical support becomes available. Some degree of piracy is beneficial to Companies, as some of these pirates will purchase the software in a later time.

2.2.3 Game Theory Models

As levels of software protection can vary, game theory allows modeling what level of protection is appropriate for a given software. Altinkemer and Guan (2003) develop a game theory model to analyze firms' protection strategies for online software distribution. The basic setup of the models is as follows: there is a software market and two firms A and B present in both periods $s1$ and $s2$. Each firm produces software in period $s1$ an upgrade version in period $s2$; they both maximize profit. Consumers purchase, in each period, one unit of software. The quality of the pirated software is assumed to be the same as the original ($Q_p = Q_o$). This assumption is not far from the truth, if all the software components are present and functional; one single line of code (missed or corrupted) can make the software unusable. Many times the most significant differences between the original and the cracked software are related to the package presentation and printed materials. Additional to these two firms a firm that pirates firm's *A* software is introduced (*AP*) behaving the same as firms *A* and *B*.

Piracy is present in period *s1* when the price of *AP* is between firm *A* and *B*. In this situation firm *B* has higher pricing power in period *s1* but the market combined share of firm's *A* products (legitimate and pirate) is larger. A firm that protects the software has more pricing power that a firm that does nothing. In period *s2*, two scenarios can occur: pirate software stays in the market or disappears. In the first case, the price of firm *A* is always lower than the price of firm *B*. In the second scenario (pirate software disappears), if firm *A* has many costumers in period *s1*, a higher pricing power in period *s*2 will be achieved. Sometimes it is beneficial to allow some piracy in their products, knowing that, in the future, consumers will be locked to that software. When possible, firms implement protection with the updates that, when detect pirated products, influence pirates to purchase the software (sometimes with incentives like considering the pirated copy legit as long as the update are performed legally).

More recently, in a study analyzing a copyright owner and several pirates that sell the same information good, and compete with each other, Kiema (2008) has considered the costs incurred by pirates, namely fixed costs and "advertising costs". One important conclusion is that, as the quality of pirated copies increase, the revenue of pirates decrease.

D. S. Banerjee (2011) shows that the socially optimal monitoring rate can prevent piracy and there is no investment in anti-copying technology in equilibrium.

A group of software's that suffers from piracy is the video-game industry. Gürtler (2005) considers both software and hardware game industry. Home consoles can be modified, losing their warranty. This modification allows the use of contents other than games and in non-original supports. Additional to this, games must be hacked in order to be reproduced in a DVD or Blue-Ray. Some firms make both games and consoles, while others sell and/or develop only games for other firm's consoles. Consoles can be expensive but they are purchased only once; one the other hand games are constantly being purchased. Some firms can allow some piracy. With this, they expect to increase the profits coming from the hardware. In the theoretical framework developed by Gürtler (2005) there are four firms: two competing in the market of hardware and video games (*F1* and *F2*) and two firms compete only in the market of video games (*F3* and *F4*). Firm *F1* compete with firm *F3* and firm *F2* compete with firm *F4*. With complete market covering (e.g. consumers choose to purchase hardware and software), both firms have the same probability of being affected by software piracy (they set the same level of protection). With partial market covering (e.g. some consumers will not purchase software at all) *F1* chooses the lowest possible level of copy protection. This is also true for *F2*.

Alliances such as *Business Software Alliance* implement policies to deter piracy and its findings can influence anti-piracy laws. Jaisingh (2009) analyze how innovation with piracy is affected by policies implemented by these alliances. He develops a model in which there are three agents: a firm that develops the software, a pirate that creates an illegal copy and an alliance, such as *Business Software Alliance*, that implements anti-piracy policies. Firms and consumers share the market, being the consumers heterogeneous, which will depend on ethics and the cost of piracy. Depending on the quality and the level of policy implemented by the *Business Software Alliance*, the firm can choose to set a low price to make unprofitable (low policy) to pirate, or a high price allowing some piracy (high policy). It is possible to increase the surplus of legal users allowing at the same time firms to maximize its profits, depending on the bargaining power of both Governments and the *Business Software Alliance*. When *Business Software Alliance* set an aggressive policy against software piracy, making the perceived cost of using illegal software higher by the end-users, in some cases will increase software piracy and decrease software quality.

Summary: These models allowed determining the optimal level of protection in the presence of piracy. A firm can shift the profits from the software to the hardware products, in a first moment, allowing (and even encouraging) some level of piracy; then it is implemented more protection in the form of hardware protection or software updates. Protection in the Software and Hardware is important to deter piracy.

2.3 Empirical literature

Empirical literature has used the estimates provided by the *Business Software Alliance* to explain the phenomenon of software piracy. One measure that is present in all the studies is the *Gross Domestic Product per capita (GDPpc).* Several approaches were used: surveys using respondents from universities and in the labor market; longitudinal/panel studies and cross sectional studies; the last two rely on macroeconomic data. Results presented by these studies are very important complementing each other and, at the same time, they provide actions for policymakers.

Empirical literature that uses surveys can obtain richer results, being able to model each parameter (age, sex, income), but it relies on the willingness of the respondents to answer truthfully. Even if the inquiry is anonymous, due to the nature of the crime, they may sometimes underestimate responses. Surveys are used in a particular group of the population (students, business users) in a particular city. Many questionnaires rely on a likert scale[6]. When respondents answer questions it is possible that they go to the extremes or the middle (neither agree nor disagree), which can be sometimes a problem. In 2010 *Business Software Alliance*, with the help of *IPSOS*, performed a survey on 15000 computer users[7] to measure the commercial value of unlicensed software and the piracy rates.

When surveys are implemented they suffer from a population bias problem, which can influence the main findings and extension of results. These studies covered specific population, like students Ram D. Gopal and Sanders (1998), Butt (2006), Higgin (2006) and Gan and Koh (2006) or business users Lau (2004). To overcome these problems authors such as Ram D. Gopal and Sanders (1998) and Holm (2003) used a cross sectional model that explained the phenomenon at a country level, complementing the results from the surveys.

Several factors can influence questionnaires, from the group of people surveyed, to the age, sex and location of the survey. Among the questions that can be asked we can find the following:

[6] A Likert scale is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with rating scale. Usually it is divided into 5 ordinal values: 1. Strongly disagree, 2. Disagree; 3. Neither agree nor disagree; 4. Agree and 5. Strongly agree. See Wuensch, Karl L. (October 4, 2005). "What is a Likert Scale? and How Do You Pronounce 'Likert?

[7] For more information see http://portal.bsa.org/globalpiracy2010/

- Do you use pirated software and how often do you use it?
- Do you use legal, illegal or open source software?
- Income plays an important factor in the choice to pirate?
- Culture, education or legal system plays an important factor in this decision?

These four examples can measure simultaneously several influences that the cross-sectional or panel data analyses can lose. The location in which the survey is made can affect results. Lau (2004) conducted a survey in Hong Kong, which is a place with one of the highest piracy rates compared with the Western Europe (+33%), North America (+21%) and the European Union (+35%); in 2010 the piracy rate in Hong Kong was 45%. The main conclusion of this study is that knowledge of software copyright law and the availability of original software have direct effects on self-reported leniency towards software piracy.

Being the empirical literature an important source for both policymakers and researchers, but being at the same time still in it's infancy, we compile the major macroeconomic findings found by previous authors. Several dimensions have been found to affect piracy: Economic, Cultural, Educational, Technological and Legal dimensions; these will be discussed on the next subsections.

2.3.1 Economic dimensions

Stylized fact 1: Gross Domestic Product per capita affects negatively software piracy and Gross Domestic Product Growth is influenced by the correct enforcement of Intellectual Property Rights.

Income affects the decision to purchase or to pirate by the consumers or firms. One measure that is present in many studies on the determinants of software piracy is the *Gross Domestic Product per capita*. Some examples are Ram D. Gopal and Sanders (1998), Marron and Steel (2000) and Goel and Nelson (2009). The results show that an increase in income can decrease software piracy. Other measures can be used that reflect the levels of income of a country; Holm (2003) used the *Gross National Income per capita (GNIpc)* and obtained the same results. Levels of income are heterogeneous among countries, furthermore, many software products are sold at the same price across countries; examples are movies, video games and music. Shin, Gopal, Sanders, and Whinston (2004) split the *GDPpc* into two subsamples: one which represents income less than 6 000$ and other that represents more than 6 000$. In countries that have *GDPpc* less than 6 000$, income affects negatively software piracy (-0.0032), but when *GDPpc* is higher than 6 000$, this negative effect becomes marginal (-0.0008). This result indicate that on households that have more disposable income the fraction of the income that is allocated to software is reduced. On the other hand, when the income is low this fraction increases. Increasing income on households with less income will result in less software piracy.

Other authors studied what were the effects of piracy on economic growth. In spite of high piracy rates, indicating that property rights protection were not perfect, Andrés and Goel (2012) found that the existence of software piracy increased economic growth. Using an index of Intellectual property Rights, Park and Ginarte (1997) and Falvey, Foster, and Greenaway (2006), found that intellectual property rights could promote growth.

Stylized fact 2: Income inequality measured by the GINI index affects negatively software piracy.

Additional work was done in explaining these differences using the *GINI* Index. To check this, Fischer and Andrés (2005) used a sample of 71 countries to analyze the relationship between income distribution and software piracy rates. To analyze this income inequality it is used quintile shares. This quintile analysis is divided into three classes: Q1 is low-income class; Q2-Q4 is middle-income class and Q5 is upper-income class. Software piracy is a middle class crime in Latin America, Caribbean, East Asia and the Pacific Regions. Software piracy is a crime committed by middle and lower class in the Central Asia and Eastern Europe and is an upper class crime in Western Europe and North America. In a recent study and using a sample of 35 countries, Andrés (2006b) found income inequality to be negatively related with software piracy; more equal societies have higher piracy rates.

In a theoretical paper Poddar (2005) tried to study differences of software piracy across countries; using the same variables of interest *(GINI index)*, but with opposite results. Poddar (2005) developed a model that assumes that software firms undertake R&D to prevent piracy, which can be replicated with measures of IPR (*Intellectual Property Rights* *protection*). He considers three types of consumers: one that buys, one that pirates and other that do not use any type of software. These consumers are a simplification of the reality; in real life each one can, at the same time, use both legal and illegal software. A high income gap between users and a low protection cannot prevent software piracy. When this gap is reduced and with the existence of some protection, there is a probability of mitigating software piracy. This result was studied by Fischer and Andrés (2005) and Andrés (2006b) using the *GINI* index[8].

Stylized fact 3: HDI affects positively software piracy

Software piracy can affect the development of a country; software development and distribution activities gives jobs to thousands of people, but these jobs are not necessarily made available where we buy the software. It can happen that national companies outsource software development to countries with highly qualified labor force but with lower wages. Using a panel data combining three years (1995, 2000 and 2002), Bezmen and Depken (2005) study this phenomenon. The measure of economic development is introduced with the *HDI* (*Human Development Index*). They used an equation system. In the first equation, piracy rates were the dependent variable and, in the second *HDI* where the dependent variable. This measure was used by Boyce (2011) introducing GINI index as well. In both works this variable increase software piracy rates.

2.3.2 Cultural dimensions

Stylized fact 4: Hofstede cultural dimensions explain levels of software piracy across countries.

[8] This variable "measures the extent to which the distribution of income among individuals, within an economy, deviates from a perfectly equal distribution". A low value of this index represents an equal society while a high value represents an extremely unequal society. *Source: Key Indicators of the Labour Market (KILM):2001-2002, International Labour Organization, Geneva, 2002, page 704.*

The Hofstede cultural dimensions (see G. Hofstede (2004)) cover several dimensions: power distance (PDI)[9], individualism (IDV), uncertainty avoidance (UAI)[10] and masculinity (MAS)[11]. They represent "four anthropological problem areas that different national societies handle differently: ways of coping with inequality, ways of coping with uncertainty, the relationship of the individual with her or his primary group, and the emotional implications of having been born as a girl or as a boy"[12]. They allow a comparative analysis between the national culture and the levels of software piracy. Although this measure allows a rich analysis, but suffers some drawbacks as it does not vary over time, and the sample covered is not large enough. In 1991 it was introduced a fifth dimension: the Long-Term Orientation (LTO)[13]. This dimension was developed by Minkov (2007). More recently, in 2010, it was introduced a sixth dimension: the Indulgence versus Restraint (IVR)[14], developed by Geert Hofstede, Hofstede, and Minkov (2010).

Nevertheless, several authors used these dimensions to explain the levels of software piracy rates across countries. Some examples are Marron and Steel (2000), Moores (2003), Shin et al. (2004)[15] and Kovačić (2007). These studies used a cross sectional analysis, covering at most 72 observations. Results show that individualism is negative and significant. Additional to this, Masculinity has a negative value and power distance a positive value. Other studies analyzed the effect of religion on the decision to pirate. Al-Rafee and Rouibah (2010) found that religion factors affect the decision to pirate. This was done with a questionnaire saying that, based on the individual religion, software piracy was stealing.

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[9] This dimension expresses the degree to which the less powerful members of a society accept and expect that power is distributed unequally

[10] The uncertainty avoidance dimension expresses the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity.

[11] The masculinity side of this dimension represents a preference in society for achievement, heroism, assertiveness and material reward for success.

[12] http://www.geerthofstede.nl/

[13] The long-term orientation dimension can be interpreted as dealing with society's search for virtue.

[14] Indulgence stands for a society that allows relatively free gratification of basic and natural human drives related to enjoying life and having fun.

[15] These authors used collectivism, which is the opposite of individualism. The high side of this dimension, called Individualism, can be defined as a preference for a loosely-knit social framework in which individuals are expected to take care of themselves and their immediate families only. Its opposite, Collectivism, represents a preference for a tightly-knit framework in society in which individuals can expect their relatives or members of a particular in-group to look after them in exchange for unquestioning loyalty. A society's position on this dimension is reflected in whether people's self-image is defined in terms of "I" or "we."

2.3.3 Educational dimensions

Stylized fact 5: Overall level of Education affects negatively the levels of software piracy.

Education plays an important factor in the construction of the perception of an individual towards using or not legal or illegal software. Several questions are raised with this respect: (i) more education can affect the levels of software piracy? ; (ii) education can bring an increase use of legal, illegal or both types of software? Several dimensions related to education can be used, from the literacy rate to the level of education attained. A challenge is posed on the availability of data for large group of countries. The World Bank, namely the *World Development Indicators* (WDI) has information on several dimensions related to education from the school enrolment ratio (primary, secondary, and tertiary), expenditure on education and years of primary and secondary schooling. The Eurostat provides a broader picture, introducing additional financial and not financial measures, but information is only available for a small group of countries (the European Union).

In spite of a broad range of variables available in this dimension, but due to data restrictions, cross-sectional analysis has been implemented restricting the analysis. This dimension has been studied by Marron and Steel (2000) and Andrés (2006b) with the introduction of average years of secondary education of people with more than 25 years old (Barro & Lee, 2013). Their results show that more education reduces software piracy. Goel and Nelson (2009) and Andrés and Goel (2011) used literacy rate; this variable has a positive sign. The statistical significance of this variable in the first study was at most 5% but, in the second study, significance was not achieved. Literacy rate omits the level of education attained; a person can be literate and have a low level of education. It also omits the various ISCED (International Standard Classification of education) levels. Measures that reflect the specific level attained by person measured by the ISCED 1997 or ISCED 2011 classification, reflect the expenditure on education and can improve results. Other measure that has been studied by MacDonald and Fougere (2003) is the inclusion of the word “software piracy” in textbooks. For this purpose he analyzes the MIS textbooks. Software piracy is present on 72% of the textbooks; Ethics is present in 67%, software license in 50%, copyright (50%) and Intellectual Property 39%. This is only an example of a particular field of knowledge;

introduction of additional fields of knowledge such as Management and Economics could improve results.

2.3.4 Technological dimensions

Stylized fact 6: Types of software protection affects levels of software piracy. Choice of type of Internet access and associated services will depend on its price, availability and the utility given by additional services, which will affect the availability of software.

Before the rise of the Internet, software piracy was made with the replication of the original software, from its original support, to several pirated CDs or floppy-disks; protection was both in the software itself in the form of serial keys, some with many digits, and requiring a special number that was provided by telephone as an additional protection barrier. The hardware protection in PC software is generally attached to the support (CD, Floppy, etc.) and not in the PC itself; functional copies were more difficult to produce. It is often hacked with more or less effort.

There are different ways to protect software; some of these are License Keys and Product Activation[16] (Anckaert, Sutter, & Bosschere, 2004). Djekic and Loebbecke (2007) studies the influence of technical copy protections on application software piracy, following Ram D. Gopal and Sanders (1997), Prasad and Mahajan (2003) and Anckaert et al. (2004), they distinguish between software-based and hardware-based technical copy protections. A survey is conducted using 219 professional users and an amateur group. Software based protection and hardware based protection are analyzed separately.

Personal context variables are always significant and positive. This context is represented by income, requirements of usage in the workplace and the intensity of

[16] One example is the Windows Genuine Advantage (WGA). It is an anti-piracy system created by Microsoft that enforces online validation of the licensing of several recent Microsoft Windows operating systems when accessing several services, such as Windows Update, and downloading Windows components from the Microsoft Download Center. In Windows 7, WGA is renamed Windows Activation Technology. WGA consists of two components: an installable component called WGA Notifications that hooks into Winlogon and validates the Windows license upon each logon and an ActiveX control that checks the validity of the Windows license when downloading certain updates from the Microsoft Download Center or Windows Update. http://en.wikipedia.org/wiki/Windows_Genuine_Advantage

application software usage. These variables affect more the amateur group. Legal software use that is protected with license key or product activation is higher in the amateur group while software that is protected with hardware protection is higher in the professional group. This work shows that being able to work properly with software can affect their valuation of the software; the full capabilities and price of the software are understood. Some productivity tools like Photoshop® can be pirated by home users but the full capabilities are not used. This can be seen by the firm as a loss, but this might not be completely true if we consider an inexperienced user. On the other hand if this software is used illegally at the workplace this is not true; it is a loss, the worker knows how to use the software at its full.

When the hardware protection and Software protection is overcome by hackers, the next step is to upload the software, which will depend on the type of Internet access and upload speeds. Hackers may use public Internet providers such as universities. Broadband Internet access plays an important role in the decisions to download legal or illegal software by potential pirates. One of the first studies in Europe that focuses on the demand for broadband Internet services in Austria focusing on residential consumers, was conducted by Cardona, Schwarz, Yurtoglu, and Zulehner (2009). Using 3000 households and analyzing four types of Internet access: narrowband, cable, DSL and mobile, they found that demand for DSL is elastic and cable networks are likely to be in the same market as DSL connections. This study must be contextualized; narrowband was the first to arrive and it is not an option anymore. The three remaining services will strongly depend on the development of the infrastructures. Since this study, Internet services have evolved. In A1, an Internet provider in Austria fixed the typical prices of Internet at speeds of 50MBPS and 100MBPS to 29,90€ and 44,90€ respectively.

Choice of alternative types of Internet access will depend on price, availability, but also the utility that consumers give to this service. Some are willing to pay more for the same service. Using a large sample of individuals, Rosston, Savage, and Waldman (2010) study this phenomenon, comparing experience users to inexperience users. In their sample, 5799 were experience users and 479 inexperience users. The willingness to pay is estimated which is represented by the marginal utility of changing from one service (Internet speed) to other service but with higher speeds. In this context an experienced user is a user that had used Internet more than twelve months. Several measures are included in their analysis; cost, connection speed, reliability, use Internet away from home, watch high definition content, interaction with health specialists and being able to perform free videophone calls over the Internet. An experienced household is willing to pay 59$ for a basic service[17], 85$ for a premium service[18] and 98$ for a premium plus service[19], while an inexperienced user is only willing to pay 31$, 59$ and 71$ respectively for an improvement on these services. These results show that being able to work with Internet will affect its utility and that the willingness to pay for additional services depend as well on his utility.

These numbers reported here cannot be extended to countries in Europe; the willingness to pay in Europe would be far less than the reported by this study. Infrastructures in Europe allow smaller prices and higher speeds. Each country has several Internet providers that cover a small geographical area while the USA has the same geographical area as Europe, which can make difficult the development of infrastructures that allow higher Internet speeds. Prices for a service of home phone & Internet cost 37$; home phone, Internet & Wireless cost 89.94$ and Home Phone, Internet & TV cost 93.94$ for an Internet speed of 30MBPS in AT&T[20]. VOO, a Internet provider in Belgium offers Internet, Telephone and Television for 62,41€ for Internet speeds of 50MBPS and 81.96€ for 100MBPS[21]. With respect to mobile broadband Internet access, Portugal is ahead of countries such as the United States, both in speeds and prices. In the US, Verizon sells mobile broadband plans that range from 2GB-30$/Month to 10GB-80$/Month[22]. For the same Internet speeds, Internet providers in Europe offer a lower price than those in the USA. In the USA Internet speeds only reach 30MBPS while in Europe these speeds can reach 50MBPS or 100MBPS.

[17] "Basic" Internet service has fast speed and less reliable service
[18] "Premium" service has fast speed, very reliable service and the ability to designate some downloads as high priority
[19] "Premium Plus" service has fast speed, very reliable service plus all other activities bundled into the service
[20] http://www.att.com/gen/general?pid=11623&CI=CJ_AFFILIATE&RI=CJ1&RD=37922269&source=ECdAAT11600aff12A&CJPID=2432921
[21] http://www.voo.be/fr/pack/trio/
[22] http://www.verizonwireless.com/b2c/plan-information/?page=mobileBroadband

2.3.5 Legal dimensions

Stylized fact 7: Rule of Law affects levels of software piracy.

Some of the World Governance Indicators (*WGI*) that analyze several dimensions like the effectiveness of the legal system were used both in cross-sectional and panel data. They represent six dimensions: Voice and Accountability[23], Political Stability and Absence of Violence/Terrorism[24], Government Effectiveness[25], Regulatory Quality[26], Rule of law and Control of Corruption[27]. The rule of Law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence[28]. Rule of Law was used by Andrés (2006a); Goel and Nelson (2009); Png (2010) and Boyce (2011) having mixed signs. Introduction of additional measures such as the Government effectiveness could improve results.

The use of the *WGI* have no significance if we consider homogeneous countries such as the European Union; small variations exist but they cannot explain this phenomenon. More recently Andrés and Goel (2011) analyze the impact that corruption has on the levels of software piracy. They construct a corruption perception index[29] that measures the level of corruption in a country. This measure is different than those provided by the World Bank[30]; this index is not available for many countries of the European Union. More corruption resulted in more piracy.

[23] Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

[24] Political stability and absence of violence measures the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism

[25] Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

[26] Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

[27] Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

[28] http://info.worldbank.org/governance/wgi/index.asp

[29] This Index is measured as: $CPI_{index} = \log\left(\frac{10-CPI}{CPI}\right) -$ higher values means higher corruption.

[30] They consulted the www.transparency.org webpage in order to make this alternative index.

Stylized fact 8: International organizations can prevent software piracy, enforcing copyright treaties, making pressure and improving software protection.

Software is Copyright protected; unfortunately it is often pirated. This piracy can come in the form of commercial software, corporate piracy or softlifting, which occurs when a software is copied to computers, violating licensing agreement. Due to the high market that software has (computers, tables, smartphones, consoles), this industry have been subject of several campaigns (on the Internet, journal, etc.) to deter potential pirates. Nowadays *Business Software Alliance* serves as a group pressure to ensure property rights protection. These can come in the form of trade secrets, patents, licensing, copyright, civil liberties (they grant civil rights to software owners) and criminal liabilities. Unfortunately not all countries offers strong property rights protection. Examples of these are countries with piracy above 80% that are present in the least developing countries (Africa, Latin America). On the other end, there are countries that protect software such as the USA; the piracy rate is only 20%. (See Clifford and Jin (1997)).

The exponential growth of the information society led to a necessity of protection of the owners of these advances (hardware industry and software industry). Countries must implement protection mechanisms. Shadlen, Schrank, and Kurtz (2005) study in what extend software protection is sufficient to deter piracy. Many Companies like Microsoft® have his headquarters in the US, but sell the products worldwide. At home they are protected by strong intellectual property rights laws; the problem arises when dealing with countries that don't have this type of protection and do not signed international treaties or do not make part of international organizations. They analyze the direct pressures exerted by the US (US Special 301[31]), for the foreign countries to increase or to exert more efficiently intellectual property rights protection. Bilateral Political Pressures, TRIPS[32] and Trade dependence on

[31] The Special 301 Report is prepared annually by the Office of the United States Trade Representative (USTR) under Section 301 as amended of the Trade Act of 1974. The reports identify trade barriers to US companies and products due to the intellectual property laws, such as copyright, patents and trademarks, in other countries. Each year the USTR must identify countries which do not provide "adequate and effective" protection of intellectual property rights or "fair and equitable market access to United States persons that rely upon intellectual property rights". http://en.wikipedia.org/wiki/Special_301_Report

[32] Agreement on Trade-Related Aspects of Intellectual Property Rights

US can explain the levels of piracy in these countries. Software protection must be accompanied and legislated by international organizations.

Countries which make part of international organization have power to propose actions to protect their domestic market. Andrés (2006a) constructed an index of copyright protection for the European Union that measures in what extend software is protected. Within the European Union each country must transpose Norms and Directives that deal with copyright laws, but some room is left for each country to legislate. It is difficult for an Index to capture all legal aspects; some cannot be quantified into numbers. For the construction of this index the author used two proxy's for the strength of software protection: i) membership in international copyright treaties - this variable includes the signatories of the Bern convention (1886), WIPO (1996) and TRIPs (1994) and ii) enforcement provisions which is a measure of severity of punishments (jail, fines) and how these laws are being applied (Ostergard, 2000; Samuelson, 1999). In the absence of theoretical background the author uses the same weight for each country. It is used a panel data analysis using 69 observation for 1994, 1997 and 2000. Fixed effects model was adopted; the Index had negative effects, which means that a lack of protection can increase piracy. This index is constructed based on homogeneous countries that must obey to minimum rules set by the European Commission.

International organizations are important to enforce Intellectual Property Rights; examples are the WTO (World Trade Organization) and WIPO (World Intellectual Property Organization). Dordi (2008) analyzes the improvements made, namely the road that resulted in the ACTA (Anti-Counterfeiting Trade Agreement)[33]. In the European Union, Regulation (1383/2003) and the Directive (2004/48/CE) provide a good level of enforcement of intellectual property rights. The final version was published on April of 2011, being not yet in force[34]. This treaty has a problem of not including developing countries.

[33] The Anti-Counterfeiting Trade Agreement (ACTA) is a multinational treaty for the purpose of establishing international standards for intellectual property rights enforcement. The agreement aims to establish an international legal framework for targeting counterfeit goods, generic medicines and copyright infringement on the Internet, and would create a new governing body outside existing forums, such as the World Trade Organization, the World Intellectual Property Organization, or the United Nations.

[34] The Negotiators where: Australia, Canada, the European Union, Japan, Mexico, Morocco, New Zealand, Korea, Singapore, Switzerland and the United States and the signatories where the United States, the European Union and 22 of its Member States, Australia, Canada, Japan, Morocco, New Zealand, Singapore, and South Korea.

When macroeconomic data is available on variables such as the type of legal system (Goel & Nelson, 2009), effectiveness of courts and legal implications, econometric methods such as OLS (ordinary least squares), FE (fixed effects) or RE (random effects) are used. However, these variables miss the behavior of each potential software consumer. To empirically analyze this behavior, a survey is implemented that allow a richer analysis. Using a sample of students at a leading college of business administration, summing 319 observations, 190 females and 129 males, Al-Rafee and Rouibah (2010) studied the impact that religious factors, awareness factors and legal factors has in the decision to pirate. The author splits the group into four treatment groups performing a pre and post questionnaire: (i) the control group that reflects the unchanged behavior, (ii) legal and (iii) awareness groups are supported, the (iv) religious group is rejected. Awareness and religion factors have impact on the decision to pirate; legal factors was not significant. More information on legal consequences of violating property rights will lower piracy.

These results support that our perception evolves over time, being the most important factor the awareness of penalties related to violation of property rights. In a cross sectional data the results that relate to awareness factors and legal factors can be implemented with the World Governance Indicators, namely the rule of law and government effectiveness.

More recently Hashim, Kannan, and Wegener (2009) extending the model of Beck and Ajzen (1991) of the theory of planned behavior[35] introduce an additional variable that is a message of anti-piracy.

The model proposed by Ajzen (1991) assumes that the individual has behavioral beliefs, normative beliefs and control beliefs, that will affect its perception of the reality, the attitude towards the behavior, subjective norms and perceived behavioral control, respectively. Each individual gives different importance to these factors; these affect its intention and behavior. The perceived behavior control can predict the behavior. In this survey, pirates will be nudged by this message and will not undertake deviant behavior. A survey was made on 218 undergraduates students at a large university in the Midwest region

[35] In psychology, the theory of planned behavior is a theory about the link between attitudes and behavior. The concept was proposed by Icek Ajzen to improve on the predictive power of the theory of reasoned action by including perceived behavioral control. For additional information see http://people.umass.edu/aizen/tpb.diag.html

of the United States. Out of these 218, 98 questionnaires presented a message of anti-piracy. They identify in witch circumstances an individual is susceptible to exogenous nudging from a software company. The anti-piracy message can affect the behavior of a software pirate.

Chtouki (2008) addresses the effects on Government and Law of this crime; depending on the legal systems, punishments are different. Depending on the severity of the crime or the perception of the infringing, the penalty will be set accordingly. European Union sets the basic copyright principles but leaves the rest to the Member-States. United States are more severe with respect to this crime. Availability of software affects the choice to pirate or not Lau (2004). Some software is released simultaneously worldwide, such as an operating system. Other are that we must wait months until the official release in a country (video-games).

2.4 Conclusions

Software firms face the problem of software piracy. With the global digitalization of content this phenomenon will only worsen. Firms suffering from this phenomenon will have difficulties promoting new jobs, profits are not taxed, etc. This will lead to an overall increase in software price in order to maintain the same revenue. On the other side the "shadow economy" in which illicit software is sold will bloom and create jobs. To combat this, Companies such as Microsoft® sell their Office suit at different prices that attract consumers with low valuation for their software.

Nowadays the only methodology that covers a large group of countries over a large period of time is the one provided by the *Business Software Alliance*. Over the years this methodology was improved with the introduction of more countries and consumers in the analysis. These estimates were used in empirical studies analysis. Nevertheless, the studies relied on small samples (in-cross section) and in the panel data analysis; few years were studied. Further research must be implemented considering these five dimensions. Empirical works can be extended to allow a disaggregated analysis in the educational dimension; for instance, education can be divided into ISCED 1997 levels. This disaggregation will help policymakers to better implement policies. Additional, more indicators that reflect the effectiveness of Governments must be used to analyze the laws and the legal system.

Annex I BSA Publications

In this annex we will review the publications presented by the Business Software Alliance (BSA) over the years of 1994 to 2010. Among other studies, annually the BSA presents annual software piracy reports; these reports begun in 1994. They report the results of software piracy rates and losses for the previous year for a large group of countries. For example, the report presented in 2005 reports the results of piracy rates and losses of the previous year (2004). Unfortunately not all reports are available since the beginning, bearing this in mind we try to give a broad picture of the main findings of those that are available, summarizing the main findings.

The *"1998 Global Software Piracy Report"* (BSA & SIIA, 1998) was the fourth in the series[36]; it was developed by IPRC (International Planning and Research Corporation) for the BSA and SIIA (Software & Information Industry Association). In this year the global piracy rates had dropped below 40% from 49% in 1994. It had a declining pattern over the years. The study presented six reasons for this decline, among other there was the reduction of software price but this relation may be weak, especially if we speak of reductions from a previously high value (for example 4 000$ to 2 000$). The software becomes obsolete quickly. Economic recession brought lower losses to Asia, Eastern Europe and the Middle East that would happen without a recession. Eastern Europe had the highest piracy rates, in part because of Russia. The lowest piracy rates were in North America and Western Europe. Latin America, El Salvador, Guatemala and Paraguay presented one of the highest piracy rates, but this was a systemic problem. The Unites States had a piracy rate of 25% but represented 28% of all losses. Western Europe represented 25%. These two markets represents approximately the same size.

This methodology applied and developed by IPRC was a methodology that analyzed two data sets, the demand for new software application and the legal supply of new software applications. PC shipments were collected from proprietary and confidential data supplied by BSA member Companies. They had into account home vs. non home segments and replacements PCs vs. new units. They separated "Replacement Shipments" that replace old and obsolete Computers from "New Shipments", this variable measured the growth of

[36] Information on the previous reports is not available

the capacity installed. It also had into account the base PC capacity installed, namely which measure is taking into account "white-collar workers". The level of penetration of PC was ranked into five magnitude scales. Software demand was developed from market research on the US market. They developed ratios for the amount of software installed on each PC. A weak point that must be referred here is the use exclusively of one market (US); it can happen that it is not representative of others, especially Europe and Asia.

These ratios were calculated by the four shipments groups and for each of the five magnitude classes:

1. Home - New shipments,
2. Non-Home - New shipments,
3. Home - Replacing Shipments, and
4. Non-Home - Replacement Shipments.

Piracy rates are not homogeneous for every type of product, because of that, IPRC estimated 3 tiers of applications; General Productivity Applications[37], Professional Applications[38], and Utilities[39]. One limitation is that they do not present separate piracy rates for different types of products, in the final reports. Each of these categories presented different challenges, if they were analyzed separately it could improve the knowledge of the problem.

For the PC shipped they had taken into account four dimensions:

1. Home vs. Non-Home,
2. New PCs vs. Replacement PCs,
3. Level of Technological Development, and
4. Software Application Tier.

This resulted of an estimate of total software installed both legal and illegal. This was the demand side!

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[37] 1. Databases, 2. Presentations Graphics, 3. Project Management, 4. Spreadsheets, 5. Word Processing.
[38] 6. Accounting, 7. C.Languages, 8. Curricular, 9. Desktop Publishing, 10. Other Languages, 11. Professional Drawing and Painting, 12. Programming Tools.
[39] 13. Application Utilities, 14. Calendar & Scheduling, 15. Clips, 16. Communications, 17. Education Administration & Productivity, 18. Electonic Mail, 19. Fonts, 20. Forms, 21. General Business, 22. Internet Access and Tools, 23. Personal and Business Productivity, 24. PIM's, 25. System Utilities and 26. Training.

The supply side was given by the members of BSA that volunteered their proprietary shipments data. With this it was possible to estimate software shipments. This data was collected in each country and by each type of software. Only business software applications were used[40]. The data on Supply shipments didn't covered all the Companies. For the rest, an uplift factor reflecting an estimate of shipments by Companies participating in the study as a percentage of software shipped by all US software Publishers was considered. One limitation of this methodology was that they only considered Business Applications, although referring this in their report, only a full knowledge of the market can have an impact on the actions that policymakers take to reduce the problem.

To estimate the total shipments of the world, IPRC applied a second uplift factor that was: software shipped by US software publishers as a percent of software shipped by all software publishers. The difference between software application installed (demand) and applications legally shipped (supply) gave the amount of software pirated. Multiplying the average price of the software by the number of legal and illegal units gave the total market value. (BSA, 2002).

The *"SIIA's Report on Global Software Piracy 2000"* (BSA & SIIA, 2000) was the sixth annual report. In 1999 the worldwide revenue losses rose to 21.6 billion dollars, from around 11 billion in 1999, in part because of the massification of use of both Software and PC. Software & Information Industry Association (SIIA) presented some important ideas that were relevant, namely legal aspects. A strong intellectual property protection leads to higher investment in a country which encourages local software industries to compete with bigger multinational Companies, promoting employment. But for this benefits to have effects there must be laws, and these laws must met the requirements of the WTO (World Trade Organization), TRIPs (Agreement on Trade-Related Aspects of Intellectual Property Rights), WIPO (World Intellectual Property Organization) and Bern convention. But this is not enough, these laws must be effectively enforced, the legal system must work without much delays and the public opinion must be educated. These treaties provide a minimum of protection that must be enforced by all his participants, without exception. The United States in 1999 changed the law, with respect of pirated software, fixing fines that ranged from 200$ to 100 000$, and of course jail.

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[40] The following applications were excluded: Recreation, Home Creativity, Home Education, Integrated, Personal Finance, Reference Software and Tax Programs.

There are different types of software piracy: Softlifting[41], Internet[42], Software counterfeiting[43], OEM unbundling[44], Hard disk loading[45] and Renting[46]. The most important is the Internet and Software counterfeiting. The Internet has been growing, being the place that people search for pirated software, but it has risks. Buying and selling illegal software to a person brings risks, depending on the country and legal system. But this type of software sometimes comes with virus; don't have valuable support and documentation. SIIA set's Benchmark for intellectual property rights, these are the minimum that the countries must enforce. Annually SIIA and the US government present the Special 301 Report[47], in this report are the countries that must improve its protection.

The *"Seventh annual BSA Global Software Piracy Study"* (BSA, 2002) was published in early 2002. There was a decline in losses by 6.7%, relative to 2000, corresponding to 10.7 billion dollars. In the year 2001 the dollar was strong relative to other currencies, the decline was only because of this. Additionally to this, the legal market for software decreased in 2001 because of the recession. This recession had a strong impact on technological spending. In this research they found that there exists a minimum piracy, similar to natural unemployment rate. It is impossible to reduce it to zero. IPRC found that there exists several factor for a continuous decline on piracy, like reduced price and increased government cooperation. Eastern Europe, North America and the Middle East/Africa assisted a decline in losses, while Asia/Pacific and Easter Europe an increase. North America and Eastern Europe were below the average global piracy rate but they represented 18% and 24% of total losses, representing Asia a total of 43% of total losses.

In the *"Eight Annual BSA Global Software Piracy Study"* (BSA, 2003), they analyzed the evolution of software piracy rates and losses from 1994 to 2002. In almost all regions the piracy losses increased, North America and Western Europe were below the mean piracy rate, but represented 41% of the losses. From 1994 to 2002 the piracy rates

[41] purchasing a single licensed copy of software and loading the same copy onto several computers, contrary to the license terms
[42] making unauthorized copies of copyrighted software available to others electronically
[43] the illegal duplication and distribution of copyrighted software in a form designed to make it appear to be legitimate
[44] selling stand-alone software that was intended to be bundled with specific accompanying hardware
[45] installing unauthorized copies of software onto the hard disks of personal computers, often as an incentive for the end user to buy the hardware from that particular hardware dealer
[46] unauthorized rental of software for temporary use, like you would a video
[47] http://www.iipa.com/special301.html

declined, in Middle East dropped from 80% to 49%, Latin America dropped 23 percentage points (pp.), Western Europe 17 pp., Eastern Europe 14 pp., Asia/Pacific 13 pp. and North America 8 pp.. North America was the region that dropped less, this can result in the fact that in 1994 it already had a low piracy rate. When we reach piracy of 20% or 30% it is difficult to drop more, because there will be always someone pirating a software, this percentage don't mean necessarily a bad future, sometimes a pirate user, likes and then purchases the software.

The *"First Annual BSA and IDC Global Software"* (BSA, 2004), was the first report in which BSA changed its consultant to International Data Corporation (IDC). With this change, the methodology to calculate piracy rates and losses changed. IDC used its proprietary statistics for software and hardware shipments, and conducted more than 5600 interviews in 15[48] countries. IDC expanded the market of software, now including beyond business applications, operating systems, consumer-oriented software (games, personal finance and reference) and local-language software. Because of this the revenue losses increased in relation to the previous year. Eastern Europe had a piracy rate of 71% and US/Canada 23%, this differences comes because different prices, taxes, different levels of protection of intellectual property rights and cultural differences. Software piracy has several negative effects, the report presented some of them; local software industries crippled from competing with high-quality pirated software from abroad, loss of tax and jobs. A low piracy rate, depending of the size of the market can result in huge losses. Example of this is the US/Canada having 7 232 000 Million dollars of losses. From this year onward the measure of losses is in thousands (1000$=1$).

The basic methodology implemented by IDC is:

1) Determine how much packaged software was put into use in 2003;
2) Determine how much packaged software has been paid for during the year;
3) Subtract one from the other to get the amount of pirated software.

One flaw of this methodology is because of the use of confidential information. The step-by-step process implemented by IDC is as follows:

[48] The countries are: China Malaysia, Taiwan, Spain, Romania, Brazil, Bolivia, Chile, Colombia, Mexico, Costa Rica, Dominican Republic, Guatemala, Kuwait and the United States

- PC Shipments; Quarterly, IDC collect data for more than 60 countries. For the 30+ countries the data were or collected in the countries or modeled. PC includes desktops, laptops and tablets.
- PC installed base; this is captured though tracking exercises.
- Software Revenue; they measure annually for 60+ countries, results from interviews. For the countries not covered by IDC the data were collected in-country or modeled regionally based on IDC's "rest-of-region estimates".
- Software shipments (Legitimate); these result from average system values estimated country-by-country and regional analysis for five software categories (collaboration, office, security, operating system, others), they result from interviews and IDC' pricing trackers. They adjusted for software sold OEM and sold separately. Software unit's shipments were derived from taking revenues and dividing by the average system values.
- Software Load is the amount of software units installed or pre-installed (OEM). IDC survey the 15 countries. These results serve to populate IDC's input model for the other countries. In software load IDC takes into account some factors[49].
- Total Software base is the amount of software, legitimate and pirated installed during the year. It equals the number of PC getting new software multiplied by the average number of software package per PC.
- Pirated software is the difference between paid-for and the total software base. –Piracy rate is the percentage of total packages that are pirated.
- Regional piracy rate, this is the regional piracy rate taking into account software installed in the region.
- Value of pirated Software is the retail value of pirated software. The value of Pirated software equals: *Legitimate market* over *(1-piracy rate)* minus *Legitimate market. (Source: First Annual BSA an IDC piracy study)*

"Second Annual BSA and IDC Global Software Piracy study" (BSA, 2005), they found that the value of pirated software increased as a result of the fact that the global PC

[49] Software running on new computers; New software running on existing computers, software obtained from retired computers, Software obtained for free as shareware or open source and Software running and non-Windows OS

software industry grew over six percent, and the dollar fell against other currencies. Piracy rates decreased in 37 countries and increased in 34. The worldwide software piracy rate fell from 36% to 35%. IDC expanded its survey now including 38 countries (23 country increase and 7000 more interviews). With this, the data were more reliable.

"Third annual BSA and IDC Global Software Piracy Study" (BSA, 2006), in this study they found that losses increased by over 1.6$ billion. In 51 countries piracy rates dropped and increased in only 19 countries. PC unit shipments grew 16 percent in the last year. The growth of the losses is due to the growth of the market. PC software piracy in the emerging countries is a problem that deserves special attention. In this year IDC introduced statistics for six new countries. IDC presented five steps to reduce software piracy: Implement the WIPO Copyright Treaty, Create Strong and Workable Enforcement Mechanisms as Required by TRIPS, Step up Enforcement with Dedicated Resources, Increase Public Education and Awareness and Lead by Example. It was found that countries with higher piracy rates had a lower software-to-hardware ratio.

"Fourth annual BSA and IDC Global Software Piracy Study" (BSA, 2007), in this study they found that piracy rates dropped in 62 countries and increased in only 13. The size of the market grew considerably; losses from piracy rose by more than 5$ billion which is equivalent to a 15% increase. In half countries for every 1$ purchased legitimately 2$ worth was obtained illegally. The worldwide software piracy was 35%, the same as in the previous year. Three new countries were added, Armenia, Azerbaijan and Moldova. In 2005 the pirated value in the emerging countries was 18$ and in developed world was 22$; in 2006 in the developed world, the paid for values were 58$ and in the emerging countries only 7$.

"Fifth annual BSA and IDC Global Software Piracy Study" (BSA, 2008), in this year of the 108 countries analyzed, piracy rate dropped in 67 and increased only in 8. The PC market grew fast in the BRICS, because of this the worldwide software piracy rate increased to 38%. The size of the market grew significantly and the value of US$ dropped 7% against other currencies; this led to an increase of losses by 8$ billion. Russia piracy rate dropped seven percentage points to 73%. The access of Broadband by the emerging countries led to an increase of supply of pirated software. The percentage of PC shipments in the emerging markets was 46%, and 17% of PC Software Market; in the BRICS, 24% of PC shipments, but they only had 7% of PC Software Market. In this year five new countries

were added, they were: Bangladesh, Iraq, Libya, Sri Lanka and Yemen. IDC identified several trends that can lead to a downward pressure or upward pressure[50].

"Sixth annual BSA and IDC Global Software Piracy Study" (BSA, 2009), in 2008 PC software piracy dropped in 52% of the countries and remain the same in 35%. The worldwide piracy rate increased to 41% from 38% in 2007. The value of unlicensed software grew 11% to 53$ billion, but if we exclude the effect of exchange rate, it only grew 5% to 50.2$ billion. The exchange rate played an important role. The emerging markets accounted for 45% of PC Hardware market, but only 20% of the PC software market. The lowest piracy rates were in US, Japan, New Zealand and Luxembourg while the highest were in Central and Easter Europe, with an average of 61%. The software can get in our home in different ways[51], some of these not legal. The crisis didn't had a significant impact on consumers, and on business users. IDC identified factors that can help lowering piracy[52] and factors driving up piracy[53]. This year survey were a result of surveys in 24 different countries, with distinct realities.

"Seventh annual BSA and IDC Global Software Piracy Study" (BSA, 2010b), in 2009 the installation of unlicensed software dropped in 54 countries and rose in 19, it was good if this drop was in all, but because of the heterogeneity of countries this is not possible to achieve. The worldwide piracy rate dropped to 41%. PC shipments to consumers rose 17% while in business dropped 15%. Software piracy was higher in the consumers than on business because in this sector they have audits to their software. As part of the input to determine software piracy rates, IDC takes into account several factors, some of these are: PC shipments growth, consumer vs. business ownership, broadband access, desktop-to-laptop-mix, etc[54]. IDC takes into account freeware software, representing 12.22% of the market, which is low. Sometimes the quality of this software is better. IDC analyzed software-as-a-service (SaaS), but it had a weak impact. It is a good choice especially if the software needs continuously upgrades and training is necessary in a regular basis (because

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[50] For more details see page 8 of the "*Fifth annual BSA and IDC Global Software Piracy Study"*

[51] See page 2 of the "*Sixth annual BSA and IDC Global Software Piracy Study"*

[52] These factors are: Vendor legalization efforts, Vendor agreements with original equipment manufacturer (OEM), Technical advances, Software asset management (SAM), Government-led educational and enforcement, New distribution agreements, Public-private partnerships and Globalization.

[53] These factors are: Broadband, Faster grow in high piracy segments, emerging market growth, Economic slowdown

[54] For more details see page 5 of the report

of the complexity). In this year IDC analyzed a mix of 28 countries from various regions, conducting surveys on 6000 consumers and 4300 business users.

"Eighth annual BSA and IDC Global Software Piracy Study" (BSA, 2011), in 2010 the commercial value of software piracy grew fourteen percent, PC shipments to emerging economies was bigger than those on mature markets and in the emerging economies accounted for more than half of the software pirated. This year the BSA study covered a total of 116 countries, using a methodology that incorporates "182 discrete data inputs for each". This year BSA counted with Ipsos Public Affairs to make surveys on PC users on 32 countries. The commercial value of software pirated doubled since 2003. The piracy rate dropped in 51 economies and increased in only 15. BSA estimated that there are 1.4 billion PC installed worldwide. Consumers represented a total of 52% of installed PC compared to the 43% three years ago. The results of the surveys were important; 81% of PC user value legal software over illegal software, but 41% of PC users in emerging markets think that "acquiring" software downloaded from peer-to-peer networks in probably legal. This shows that a better education in this area must be done in these economies. This survey consisted of 15000 PC users both in Emerging markets[55] and Mature markets[56], these surveys were conducted online or in-person. Since 2003 the methodology were improved, introducing new elements.

For the non-survey countries IDC uses proxies. To estimate software load in these countries, IDC uses correlations between the known software loads from survey countries and their scores on emerging market measures published by the International Telecommunication Union, called the ICT Developments Index. It also considers other correlations such as gross domestic product per capita, PC penetration and measures of institutional strength[57].

"Annually", BSA publishes studies referring the impact of lowering the piracy rate (BSA, 2010a). In the study they refer what are the benefits of lowering the piracy rate by ten-points from 2008-2011. In this report they used 42 countries that represented more than

[55] These countries are: Argentina Republic (AR), Brazil (BR), China (CN), Chile (CL), Colombia (CO), Czech Republic (CZ), India (IN), Indonesia (ID), Republic of Korea (KR), Malaysia (MY), Mexico (MX), Nigeria (NG), Poland (PL), Russian Federation (RU), Saudi Arabia (SA), South Africa (ZA), Thailand (TH), Turkey (TR), Ukraine (UA), Vietnam (VN).

[56] These countries are: Australia (AU), Canada (CA), France (FR), Germany (DE), Italy (IT), Japan (JP), Netherlands (NL), Spain (ES), Sweden (SE), Switzerland (CH), United Kingdom (GB), United States (US).

[57] see page 10 of the report "*Eight annual BSA and IDC Global Software Piracy Study"*

90% of the IT market. Globally, the reduction would lead to an increase in GDP (measure in millions) of 141 000$, a creation of 600000 jobs and tax revenue (measure in millions) of 24 000$. Analyzing the Western Europe, this would mean an increase in GDP of 35 787$, a creation of jobs of 53878 and taxes of 9 322$. This increase of taxes is important in the Euro Countries because of the (<3% of GDP) budget deficit requirements. This increase in taxes would lead to a decrease in deficit or with the same deficit; improve the Economy, implementing expansionary policies to help the economies to growth.

In the "*2011 BSA global software piracy study"* (BSA, 2012) it was conducted a survey with the main goal to view the attitudes of consumers towards the use of illicit software. This survey was conducted on 14700 computer users in a total of 33 markets/countries that represent 82% of the global PC Market. This task was conducted by Ipsos Public Affairs on January and February of 2012. Results indicate that 57% of software users admit they pirate. Those that pirate often represent 31%, out of these; 5% say they pirate "all of the time", 9% "most of the time" and 17% "occasionally". In the group that says "most of the time" are the young and male individuals. 26% admit they pirate, but only "rarely". Other important result is that 4 in 10 people (38% of the sample) say they "never" pirate. All of the time/ Most of the time or Occasionally software pirate users are the most voracious pirates; on their Computers, 55% of software is pirated. Other important conclusion is that pirates in Emerging economies install almost four times as many programs as those on mature markets.

Globally, the software pirate rates are 42%. The commercial value of unlicensed software rose to 63.4$ billions in 2011. This high value of piracy is due to the large impact of the emerging economies, representing 56% of the world PC shipments in 2011. Piracy rate on Emerging markets is 68% and in Mature ones is only 24%. Two of the most big Economies in the World are the US and China, US as a piracy rate of 19% but losses of 10$ billion, China as a piracy rate of 77% and losses of 9$ billion.

Although the market for PC is large, 1.5 billion personal computers with 32 billion software programs with a commercial value of 261$ billion; the market for Tables is slowly increasing, 80 million tablets in 2011 running 3.7 billion apps with a commercial value of 7$ billion.

Surveys to determine software piracy include 182 data inputs (provided by IDC), on 116 markets either online or in-person. To improve the methodology from this year onward, 11 countries will be surveyed annually and 42 countries will be surveys at least once every two to three years.

The *"BSA Global Software survey"* (BSA, 2014) of 2014 was published two years after its predecessor. This year it was conducted surveys on IT managers. Surveys were conducted in early 2014 on 20000 consumers and enterprises PC users in 34 markets/countries and on 2000 IT managers in 20 countries. As in the previous report we have represented 116 markets.

Less that 50% of IT managers are confident that their organizations are using legal software. Furthermore they have several concerns about Malware when using illicit software, namely: i) Loss of data (39%), ii) Data breaches (50%), iii) Time and cost do disinfect (39%) and iv) Loss of IP or proprietary information (38%). Other major finding is that only 35% of Companies have written policies regarding the use of legal software. In regard to consumer users, they do not use illicit software or because of unauthorized access by hackers (69%) or due to loss of data) (59%).

Worldwide, 43% of software installed is pirated with a total value of unlicensed software of 62.7$ billion in 2013. This is a result of the growing popularity of the tablet PC; in emerging markets, PC are still dominant. Emerging markets represent 56% of PC in use and 73% of total unlicensed software.

Chapter 3 Determinants of worldwide software piracy losses

*A first version of this chapter was presented at the 15th annual Infer Conference, Orleans, May 28-June 1, 2013.

** It was also presented at the PhD Workshop in Economics; School of Economics and Management, University of Minho June 25 of 2013

3.1 Introduction

In the past decades we have witnessed a huge development on hardware and software industries. Some examples of these developments were the “Windows®” and "Apple® Macintosh” operating systems with its friendly user interfaces. These operating systems are used in working environments, and the equipment in which they operate are very expensive. Both Mac OS and Windows® operating systems evolved over several releases. For example Windows® 8 evolved from its predecessor, the Windows® 7, bringing new features such as a new UI (user interface). As the personal computers became more powerful, it made possible to develop software to an increasing array of applications as, for instance, music and digital edition.

With these developments it came also the need to improve the existing software to meet the requirements of consumers. These improvements came at a cost; continuous research and development are needed by companies in order to maintain quality and keep update with the changes in technology. The cost of these investments is passed to consumers in the form of a license; the consumer pays a license to use the software during a certain amount of time (normally annually and with updates granted within this period) or buys a perpetual license for that particular software (normally with reduced prices for future updates). This perpetual license is not really “perpetual” as software becomes obsolete quickly. Updates on operating systems and hardware are released within regular periods of time and, sometimes, these upgrades turn old software versions unusable (applications, drivers, system extensions, etc.). Investment on software must also be done into its hardware or software protections against piracy because software has the characteristic of being easily distributed with virtually no cost associated.

The massive use of computers and the Internet made the problem of software piracy potentially more severe, as the pirated software can be uploaded in the Internet within increasingly shorter periods of time. Before the expansion of Internet usage, only hard copies were available which were easier to track. To prevent this phenomenon, companies must invest to avoid pirated software from being used in addition to the investment to meet the speciation of potential consumers. Pirated software starts its journey when the original program protection is bypassed by another program or action performed by hackers. The investment that the companies make must incorporate different layers of protection.

Unfortunately the software protections are often hacked. To cover these costs the companies must increase *R&D*, which increases the initial prices, but these prices sometimes take away potential buyers. In recent years, and due to the need of the information being available anywhere and anytime, many software products offer online services that replace the need of the software being installed in the computer. These software can be free of charge or, to access its full capabilities, may be necessary an user registration fee. Because each time the user uses the software, he must be identified and logged-in, the risk of piracy is reduced.

Due to the increase importance of the software piracy phenomenon, previous research studied the determinants of software piracy resorting to the software piracy rates as the dependent variable[58]. However, official publications also report the software piracy losses and to our knowledge no empirical work conducted an analysis of this variable.

Both piracy rates and losses measure the illicit behavior in a country. In the first case it measures the percentage of software that is being illegally used at a given time, but it omits the importance of the software industry in the economy. We can have a low piracy rate and huge losses; example of this is the USA. On the other side countries with piracy rate above 90% may represent little impact on this industry due to the small domestic software markets. Piracy losses measure the benefit to the economy national income in lowering piracy.

Our contribution to the literature is as follows:

(i) We will examine what are the determinants of software piracy losses along five dimensions: the technological development, the level of education, the correct functioning of institutions the availability of information and the structure of the labor force;

(ii) We will use a panel methodology that provides consistent estimates when the dataset is persistent: the System-GMM proposed by Arellano and Bover (1995) and Blundell and Bond (1998).

The structure of the chapter is the following: section 3.1 presents a brief survey of the empirical literature on software piracy that used cross sectional and panel data analysis. Section 3.2 describes the piracy rates and losses presented by the *Business Software*

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[58] Due to data restrictions previous research used two main methodologies: cross-sectional and panel data using classical methods due to small time periods.

Alliance[59] (BSA) since 1994 in different regions of the world; section 3.3 explains the various dimensions and possible effects. Section 3.4 describes the econometric specification and the results, and section 3.5 concludes.

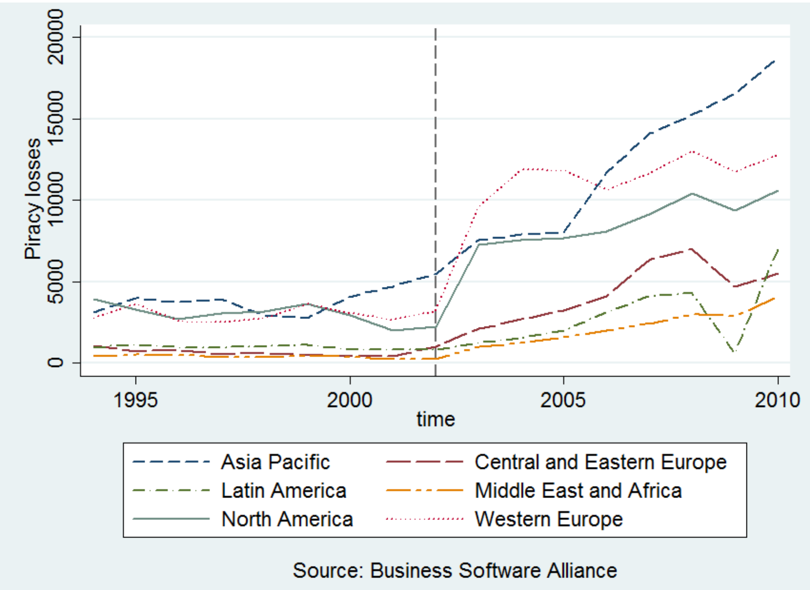
[59] *Business Software Alliance* is a group pressure that estimates annually the software piracy losses and rates across different groups of countries.

3.2 Evolution of the software piracy losses and rates over the years

This section describes the evolution of the piracy rates and losses since 1994 for different regions of the world using the data provided by the BSA.

Figure 3.1 presents the evolution of the piracy losses over the last 17 years measured at current prices (BSA, 2011) in millions of dollars. Piracy losses for each region are the result of the sum of the losses for all countries in that region[60]. The piracy rates and losses are annually published by the BSA, with the help of an external consultant. In the period of 2002-2003, BSA changed its consultant from *International Planning and Research Corporation* (IPRC*)* to IDC and, consequently, the results were substantially different. Furthermore in 2002 BSA included other types of software such as operating system and games; as previously the reports only included business applications. This figure clearly shows this changed occurred in 2002 as there is a big jump from 2002 to 2003.

Figure 3.1 Evolution of Software Piracy Losses



[60] All estimations from countries take into account the exchange rate of the dollar against national currencies

In the majority of regions the amount of losses grew at exponentially rate since 2002 with the exception of Asia Pacific, North America and Western Europe where losses grew rapidly. Some of this growth can be explained by the introduction of new countries in the sample, technological growth or the variations in the exchange rates.

In addition to this graph we calculated the $Losses/GDP$ in these regions (Figure 3.2). Piracy losses per GDP was obtained as follows: piracy losses and GDP for each region is the simple average of all countries belonging to a region; then we divided Losses over GDP. As in Figure 3.1 there exists a break in the series in 2002, but now these losses in terms of GDP are higher in Latin America, Central and Eastern Europe and Asia Pacific.

Figure 3.2 Losses / GDP on all regions

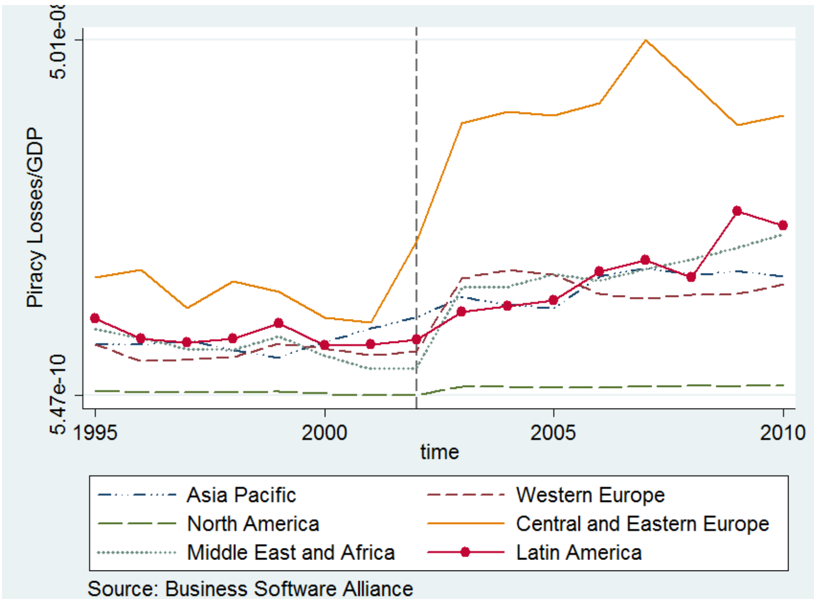
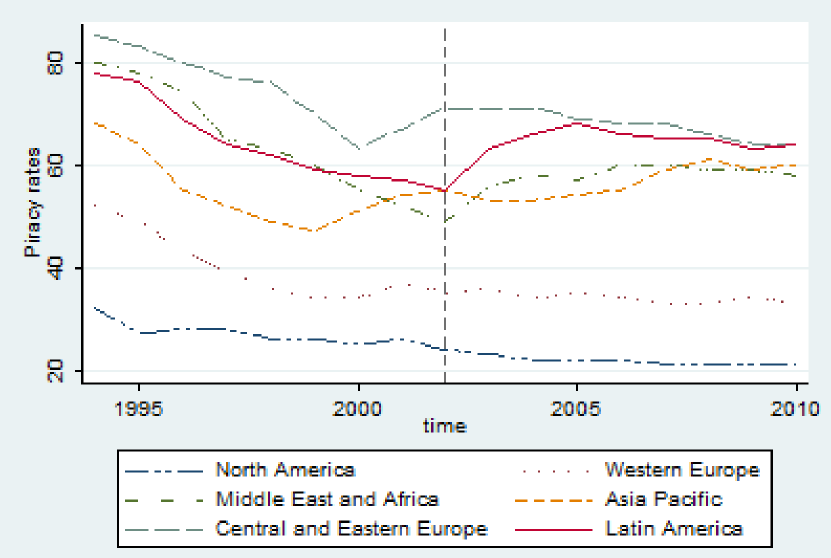


Figure 3.3 Evolution of Software Piracy Rates

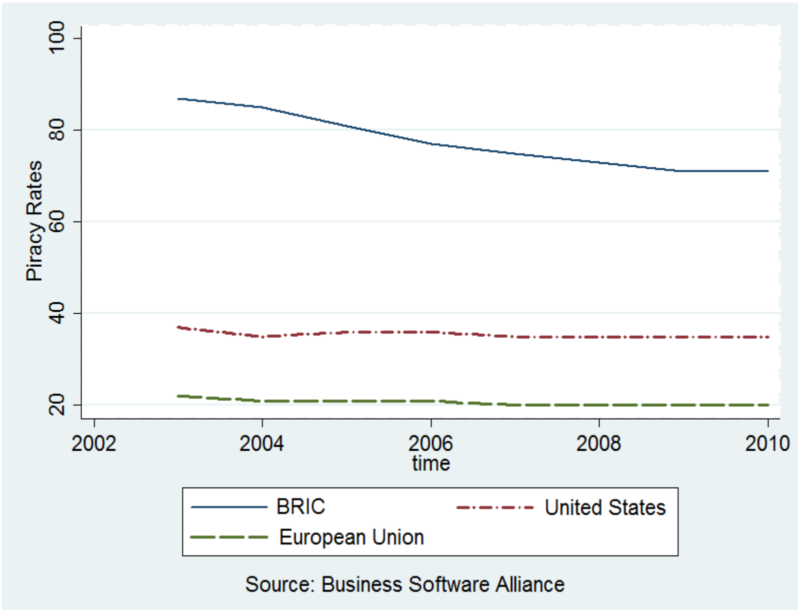


Source: Business Software Alliance

Figure 3.3 presents the evolution of the piracy rates. The relationship between the piracy rates and losses is not linear; losses increased over time while piracy rates fell. This decrease was not so drastic in 2002 compared to the losses increases. North America and Western Europe have the lowest piracy rates. These rates have been decreasing more rapidly until 2002 and, after this period, the rates had a smother pattern. In the case of Middle East and Africa, and Latin America, software piracy decreased rapidly until 2002, then increased slowly. Png (2010) found that when surveys are not applied, the software piracy rates are based on national income; it also found that the yearly rate of decrease of the piracy rates before 2003 were 2.0 (p.p), while the period after 2003 this rate of decrease fell to 1.1 (p.p) for the non-survey countries.

For a closer look, we also report the software piracy rates on three regions of the world: BRIC[61], United States and European Union from 2003 until 2010 (Figure 3.4). The piracy rates in European Union and United States have been more or less constant over the last 8 years. In the BRICs piracy rates have been steadily falling slowly, but still represent over 70% of the software used.

Figure 3.4 Software Piracy rates on selected regions



The existence of low piracy rates don't necessarily means lower losses. Figure 3.5 and 3.6 shows the piracy losses on the three regions; piracy losses have been growing at a more or less constant rate on United States and European Union. The amount of losses almost tripled in eight years in the BRICs. When losses are analyzed as a proportion of GDP, the importance of the losses in the BRICs is even higher when compared with the EU and USA. This can represent the ineffective implementation of copyright laws. Anyway, the losses in terms of GDP have (in any of the three regions) been more or less constant during the analyzed period.

[61]Brazil, Russia, India and China

Figure 3.5 Software Piracy Losses on selected regions

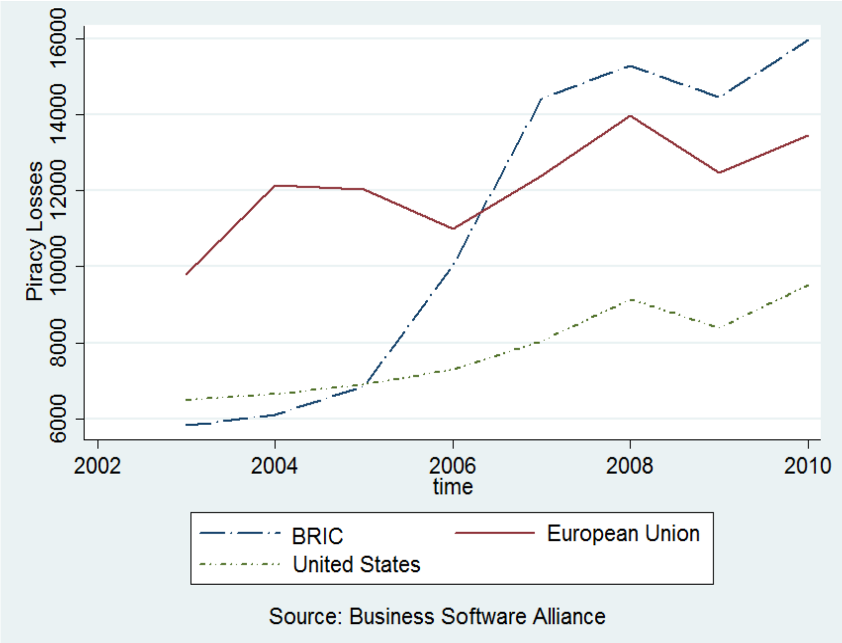
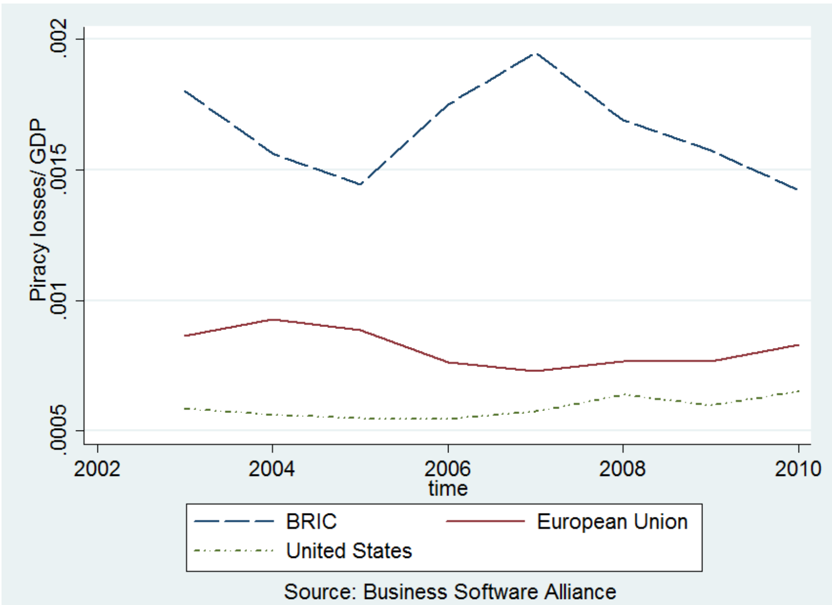


Figure 3.6 Losses / GDP on selected regions



3.3 Variables and possible effects

This section describes some of the variables used in previous research, introducing new ones. We group them into five dimensions. Theoretical background exists but at the individual/firm level. See, for instance, (Bae & Choi, 2006; Lu & Poddar, 2012). In general, studies focus on the behavior of individuals towards piracy, modeling the benefits to software firms on improved software protection, awareness and the effects of the environment (network externalities). These benefits will affect the country economy on various levels, namely in how access to information is controlled and how better protection can be implemented.

Literature at the macroeconomic level is still in its infancy. A measure of income (namely GDP) is used in many studies as a determinant of piracy (see for instance (Andrés, 2006a). Goel and Nelson (2009) provide some macroeconomic determinants using cross-sectional data. The main purpose of this chapter is to provide an historical view of the problem using a panel data analysis. We can define piracy as a function of the various dimensions: Technological, Educational, Access to Information, Institutional Dimension and Labor force. In the Labor force dimension we introduce new variables in the economic literature that affect piracy, namely the structure of the labor force and the education of active population.

3.3.1 Technological dimension

Technological dimensions can affect levels of software piracy. Expenditure on research and development (R&D) has been found to affect negatively software piracy (Marron & Steel, 2000). As with Marron and Steel (2000) we introduce this variable that may also affect piracy losses. In our case this variable indicates investment that is made on software protection, namely software code. This variable also makes part of the educational dimension.

Additional to this variable we introduce two variables that capture this dimension. To our knowledge no empirical work as studies these specific variables. They are the patent and the trademark applications done by residents and non-residents.

Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention (this can be a product or a process). The protection of this product can reach up to 20 years. Patents can be filed by domestic or by foreign applicants.

Trademark applications filed are application to register a trademark with a national or regional Intellectual Property (IP) office. A trademark is a distinctive sign that identifies certain goods or services as those produced or provided by a specific region, person or enterprise. A trademark provides protection to the owner of the mark by ensuring the exclusive right to use it to identify goods or services, or to authorize another to use it in exchange for a license or royalty. The period of protection varies. Direct resident trademark applications are those filed by domestic applicants directly at a given national IP office while those that are filed by applicants from abroad are called "direct nonresident trademark applications". The registration of a patent or a trademark has costs for the firm, but these are necessary in order to protect their products.

All these variables are expected to have a negative effect on piracy losses although the existence of a patent is not sufficient to prevent piracy; the enforcement trough strict regulation is also necessary. More technological advanced countries have more legal protection and, at the same time, firm's owner of the technology are also more close to the market and can detect more easily illegal software.

3.3.2 Educational dimension

In all countries there is a pre-determined number of years of schooling that a child needs to complete, and this number may vary from one country to another. During this period, children have specific subjects that require the usage of computers and Internet. This early introduction to new technologies will improve productivity of future workers. In some subjects, professors introduce the concept of illegal software and the risks associated with their use. The introduction of other concepts such as copyright can reduce the future use of illegal software. MacDonald and Fougere (2003) studied this effect analyzing MIS (Management Information Systems) textbooks. Previous research introduced the effective schooling years that students have (variables retrieved from the Barro and Lee (2013) dataset). Marron and Steel (2000) and Andrés (2006b) found that more schooling years reduce piracy. This variable is not available annually, we will introduce a proxy variable that indicates years of schooling that a country offers. More years of schooling indicate that children understand and are aware about the consequence of using illegal software. This variable includes years of schooling of primary education based on the ISCED 1997[62] (ISCED 1) and secondary education based on the ISCED 1997 (ISCED 2 and 3). This indicator reveals the total education that a country offers. This variable may or may not have a negative effect.

Other variables could be used such as literacy rate (see Goel and Nelson (2009)) having a positive impact (increase) on piracy. But in this case, literacy rate omits the different levels of education; a person can be literate and lack the ability to use computers and software.

No previous research focused on the financial effects that expenditure on education could have on piracy. A measure that reflects the expenditure that is made on education will be introduced. More public expenditure on education as a percentage of *GDP* can reduce illegal software that students use; this will also result in more quality of education. This financial help can go both to public or private institutions. This variable is expected to affect negatively software piracy losses.

3.3.3 Access to information

Technology has evolved over the years. Today it is difficult or even impossible to live without it. Hardware and software industry have profited with these developments but, with the dissemination of the Internet, it was also possible to download huge amounts of information, some of which not legal, such as pirated software. Authors such as Goel and Nelson (2009) analyzed the effects that internet and computer users have on piracy, results showed that more users of these devices reduces piracy. More recently Boyce (2011) found that broadband penetration rate and Internet access reduces piracy. Most modern mobile phones uses an operating system, some of which may even replace the computer (in some specific tasks - the case of smartphones).

[62] International Standard Classification of Education

We will introduce four variables that measure the availability of information (telephone, fixed broadband Internet subscriber, Internet and mobile users).

Telephone lines are physical and fixed lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange. Integrated services digital network channels and fixed wireless subscribers are included. Fixed broadband Internet subscribers are the number of broadband subscribers with a digital subscriber line, cable modem, or other high-speed technology. Internet users are people with access to the worldwide network. Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Post-paid and prepaid subscriptions are included.

All these variables affect the availability of software; more usage of these devises would lead to an increase in software piracy losses.

3.3.4 Institutional Dimensions

Past literature has found that institutional factors play an important role on piracy (see (Knack & Keefer, 1995)). Following D. Banerjee, Khalid, and Sturm (2005) and Goel and Nelson (2009) we introduce four institutional factors that can explain levels of software piracy, they are business freedom, trade freedom, freedom from corruption and financial freedom. Better institutions are associated with lower piracy losses.

Business freedom indicates if firms can be established easily with little bureaucracy. Trade freedom indicates if countries promote trade or not, for example putting high tariff rates on foreign products such as software or hardware products. Freedom from corruption can tell us how the legal system work, if officials are corrupt and if illegal activities such as piracy pass unpunished. Finally financial freedom measures banking efficiency and independence of government control. A correct functioning of the banking sector will promote credit to the economy, sometimes indispensable to purchase software in the case of expensive ones.

3.3.5 Labor force dimension

Computer skills are acquired at school or at the workplace; these can range from browsing the Internet, sending e-mails or working on business applications such as word processors or spreadsheets. Different jobs require different types of software; some include imaging suits, others productivity or econometric tools, etc. We will consider three variables that reflect the structure of the labor force of the population: employment in the primary sector (Agriculture), employment in the secondary sector (Industry) and employment in the tertiary sector (Service).

In agriculture when the production is intensive, software helps to improve efficiency; e.g. controlling various elements of a greenhouse such as the temperature or humidity. In the industrial sector, the use of specialized software is "normal", as it comes with the machine and, in many situations, is developed and used by the firms internally, thus is not for sale. The software cannot be used outside of the environment that was intended to work. Big firms develop the software, or commission its development (outsource) to a specialized company (due to smaller costs). The services sector uses specialized software of accounting, taxation and productivity. Depending on the different needs, the software can cost thousands of dollars, but it comes with technical support, extremely valuable in order to maintain productivity and prevent failures. The costs associated with the acquisition of these types of software can be deduced during a certain amount of time, reducing taxable profits.

Employment in these sectors may have impact on software piracy losses. Firms want to maximize profit; in some cases, due to budgetary restrictions, employers can introduce some illicit software that will benefit both employers and employees. The introduction of illicit software has associated risks that are, for instance, the result from external audits that can impose severe fines. In spite of this, some firms may be willing to take them. Certain types of jobs, namely in the service sector, can be done from home, as in market research. In many cases workers wanting to do their jobs at home due to reduced costs may seek illicit software to implement their research. In this case there is only a residual risk of internal audits finding illicit software. This may lead an increase of software piracy losses.

Additional to these variables we introduce the education of the labor force. We will consider labor force with primary, secondary and tertiary education. The labor force of a country plays an important role on the growth of the economy (Barro, 2013a). If it is constituted by labor force with low education, this will lead to low productivity and, consequently, to small economic growth. Also, if the labor force is constituted by highly qualified people, this will lead to increased productivity which improves the standards of living. These highly qualified employees will use computers and software. More education of the labor force characterizes a double-edged sword context: on one side there are more users of computers and software but, at the same time, some of the consumers will use illicit software[63].

Chen, Chen, and Yeh (2010) found that unemployment has a negative effect (reduce) on software piracy rates. Their sample was small and reflected a small group of homogeneous countries where the psychological aspects could be determinant.

Another measure that reflects both an income dimension and social dimension is the unemployment. We will use the total and youth unemployment that reflects people within 15-24 years without work and the total unemployment rate. Both variables are expected to have a positive effect on piracy losses. An unemployed person has less disposable income and spends more time at home. Sometimes it is necessary to use certain software to start working (in the case of self-employment), but the lack of money can shift consumers from legal to illegal copies to fill their needs.

3.3.6 General Econometric Model

These five dimensions interfere with each other as, for example, education in a country will affect the type of jobs of workers, more service-orientated or more for the industry. In addition, employment levels will be affected by the type of education. More technologically advanced countries that rely on high *R&D* promote more effectively the protection of invents and the level of education of workers. Access to information can be seen as affecting all dimensions at the same time because more information in the form of knowledge will affect education levels and its quality, will permit access to innovations patented or not, and will also affect productivity of workers and access to employment

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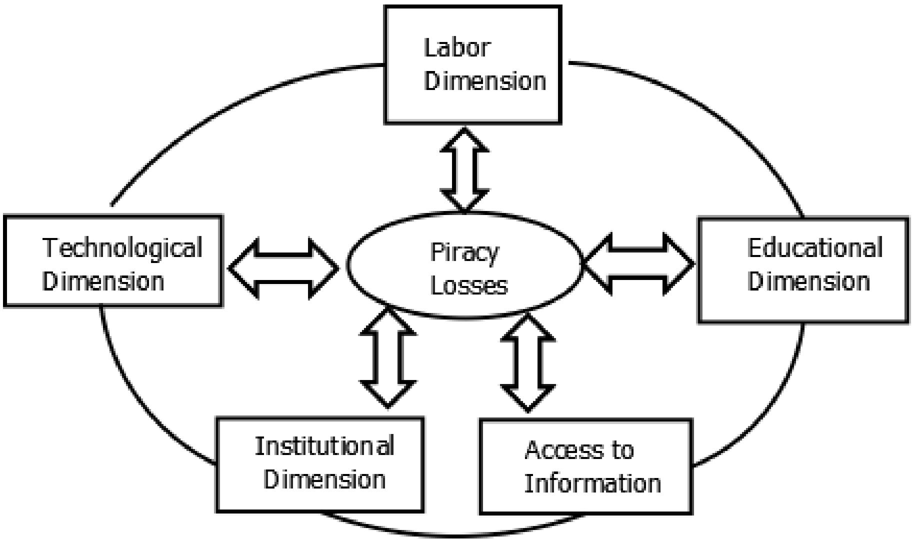
[63] We should note that the education of the labor force represents both a labor force dimension and educational dimension.

opportunities advertised on the different Media. Institutional dimension also affect all dimensions at the same time, free countries have better education, technology, better access to information and qualified labor force.

Figure 3.7 also show the relation between variables. Piracy is affecting all dimensions but also being influenced by them. Furthermore, all dimensions are linked together influencing each other.

Figure 3.7 Relationship between variables



Equation 3.1 shows the general econometric model.

$$Piracy = f(Labor\ Force, Technological, Educational, Access\ to\ Information, Institutional) \quad (3.1)$$

3.4 Empirical evidence

3.4.1 Data, econometric specification and summary statistics

Previous econometric studies relied on cross-section or panel data analysis. In the panel data models periods of study were relatively short. To our knowledge, this work is the first to introduce a large time span in the analysis. Figure 3.1 shows that software piracy losses are highly persistent over time and that its value follows closely the GDP (see Figure 3.2); its value is always increasing over time. Soto (2009) examined the properties of System GMM when the sample is small and the series is persistent, which is applicable to our dataset. This estimator was found to have lower bias and higher efficiency than the OLS or the fixed-effects estimator and, furthermore, the gain in efficiency from the two-step estimator is almost inexistent; both the one and two-step distributions are virtually the same. Based on these results we will report the one-step System GMM.

Our dataset is constituted by macroeconomic variables retrieved from the *World Development Indicators* and the Heritage Foundation[64] available for the countries present in the publications provided by the BSA and comprising 81 countries from 1994 until 2010. Variables were chosen based on their relevance and suitability and in their availability through all the period in the analysis. Due to the persistence of the piracy losses, we will use a dynamic panel data analysis, namely the Arellano and Bover (1995) and Blundell and Bond (1998) estimator. This estimator was developed because the lagged-level instruments of the original Arellano and Bond (1991) estimator become weak when the autoregressive process becomes too persistent or when the ratio of the variance of the panel-level effects and the variance of the idiosyncratic error becomes too large. The System GMM uses both level and first-difference of the lagged dependent variable as instruments.

The dependent variable is the piracy losses due to pirated software, and it's measured in millions of dollars. The independent variables measure various dimensions of a country: Technological dimensions, Educational dimension, Access to Information, Institutional Dimension and Labor Force dimension. In our analysis we will use the nominal GDP (*GDP*)[65] as a control variable.

[64] www.heritage.org

[65] GDP is measured in current US dollars - this variable will be considered as endogenous and used to control the market dimension.

The estimator used poses some problems, namely in the case of too many instruments. When the instrument count is high they may fail to expunge their endogenous components and biasing coefficient estimates toward those from non-instrumenting estimators as discussed by Roodman (2009b). With the limitation of lags we overcome this problem, e.g. the number of instruments higher than the number of countries. In the end of each regression we report the number of instruments used and also, through our analysis, the number of instruments will be smaller than the number of countries following Roodman (2009a).

The econometric specification is given in equation 3.2 as follows:

$$ln(Losses)_{it} = \beta_{it} + \theta_1 ln(Losses)_{i,t-1} + \alpha_1 ln(GDP)_{it} + X_{it}\alpha_X + Y_{it}\alpha_Y + Z_{it}\alpha_Z + W_{it}\alpha_W + \alpha_6 Change_t + v_i + \varepsilon_{it} \quad (3.2)$$

i =1,…,81 represents the countries and *t =1994,…,2010* the time periods

The variable *Losses* is the piracy losses measured in millions of dollars and *GDP* is the Gross Domestic Product at current prices. Additional to this we could also consider $\frac{ln(losses)}{ln(GDP)}$ as a dependent variable that represents the relative importance of the piracy losses in relation to GDP[66].

X_{it} is a vector of labor force. It reflects the labor force dimension and it's constituted by the labor force, type of employment and unemployment.

$$X'_{it} = [Labp_{it}\ Labs_{it}\ Labt_{it}\ Empagri_{it}\ Empind_{it}\ Empserv_{it}\ Unemyouth_{it}] \quad (3.3)$$

were *Labp* is the labor force with primary education, *Labs* is the labor force with secondary education, *Labt* is the labor force with tertiary education, *Empagri* is the

[66] To assess the validity of both assumptions we performed regressions. In both cases the variables maintain the same coefficient, being the only difference the magnitude of these. We opted by the absolute value of Losses as it provided best estimates, maintaining significance.

employment in agriculture, *Empind* is the employment in industry, *Empserv* is the employment in the services sector. *Unempyouth* is the unemployment of people from 15 to 24 years old, we also introduce *Unemp* that is the total unemployment.

Y_{it} is a vector that represents the technological dimension and it's constituted by patents, trademarks and the research and development.

$$Y_{it}' = [R\&D_{it}\ ln(Patres)_{it}\ ln(Patnon)_{it}\ ln(Tradres)_{it}\ ln(Tradnon)_{it}] \quad (3.4)$$

R&D represents the research and development expenditure as a percentage of *GDP*, *Patres* are the patent applications done by residents, *Patnon* are the patent applications done by nonresidents. *Tradres* is the trademark applications done directly by residents and the *Tradnon* is the trademark applications done directly by nonresident. Both patents and trademarks are in logarithms.

Z_{it} is a vector of the education dimensions. It combines years of schooling and public expenditure in the different levels of education (primary, secondary and tertiary) as a percentage of *GDP*.

$$Z_{it} = [Yschoolpri_{it}\ Yschoolsec_{it}\ Exppri_{it}\ Expsec_{it}\ Expter_{it}\ Pubexp_{it}] \quad (3.5)$$

$Yschoolpri$ is the duration in years of primary education, *Yschoolsec* is the duration in years of secondary education. *Exppri*, *Expsec* and *Expter* is expenditure on primary, secondary and tertiary education as a share of GDP. *Pubexp* represents public expenditure on education as a percentage of GDP.

The vector W_{it} represents the various variables that represent access to information.

$$W_{it} = [ln(Fbis)_{\ it}\ ln(Mobile)_{it}\ \ ln(Phone)_{it}\ \ ln(Net)_{it}] \qquad (3.6)$$

Fbis is fixed broadband Internet subscribers, *Mobile* is mobile cellular subscriptions, $Phone$ is the phone lines and *Net* is the access to the Internet. These variables are measured per 100 people. We introduce logarithms in this dimension.

Vector I_{it} represents the institutional dimension.

$$I_{it} = [BusFreed_{it}\ TradFreed_{it}\ CorrFreed_{it}FinFreed_{it}] \qquad (3.7)$$

Variables are business freedom (*BusFreed*), trade freedom (*TradFreed*), freedom from corruption (*CorrFreed*) and financial freedom (*FinFreed*)

Additional to these variables, a dummy variable *(Change)* will be introduced that reflects the change in methodology provided by the BSA. Before 2003 it will have a value of 0 and of 1 afterwards. We will also introduce a set of time dummies.

Table 3.1 presents the descriptive statistics of the various dimensions. In 2010 data for software piracy losses was available for 81 countries. Every year the BSA improves its estimates performing more surveys; initially surveys were made on 15 countries[67] (BSA, 2003); in 2010, surveys were made on 32[68] countries (BSA, 2010b), a total of 15000 computer users were inquired. Since 1994 a total of 1217 observations are available.

[67] Bolivia; Brazil; Chile; China; Colombia; Costa Rica; Dominican Republic; Guatemala; Kuwait; Malaysia; Mexico; Romania; Spain; Taiwan and the United States.

[68] Emerging markets include: Argentina; Brazil; China; Chile; Colombia; Czech Republic; India; Indonesia; Korea, Republic of; Malaysia; Mexico; Nigeria; Poland; Russian Federation; Saudi Arabia; South Africa; Thailand; Turkey; Ukraine; Vietnam. Mature markets include: Australia; Canada; France; Germany; Italy; Japan; Netherlands; Spain; Sweden; Switzerland; United Kingdom; United States.

Table 3.1 Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Losses	1217	353.80	929.37	0.902	9515
Losses/GDP	1217	0.00082	0.00088	0.000088	0.016
GDP	1373	478804.7	1400089	1170.785	1.44e+07
Labor Force dimension					
Empagri	1176	15.81	15.90	.2	72.2
Empind	1177	24.78	6.24	6.5	43.1
Empserv	1177	58.79	14.42	13.3	87.4
Labp	781	29.92	17.68	0	89
Labs	775	43.13	16.89	2.9	80.2
Labt	781	23.94	10.68	0	66.1
Unempyouth	1006	17.43	9.33	2.2	629
Unemp	1200	8.49	5.04	0.9	36.4
Technological dimension					
Patres	1186	12211.37	49331.09	2	384201
Patnon	1196	6987.64	21961.23	1	248249
Tradres	1174	23936.59	64011.48	1	973460
Tradnon	1177	6356.59	7613.16	33	67838
R&D	862	1.12	.98	.02	4.8
Educational dimension					
Pubexp	726	4.81	1.42	2.20e-06	9.51
Yschoolpri	1375	5.43	.99	3	8
Yschoolsec	1130	6.54	1.01	4	9
Access to Information dimension					
Net	1341	23.41	25.73	0.00	95.63
Fbis	928	7.11	9.77	0.00	38.10
Phone	1366	29.39	19.51	0.61	74.69
Mobile	1367	48.56	45.15	0.00	195.57
Institutional dimension					
BusFreed	1256	50.59	24.53	10	100
TradFreed	1256	70.62	13.37	36.3	100
CorrFreed	1256	72.08	13.23	0	95
FinFreed	1256	59.19	18.02	10	90

Notes: Std. Dev. represents the standard deviation; Min the minimum and Max the maximum.

3.4.2 Empirical application

This section presents the empirical results for the various dimensions. Some of our variables in education don't vary over time and, consequently, the fixed effect was not the best choice as it omits invariant regressors. Based on the Hausman test, Andrés (2006a), Chen et al. (2010) and Boyce (2011) found that the fixed effect was more appropriated in panel data analysis. Traditional methods such as fixed effects or random effects produce inconsistent estimates when the lagged dependent variable enters as a regressor. Due to the nature of our dataset (extremely unbalanced when considering certain dimensions), we will split our analysis into 15 regressions in the dynamic model. In all of them there will be control variables for each dimension. Our results will be conducted using the one-step System GMM[69].

For the System GMM to be applicable there must be no evidence of second order autocorrelation AR(2). Additional to this, instrument must be valid. To test this we report the Hansen test for validity of instruments (Hansen, 1982). This test assumes, under the null hypothesis, that instruments are valid and it's a robust version of the Sargan test[70]; one problem that may occur is that it can be weakened by a proliferation of instruments. We also report the number of instruments following Roodman (2009a).

Table 3.2, Table 3.3 and Table 3.4 presents the regressions within each dimension. All of the regressions include control variables for the remaining dimensions. The control variable in the educational dimension is the result of the sum of primary and secondary schooling years, "*School*". In the Technological dimension, variables were constructed providing the best estimates; the sum of patents from residents and nonresidents, "*ln(Patents)*"; the sum of trademark from residents and nonresidents, "*ln(Trademark)*". When necessary, we also summed the total patents and trademarks, "*ln(Legal)*"; this variable give us a general idea of the overall demand for this kind of protection.

Columns 1 through 5 summarize the results from the labor force. From these results we conclude that the higher the share of people working in the services sector the lower will be the piracy losses. This can be seen in columns 1, 2 and 4 where the base sector (omitted

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[69] The two-step System GMM is presented in Annex because the gains from the one-step to the two-step System GMM are marginal Soto (2009). In the two-step System GMM we take into account the corrected covariance matrix proposed by Windmeijer (2005).

[70] This test is also reported. It´s not affected by the proliferation of instruments, but it's not robust.

variable)[71] was the share of people working in the agriculture sector or in the industrial sector. In either case the share of people working in the services sector has a negative significant impact in the piracy losses. If we use the services sector as the base sector (column 3 or 5) the industrial and agricultural sectors have positive and significant impact (although the significance of the agricultural sector is not robust across specifications) pointing to the same conclusion: the higher the share in these sectors (and lower in the service sector) the higher will be the losses due to software piracy. This result was unexpected.

As for the labor qualifications referred above, we have to omit one of the education variables and use it as the base case. In this case the higher the share of workers with tertiary education the higher will be the losses due to piracy. Furthermore, the results indicate that is the division between the share of the workers with the tertiary education and the others that matters. This can be seen in columns 1 and 2 when we consider the share with primary education; the estimated coefficient of the share with secondary education is close to zero and non-significant. The same result is obtained in column 4 when we use the secondary education share as the base and analyze the estimate of the share with primary of education. This result is in line with what we expected.

Another important variable present in the labor force is the youth unemployment. This variable combined with the level of education of the labor force and access to technology will determine the use of software at home. This variable has always a positive impact, but it was significant only in regressions 1 through 5 in which labor force and type of employment were present. There are other types of unemployment. Some examples are the long-run unemployment and total unemployment. The first variable was not suited as the reduced number of observations made difficult to estimate with this methodology. As an additional robustness check we included total unemployment; significance was not present, nevertheless it maintains the positive coefficient.

[71] We should note that the sum of the three sectors adds up to 1, so we cannot have the three variables simultaneously in the regression due to multicolinarity. In this case we consider one sector as the base one (and omit it from the regression) and the coefficients of the others sectors are the differential impacts between each sector and the base sector.

Table 3.2 Dynamic model using one-step System GMM

Variables	1	2	3	4	5
L.ln(losses)	0.572***	0.513***	0.586***	0.579***	0.460***
	(6.930)	(5.121)	(6.310)	(7.081)	(4.072)
ln(GDP)	0.282**	0.308***	0.326***	0.274**	0.404**
	(2.524)	(3.009)	(3.397)	(2.563)	(2.312)
ln(Mobile)	-0.005	-0.025			
	(-0.124)	(-0.627)			
*ln(Mobile)*Change*		0.348**			
		(2.168)			
ln(Phone)			0.148	0.054	
			(0.701)	(0.347)	
*ln(Phone)*Change*			0.018	-0.102	
			(0.098)	(-0.600)	
ln(Fbis)					0.026
					(0.731)
*ln(Fbis)*Change*					0.066
					(1.014)
Empagric			0.016*	-0.021	0.019**
			(1.720)	(-1.473)	(2.368)
Empind	0.021*	0.016	0.026**		0.028**
	(1.727)	(1.410)	(2.344)		(2.523)
Empserv	-0.012**	-0.013**		-0.033***	
	(-2.159)	(-1.972)		(-3.029)	
Labp			-0.014*	0.004	-0.015*
			(-1.734)	(0.685)	(-1.729)
Labs	-0.004	-0.004	-0.014*		-0.013*
	(-0.756)	(-0.604)	(-1.753)		(-1.839)
Labt	0.016**	0.009		0.021**	
	(2.009)	(0.821)		(2.328)	
Unempyouth	0.013**	0.014**	0.012**	0.013**	0.010**
	(2.279)	(2.522)	(2.158)	(2.241)	(2.182)
ln(Patents)	-0.006	0.001	-0.022	-0.007	-0.001
	(-0.199)	(0.022)	(-0.535)	(-0.200)	(-0.049)
ln(Trademarks)	0.071	0.090**	0.048	0.069	0.054
	(1.481)	(2.042)	(0.718)	(1.195)	(0.797)
School	0.021	0.048	-0.153	-0.011	-0.034
	(0.220)	(0.464)	(-1.161)	(-0.119)	(-0.248)
TradFreed	0.009			0.009	0.001
	(1.410)			(1.222)	(0.070)
BusFreed		0.002	0.008		
		(0.643)	(1.587)		
Change	0.413***	-1.000*	0.351	0.749	0.359**
	(4.124)	(-1.657)	(0.497)	(1.161)	(2.349)
Constant	-7.755***	-8.072***	-6.466***	-5.597**	-8.861***
	(-2.993)	(-3.034)	(-2.695)	(-2.243)	(-2.880)
Observations	501	501	501	507	415
Countries	61	61	61	61	59
AR1	-4.596	-4.334	-4.489	-4.591	-3.587
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
AR2	-0.0340	0.417	-0.441	-0.339	0.300
p-value	[0.973]	[0.677]	[0.659]	[0.735]	[0.764]
Instruments	53	53	53	53	51
Sargan	80.39	78.18	78.64	73.51	79.39
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Hansen	42.47	37.52	40.84	37.26	42.20
p-value	[0.180]	[0.311]	[0.195]	[0.321]	[0.107]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument.

Columns 6 through 10 show the different variables in the Technological dimension. Patents and trademarks offer protection for those who innovate; this protection can be done by residents or by non-residents that will protect their product. In columns 9 and 10 *ln(Patents)* has a significant positive impact on the losses, as *ln(Trademarks)* is non-significant. When a disaggregated analysis is made on the origin of patents and trademarks applicants (columns 6 to 8) the trademarks continue to not have a significant impact in losses. In terms of the number of patents is the number of patents done by residents that have a significant impact on losses. A final variable that was found to have a strong effect in deterring software piracy losses was *R&D*, which has always a negative coefficient. This can indicates that investment is being implemented correctly, namely in writing software code that protects software from hackers.

The positive coefficient of patents and the negative coefficient of *R&D* at first may appear odd, but it can be explained as follows: a company makes a breakthrough after many years of research, what will allow increased productivity, efficiency and protection for different components of the company products. This can also be extended to other products from other companies. In order to protect this discovery, the company will file a patent of the discovery that will allow some level of protection from other companies and from potential pirates. The existence of the patent by itself it's not synonym of protection; national Intellectual Property offices must also be able to enforce and protect them. The positive coefficient can be explained by the existence of patents that are the result of research, but the lack of power exerted by national IP offices will not prevent piracy in spite of the existence of patents.

All regressions control for institutional dimensions. Tests were performed using variables that represent institutional factors, the reported ones provide the best estimates. Only Freedom from Corruption Index (*CorrFreed*) (column 8) presented significance. This index ranges from 0, high corruption, to 100, no corruption. Results show that low levels of corruption leads to less piracy losses. Goel and Nelson (2009) and Andrés and Goel (2011) also found that in more corrupt nations, software piracy was higher.

Table 3.3 Dynamic model using one-step System GMM (cont.)

Variables	6	7	8	9	10
L.ln(losses)	0.514***	0.610***	0.552***	0.544***	0.541***
	(5.457)	(6.410)	(5.570)	(5.028)	(4.909)
ln(GDP)	0.347***	0.294**	0.448***	0.387***	0.387***
	(3.033)	(2.143)	(2.706)	(2.843)	(2.788)
ln(Mobile)	-0.013	0.075	0.076	0.169**	0.148
	(-0.145)	(0.679)	(0.674)	(2.166)	(1.642)
*ln(Mobile)*Change*	0.267*	0.009	-0.025		0.097
	(1.802)	(0.054)	(-0.156)		(0.621)
ln(Fbis)	0.002	-0.016	-0.004	0.003	0.005
	(0.044)	(-0.617)	(-0.177)	(0.101)	(0.174)
Unemp	0.000	-0.019	-0.013		
	(0.011)	(-1.245)	(-0.854)		
Unempyouth				0.011	0.011
				(1.268)	(1.316)
School	0.079	-0.062	0.032	0.058	0.067
	(0.985)	(-0.614)	(0.334)	(0.553)	(0.636)
R&D	-0.307***	-0.134*	-0.021	-0.260**	-0.265**
	(-3.188)	(-1.901)	(-0.290)	(-2.396)	(-2.500)
ln(Patres)	0.131**				
	(2.571)				
ln(Patnon)	0.017				
	(0.491)				
ln(Tradres)		0.123	-0.052		
		(1.505)	(-0.433)		
ln(Tradnon)		-0.082	0.006		
		(-1.429)	(0.098)		
ln(Patents)				0.056**	0.058**
				(2.009)	(2.163)
ln(Trademarks)				-0.036	-0.037
				(-0.665)	(-0.668)
CorrFreed			-0.008**		
			(-2.000)		
TradFreed	-0.004			0.001	-0.001
	(-0.586)			(0.127)	(-0.141)
Change	-0.664	0.311	0.459	0.345***	-0.062
	(-1.134)	(0.498)	(0.719)	(2.855)	(-0.099)
Constant	-8.148***	-5.597**	-9.336***	-9.481***	-9.339***
	(-3.327)	(-2.561)	(-3.267)	(-3.377)	(-3.313)
Observations	478	473	472	411	411
Countries	75	75	75	66	66
AR1	-3.035	-3.277	-3.345	-3.606	-3.583
p-value	[0.002]	[0.001]	[0.001]	[0.000]	[0.000]
AR2	0.499	0.195	0.309	-0.200	-0.142
p-value	[0.618]	[0.846]	[0.757]	[0.842]	[0.887]
Instruments	51	51	51	51	51
Sargan	62.12	70.54	67.59	58.87	58.80
p-value	[0.002]	[0.000]	[0.001]	[0.007]	[0.005]
Hansen	35.78	44.43	42.84	33.86	33.36
p-value	[0.385]	[0.132]	[0.142]	[0.523]	[0.499]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument.

Regarding education we included financial and non-financial measures. The first perspective was never considered in previous studies and, in the second case, variables used on previous research were literacy rate and the average years of schooling of people age 25 and over (Barro & Lee, 2013). Both of these variables have the problem of data availability. To overcome this problem we will introduce a proxy variable that indicates the years of schooling of both primary and secondary education offered by the educational system of a country. This variable is not perfect as it omits the education attained, but it offers us a benchmark. Additional to this, we will introduce a variable that indicates spending on education. Columns 11 through 15 show the results.

Columns 11 through 13 present the years of schooling. As in the labor force dimension, we include the education of the labor force; results are robust. An increase of years of primary and secondary education appears to have a negative impact on piracy losses, but only in the first case this variable is significant across all regressions with a coefficient of around -0.250.

The financial aspects of education are presented in columns 14 and 15. Public spending on education can go both to public or private institutions and depending on the different levels of education different resources are allocated. Public expenditure on education has a positive effect and is significant at 1% (column 15). This public spending can also go directly to students through direct help in the form of scholarships. There are many ways a student can use this help. Some examples are: acquisition of computer, software, access to the Internet, etc. This will increase the availability to digital content such as music, software and movies. We were expecting a negative impact; nevertheless this may indicate that more access to digital content can also increase the availability of illegal software. Only with increase awareness this problem can be mitigated.

Several alternative hypotheses were considered with different variables within the dimension that reflect the access to information. The access to Internet – *ln(Net)* – has a negative and significant effect on losses (columns 14 and 15), while the access to a broadband connection has no impact on losses (columns 5 through 10). This is clearly unexpected, but seems that access to Internet reduces the losses because of increased awareness of the problem by the consumers, because countries with a higher share of people connected to the Internet are able to track those who use illicit software, or simply because you can download and buy the software directly from the original company and not from local intermediaries - many of them may be selling pirated software. These results are in accordance with the findings of Boyce (2011).

To assess the validity of our findings we also performed regressions in which the dependent variable was a fraction of GDP, *ln(Losses/GDP)* (see Annex III). In these regressions only the dimension related to the labor force was statistically significant being robust across all regressions. In the technological dimension, patents applicants from residents maintained significance. Variable that represents access to information, namely Internet users, and mobile subscriptions, maintained statistical significance.

Table 3.4 Dynamic model using one-step System GMM (cont.)

Variables	11	12	13	14	15
L.ln(losses)	0.555***	0.551***	0.541***	0.577***	0.617***
	(6.908)	(7.951)	(7.338)	(6.213)	(6.180)
ln(GDP)	0.450***	0.360***	0.382***	0.387***	0.297***
	(5.051)	(4.260)	(4.743)	(3.816)	(2.914)
ln(Mobile)	-0.019	-0.022	-0.012		0.029
	(-0.548)	(-0.689)	(-0.349)		(0.427)
*ln(Mobile)*Change*					0.356***
					(2.690)
ln(Net)				-0.100*	-0.158*
				(-1.886)	(-1.806)
R&D				-0.143*	-0.181**
				(-1.785)	(-2.123)
Yschoolpri	-0.242*	-0.236***	-0.259***		
	(-1.830)	(-3.343)	(-3.522)		
Yschoolsec	-0.037	-0.112	-0.026		
	(-0.272)	(-1.267)	(-0.245)		
Pubexp				0.150**	0.180***
				(2.382)	(2.771)
Labp	-0.016**	0.002			
	(-2.473)	(0.438)			
Labs	-0.021***		-0.010*		
	(-2.576)		(-1.847)		
Labt		0.011*	0.014***		
		(1.890)	(2.580)		
Unemp	0.001	-0.010	-0.005	-0.010	0.003
	(0.054)	(-1.014)	(-0.484)	(-0.682)	(0.153)
ln(Legal)	-0.035*	-0.005	-0.010	0.010	0.042
	(-1.788)	(-0.207)	(-0.363)	(0.543)	(1.657)
CorrFreed	-0.002			-0.004	
	(-0.655)			(-0.922)	
TradFreed		0.001	0.002		
		(0.190)	(0.381)		
FinFreed					-0.002
					(-0.468)
Change	0.379***	0.426***	0.411***	0.478***	-1.008*
	(4.357)	(5.414)	(4.636)	(4.650)	(-1.917)
Constant	-6.049***	-5.552***	-6.225***	-8.355***	-6.948***
	(-2.988)	(-3.414)	(-3.764)	(-3.992)	(-3.381)
Observations	515	521	515	441	441
Countries	64	64	64	66	66
AR1	-4.290	-4.281	-4.145	-3.740	-3.824
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
AR2	-0.387	-0.469	-0.275	-0.552	0.126
p-value	[0.699]	[0.639]	[0.783]	[0.581]	[0.900]
Instruments	55	55	55	47	47
Sargan	73.64	93.63	80.82	73.21	51.85
p-value	[0.001]	[0.000]	[0.000]	[0.000]	[0.011]
Hansen	41.64	46.05	44.08	43.78	35.21
p-value	[0.357]	[0.203]	[0.265]	[0.099]	[0.276]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument.

3.5 Conclusion

This chapter examined the impact of several dimensions that might explain the phenomenon of software piracy losses. Due to the nature of our dataset and the availability of information we opted to use a dynamic panel data analysis that could track the growth of piracy losses over time. We found that several dimensions could explain this growth; Labor Force, Technological, Educational, Access to Information and Institutional.

The labor force was one of the dimensions considered. Higher levels of education resulted in more losses, but a higher share of employment in the service sector has a negative impact on losses. This is a result of more access to information by employees with higher education and the capability to track illicit content through internal audits in the service sector.

In the technological dimensions, patents and trademarks were analyzed as one of the explanations of software piracy. Patents were significant and positive; they grant a protection for those who innovate but other factors must be considered (that could explain the positive sign) such as the effectiveness of this protection and the punishment for those who infringe the law. Our findings suggest that more protection in the form of trademarks or patents can in some cases reduce losses. Another variable introduced was *R&D*, which was found to have a negative effect on software piracy losses.

The results from the education dimensions show that more years of schooling have a deterrent effect on piracy. When our analysis turns to financial aspects of education, more spending means more piracy losses.

More Access to information has mixed results on piracy losses. This can be explained by the nature of the different devices used to access digital content, for example through the Internet.

The correct functioning of institutions can reduce piracy. Our results show that less corruption is associated with lower piracy losses.

BSA provide some blueprints in order to reduce piracy, namely to “modernize IP Laws to account for new innovations”, these innovations that are patented both at home and abroad, have different results. Better attention should be given on the origin of patents and trademarks, providing better protection. In 2012, the ninth edition of the BSA (2012) global piracy study presented some “blueprints” to reduce, or at least mitigate piracy. One of these solutions is the increase of public education and awareness. Results show that more education reduces piracy although special attention must be made on educational expenditure. Better attention must be done on the different sectors of activity that are the building blocks of the economy of a country.

Although this chapter had provided new insights on the major macroeconomic determinants of losses caused by piracy, lack of data on some dimensions reduced the number of observations and weakened the possible conclusions. Further analysis using panel data and introducing large time span should be followed. Using small group of countries such as the European Union, or an in deep analysis of the various dimensions, could provide valuable tools for policymakers as changes in education can only be viewed in the long-run. Further research introducing additional variables such as taxation must be followed.

Annex II Methodology used by the BSA

To determine the software piracy rates and losses the *Business Software Alliance* has at his disposal huge amounts of information, being able to conduct extensive surveys in the population. In the estimates of 2010, presented in the eighth annual BSA study, the BSA relied on Ipsos Public Affairs that conducted more than 15000 surveys on business and consumer PC users. A brief description of the methodology is presented in the report and reproduced here.

The methodology was the following to obtain piracy rates:

$$Piracy\ rate = \frac{unlicensed\ software\ units}{total\ software\ units\ installed} \tag{II.3.1}$$

To obtain the total software units installed it was used the following:

$$Total\ Software\ Units\ Installed = \#PCs\ Getting\ Software \times Software\ Units\ perPC \tag{II.3.2}$$

The legitimate software units and the unlicensed software units are given by the following expressions:

$$Legitimate\ Software\ Units = \frac{Software\ Market\ Values}{Average\ Software\ Unit\ Price} \tag{II.3.3}$$

$$Unlicensed\ Software\ Units = Total\ Software\ units\ Installed - Legitimate\ Software\ Units \tag{II.3.4}$$

Finally the commercial value of unlicensed software is given by:

$$Commercial\ Value = \#Unlicend\ Software\ Units\ \times Average\ Software\ Unit\ Price \tag{II.3.5}$$

Business Software Alliance uses confidential information to achieve these results; it does provide us, in their annually reports, the basic methodology, omitting many variables that are used.

Annex III Additional regressions

Table 3.5 Two-step System GMM

Variables	16	17	18	19	20
L.ln(losses)	0.598***	0.475***	0.538***	0.583***	0.442***
	(7.044)	(3.965)	(4.599)	(6.395)	(2.972)
ln(GDP)	0.294**	0.333***	0.386***	0.301**	0.412**
	(2.417)	(3.323)	(2.814)	(2.362)	(2.221)
ln(Mobile)	-0.008	-0.047			
	(-0.223)	(-1.345)			
*ln(Mobile)*Change*		0.410**			
		(2.095)			
ln(Phone)			0.017	-0.104	
			(0.080)	(-0.795)	
*ln(Phone)*Change*			-0.080	-0.094	
			(-0.340)	(-0.579)	
ln(Fbis)					0.040
					(0.833)
*ln(Fbis)*Change*					0.091
					(1.277)
Empagric			0.009	-0.030*	0.020*
			(0.825)	(-1.652)	(1.651)
Empind	0.022	0.012	0.021		0.019
	(1.583)	(0.930)	(1.196)		(1.420)
Empserv	-0.015*	-0.012		-0.040***	
	(-1.806)	(-1.552)		(-2.815)	
Labp			-0.010	0.005	-0.006
			(-0.939)	(0.654)	(-0.565)
Labs	-0.004	-0.003	-0.012		-0.007
	(-0.608)	(-0.487)	(-1.244)		(-0.885)
Labt	0.021*	0.007		0.024***	
	(1.852)	(0.498)		(2.921)	
Unempyouth	0.013***	0.013***	0.009	0.012**	0.008*
	(2.634)	(3.164)	(1.630)	(2.460)	(1.806)
ln(Patents)	-0.012	-0.005	-0.009	-0.003	-0.001
	(-0.305)	(-0.150)	(-0.212)	(-0.079)	(-0.026)
ln(Trademarks)	0.071	0.115**	0.018	0.060	0.050
	(1.284)	(2.257)	(0.250)	(0.875)	(0.681)
School	0.052	0.093	-0.189	0.048	-0.107
	(0.389)	(1.111)	(-0.986)	(0.386)	(-0.741)
TradFreed	0.007			0.007	-0.003
	(0.921)			(1.006)	(-0.242)
BusFreed		0.000	0.005		
		(0.088)	(0.827)		
Change	0.370***	-1.209*	0.732	0.676	0.322*
	(3.091)	(-1.709)	(0.852)	(1.120)	(1.896)
Constant	-8.225***	-9.212***	-6.338*	-5.908**	-8.046***
	(-2.864)	(-4.066)	(-1.934)	(-2.338)	(-2.803)
Observations	501	501	501	507	415
Countries	61	61	61	61	59
AR1	-3.464	-3.115	-3.391	-3.325	-2.389
p-value	[0.001]	[0.002]	[0.001]	[0.001]	[0.017]
AR2	-0.0700	0.472	-0.717	-0.468	0.0549
p-value	[0.944]	[0.637]	[0.474]	[0.640]	[0.956]
Instruments	53	53	53	53	51
Sargan	80.39	78.18	78.64	73.51	79.39
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Hansen	42.47	37.52	40.84	37.26	42.20
p-value	[0.180]	[0.311]	[0.195]	[0.321]	[0.107]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument

Table 3.6 Two-step System GMM (cont.)

Variables	21	22	23	24	25
L.ln(losses)	0.502***	0.603***	0.575***	0.564***	0.560***
	(4.620)	(5.889)	(5.418)	(4.021)	(4.117)
ln(GDP)	0.365**	0.273*	0.396**	0.385**	0.395**
	(2.527)	(1.761)	(2.529)	(2.045)	(2.197)
ln(Mobile)	-0.042	0.047	0.102	0.082	0.043
	(-0.441)	(0.345)	(0.825)	(0.802)	(0.403)
*ln(Mobile)*Change*	0.277*	0.032	-0.022		0.098
	(1.899)	(0.170)	(-0.153)		(0.570)
ln(Fbis)	0.008	-0.027	-0.007	0.008	0.012
	(0.181)	(-0.798)	(-0.187)	(0.185)	(0.284)
Unemp	-0.003	-0.020	-0.004		
	(-0.121)	(-1.162)	(-0.203)		
Unempyouth				0.012	0.012
				(0.968)	(0.934)
School	0.146	-0.049	0.053	0.113	0.120
	(1.475)	(-0.415)	(0.433)	(0.540)	(0.566)
R&D	-0.353**	-0.091	0.050	-0.320*	-0.328*
	(-2.561)	(-0.881)	(0.406)	(-1.893)	(-1.920)
ln(Patres)	0.148***				
	(2.741)				
ln(Patnon)	0.011				
	(0.273)				
ln(Tradres)		0.150	-0.045		
		(1.346)	(-0.345)		
ln(Tradnon)		-0.108	0.035		
		(-1.558)	(0.465)		
ln(Patents)				0.057*	0.060*
				(1.830)	(1.808)
ln(Trademarks)				-0.032	-0.035
				(-0.417)	(-0.464)
CorrFreed			-0.009*		
			(-1.667)		
TradFreed	-0.006			0.004	0.001
	(-0.648)			(0.360)	(0.116)
Change	-0.680	0.251	0.446	0.359**	-0.046
	(-1.087)	(0.344)	(0.827)	(2.480)	(-0.064)
Constant	-9.117***	-5.173*	-8.861***	-10.085***	-10.052***
	(-2.611)	(-1.764)	(-2.636)	(-3.525)	(-3.739)
Observations	478	473	472	411	411
Countries	75	75	75	66	66
AR1	-2.790	-2.704	-2.900	-2.385	-2.375
p-value	[0.005]	[0.007]	[0.004]	[0.017]	[0.018]
AR2	0.378	0.0593	0.212	-0.153	-0.0864
p-value	[0.705]	[0.953]	[0.832]	[0.878]	[0.931]
Instruments	51	51	51	51	51
Sargan	62.12	70.54	67.59	58.87	58.80
p-value	[0.002]	[0.000]	[0.001]	[0.007]	[0.005]
Hansen	35.78	44.43	42.84	33.86	33.36
p-value	[0.385]	[0.132]	[0.142]	[0.523]	[0.499]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument.

Table 3.7 Two-step System GMM (cont.)

Variables	26	27	28	29	30
L.ln(losses)	0.565***	0.578***	0.575***	0.580***	0.535***
	(5.289)	(5.904)	(5.429)	(4.903)	(3.997)
ln(GDP)	0.422***	0.291***	0.339***	0.384**	0.350**
	(3.410)	(2.904)	(2.825)	(2.537)	(2.275)
ln(Mobile)	-0.001	-0.022	-0.007		-0.040
	(-0.026)	(-0.589)	(-0.159)		(-0.574)
*ln(Mobile)*Change*					0.415**
					(2.515)
ln(Net)				-0.088	-0.064
				(-1.656)	(-0.728)
R&D				-0.175*	-0.226**
				(-1.842)	(-2.466)
Yschoolpri	-0.305**	-0.239***	-0.245***		
	(-2.004)	(-2.773)	(-3.273)		
Yschoolsec	-0.040	-0.090	0.013		
	(-0.254)	(-0.754)	(0.089)		
Pubexp				0.144*	0.198**
				(1.799)	(2.520)
Labp	-0.015**	0.004			
	(-2.417)	(0.520)			
Labs	-0.024***		-0.012		
	(-2.687)		(-1.628)		
Labt		0.012	0.013**		
		(1.254)	(2.036)		
Unemp	0.001	-0.010	-0.004	-0.013	0.007
	(0.072)	(-0.864)	(-0.374)	(-0.739)	(0.383)
ln(Legal)	-0.025	0.019	-0.002	0.006	0.051
	(-1.108)	(0.544)	(-0.034)	(0.267)	(1.390)
CorrFreed	-0.000			-0.002	
	(-0.103)			(-0.405)	
TradFreed		0.005	0.003		
		(0.645)	(0.319)		
FinFreed					-0.004
					(-0.486)
Change	0.377***	0.429***	0.395***	0.450***	-1.225*
	(3.713)	(4.524)	(3.386)	(4.562)	(-1.833)
Constant	-5.255**	-4.801**	-5.646**	-8.248***	-8.122***
	(-2.155)	(-2.588)	(-2.457)	(-2.745)	(-2.759)
Observations	515	521	515	441	441
Countries	64	64	64	66	66
AR1	-3.510	-3.497	-3.388	-2.891	-2.374
p-value	[0.000]	[0.000]	[0.001]	[0.004]	[0.018]
AR2	-0.370	-0.273	-0.189	-0.749	-0.418
p-value	[0.712]	[0.785]	[0.850]	[0.454]	[0.676]
Instruments	55	55	55	47	47
Sargan	73.64	93.63	80.82	73.21	51.85
p-value	[0.001]	[0.000]	[0.000]	[0.000]	[0.011]
Hansen	41.64	46.05	44.08	43.78	35.21
p-value	[0.357]	[0.203]	[0.265]	[0.099]	[0.276]

Notes: Dependent variable is *ln(losses)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(losses)* and *L.ln(GDP)* were considered as two endogenous instruments. Only one lag was used as instrument.

Table 3.8 One-Step System GMM for Losses per GDP

Variables	31	32	33	34	35
L.ln(Losses/GDP)	0.657***	0.627***	0.605***	0.670***	0.594***
	(5.925)	(5.571)	(6.148)	(7.723)	(3.753)
ln(Mobile)	-0.013	-0.027			
	(-0.306)	(-0.635)			
*ln(Mobile)*Change*		0.167			
		(1.378)			
ln(Phone)			-0.131	-0.174	
			(-0.308)	(-0.507)	
*ln(Phone)*Change*			0.070	0.040	
			(0.300)	(0.179)	
ln(Fbis)					-0.010
					(-0.203)
*ln(Fbis)*Change*					0.018
					(0.278)
Empagric			0.013	-0.003	0.012
			(0.932)	(-0.140)	(0.984)
Empind	-0.005	-0.013	0.021		0.026
	(-0.233)	(-0.531)	(1.161)		(1.361)
Empserv	-0.014**	-0.017**		-0.013	
	(-2.236)	(-2.436)		(-0.813)	
Labp			-0.011	0.006	-0.019**
			(-1.065)	(0.879)	(-2.304)
Labs	-0.006	-0.004	-0.016*		-0.023***
	(-1.021)	(-0.552)	(-1.760)		(-2.686)
Labt	0.010	0.008		0.020**	
	(1.213)	(0.902)		(2.169)	
Unempyouth	0.027***	0.026***	0.028***	0.023***	0.027***
	(2.883)	(2.680)	(3.619)	(3.003)	(3.409)
School	-0.075	-0.111	-0.057	0.071	0.218
	(-0.370)	(-0.527)	(-0.267)	(0.413)	(0.949)
ln(Patents)	0.033	0.027	0.047	0.018	0.014
	(0.909)	(0.707)	(0.880)	(0.367)	(0.337)
ln(Trademarks)	-0.044	-0.025	-0.061	-0.026	-0.016
	(-0.832)	(-0.502)	(-0.760)	(-0.310)	(-0.181)
TradFreed	0.001			-0.003	0.010
	(0.220)			(-0.451)	(0.957)
BusFreed		0.003	0.011*		
		(0.439)	(1.793)		
Change	0.305***	-0.406	0.060	0.082	0.282
	(2.887)	(-0.808)	(0.068)	(0.100)	(1.461)
Constant	-0.935	-0.704	-2.506	-2.593	-6.274
	(-0.326)	(-0.238)	(-1.043)	(-0.971)	(-1.638)
Observations	501	501	501	507	415
Countries	61	61	61	61	59
AR1	-4.032	-4.118	-4.079	-3.975	-3.205
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
AR2	-0.479	-0.246	-0.570	-0.484	0.520
p-value	[0.632]	[0.806]	[0.569]	[0.628]	[0.603]
Instruments	51	51	51	51	50
Sargan	75.79	74.86	63.56	73.20	61.96
p-value	[0.000]	[0.000]	[0.001]	[0.000]	[0.001]
Hansen	35.39	35.21	35.49	36.49	35.64
p-value	[0.402]	[0.364]	[0.352]	[0.310]	[0.301]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. Lags 1 through 3 were used (columns 31 to 34).

Table 3.9 One-Step System GMM for Losses per GDP (cont.)

Variables	36	37	38	39	40
L.ln(Losses/GDP)	0.649***	0.687***	0.616***	0.611***	0.611***
	(7.595)	(9.005)	(9.024)	(5.304)	(5.237)
ln(Mobile)	0.045	0.114	0.097	0.291*	0.278
	(0.500)	(0.944)	(0.634)	(1.690)	(1.530)
*ln(Mobile)*Change*	0.128	0.049	0.067		0.033
	(0.893)	(0.401)	(0.536)		(0.176)
ln(Fbis)	-0.023	-0.046**	-0.037	-0.036	-0.035
	(-0.682)	(-2.054)	(-1.450)	(-0.846)	(-0.830)
Unemp	0.009	-0.002	0.008		
	(0.501)	(-0.121)	(0.328)		
Unempyouth				0.016*	0.016*
				(1.901)	(1.936)
School	-0.011	-0.074	-0.026	0.013	0.008
	(-0.127)	(-0.938)	(-0.288)	(0.096)	(0.056)
R&D	-0.163**	-0.053	0.059	-0.181*	-0.186
	(-2.568)	(-0.798)	(0.562)	(-1.714)	(-1.641)
ln(Patres)	0.053				
	(1.613)				
ln(Patnon)	-0.004				
	(-0.201)				
ln(Tradres)		0.057	-0.019		
		(1.333)	(-0.252)		
ln(Tradnon)		-0.040	0.007		
		(-0.817)	(0.107)		
ln(Patents)				0.047	0.049
				(1.623)	(1.510)
ln(Trademarks)				-0.048	-0.049
				(-1.049)	(-1.038)
TradFreed	-0.003			0.001	0.001
	(-0.344)			(0.126)	(0.093)
CorrFreed			-0.005		
			(-1.389)		
Change	-0.253	0.060	0.036	0.239*	0.101
	(-0.421)	(0.122)	(0.069)	(1.717)	(0.133)
Constant	-2.818**	-2.134*	-2.801*	-4.282**	-4.162*
	(-2.256)	(-1.785)	(-1.921)	(-2.061)	(-1.900)
Observations	478	473	472	411	411
Countries	75	75	75	66	66
AR1	-3.929	-4.168	-3.959	-3.179	-3.128
p-value	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
AR2	0.499	0.259	0.329	-0.0575	-0.0327
p-value	[0.617]	[0.796]	[0.742]	[0.954]	[0.974]
Instruments	50	61	61	50	50
Sargan	75.71	91.85	88.29	57.51	57.90
p-value	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
Hansen	46.08	54.98	50.35	38.83	38.20
p-value	[0.081]	[0.171]	[0.270]	[0.301]	[0.284]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. Lags 1 through 3 were used (column 36, 39 and 40) and lags 1 through 4 were used in column 37 and 38.

Table 3.10 One-Step System GMM for Losses per GDP (cont.)

Variables	41	42	43	44	45
L.ln(Losses/GDP)	0.540***	0.595***	0.530***	0.656***	0.686***
	(4.456)	(5.514)	(4.427)	(6.100)	(6.139)
ln(Mobile)	-0.006	-0.035	-0.018		0.019
	(-0.150)	(-1.209)	(-0.501)		(0.170)
*ln(Mobile)*Change*					0.283**
					(2.364)
ln(Net)				-0.114**	-0.154
				(-2.428)	(-1.375)
R&D				-0.019	-0.097
				(-0.267)	(-1.289)
Yschoolpri	-0.244	-0.045	-0.196		
	(-1.104)	(-0.312)	(-1.069)		
Yschoolsec	0.029	0.104	0.074		
	(0.168)	(0.794)	(0.447)		
Pubexp				0.167	0.177
				(1.640)	(1.478)
Labp	-0.013	0.004			
	(-1.420)	(0.786)			
Labs	-0.023**		-0.011**		
	(-2.301)		(-1.963)		
Labt		0.016**	0.013*		
		(2.272)	(1.716)		
Unemp	0.029**	0.017	0.025*	0.013	0.021
	(2.010)	(1.539)	(1.881)	(0.885)	(1.212)
ln(Legal)	0.003	-0.004	0.002	0.022	0.030
	(0.137)	(-0.211)	(0.088)	(1.155)	(1.498)
CorrFreed	0.002			-0.002	
	(0.268)			(-0.655)	
TradFreed		-0.004	-0.000		
		(-0.894)	(-0.039)		
FinFreed					-0.003
					(-0.531)
Change	0.377***	0.334***	0.380***	0.378***	-0.824*
	(3.354)	(3.452)	(3.464)	(3.258)	(-1.682)
Constant	-1.451	-3.740**	-3.073*	-3.528***	-3.344***
	(-0.874)	(-2.474)	(-1.789)	(-3.575)	(-3.553)
Observations	515	521	515	441	441
Countries	64	64	64	66	66
AR1	-4.479	-4.682	-4.276	-4.216	-3.814
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
AR2	-0.459	-0.360	-0.325	-1.040	-0.575
p-value	[0.646]	[0.719]	[0.746]	[0.298]	[0.565]
Instruments	53	53	53	57	46
Sargan	79.42	93.71	84.29	63.31	46.60
p-value	[0.000]	[0.000]	[0.000]	0.0297	0.0357
Hansen	47.10	44.32	43.84	53.65	40.73
p-value	[0.148]	[0.222]	[0.238]	[0.151]	[0.113]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. Lags 1 through 3 were used (columns 41, 42, 43 and 45) and lags 1 through 4 (column 44).

Table 3.11 Two-Step System GMM for Losses per GDP

Variables	46	47	48	49	50
L.ln(Losses/GDP)	0.649***	0.660***	0.640***	0.679***	0.632***
	(6.044)	(6.334)	(6.812)	(6.613)	(4.543)
ln(Mobile)	-0.007	-0.018			
	(-0.204)	(-0.430)			
*ln(Mobile)*Change*		0.162			
		(1.421)			
ln(Phone)			-0.196	-0.193	
			(-0.406)	(-0.452)	
*ln(Phone)*Change*			0.069	-0.046	
			(0.280)	(-0.196)	
ln(Fbis)					0.002
					(0.026)
*ln(Fbis)*Change*					-0.025
					(-0.517)
Empagric			0.011	-0.000	0.011
			(0.842)	(-0.018)	(1.083)
Empind	-0.014**	-0.018**		-0.008	
	(-2.209)	(-2.170)		(-0.445)	
Empserv	-0.011	-0.016	0.015		0.010
	(-0.481)	(-0.744)	(0.631)		(0.419)
Labp			-0.012	0.005	-0.020***
			(-1.222)	(0.875)	(-2.824)
Labs	-0.006	-0.006	-0.018**		-0.020**
	(-1.122)	(-0.810)	(-2.215)		(-2.309)
Labt	0.010	0.009		0.015	
	(1.000)	(1.151)		(1.355)	
Unempyouth	0.024**	0.023***	0.025***	0.020***	0.023**
	(2.479)	(2.737)	(2.778)	(2.718)	(2.662)
School	-0.127	-0.159	-0.017	0.032	0.117
	(-0.622)	(-1.241)	(-0.072)	(0.202)	(0.547)
ln(Patents)	0.033	0.035	0.048	0.028	0.021
	(0.699)	(0.634)	(0.753)	(0.619)	(0.681)
ln(Trademarks)	-0.039	-0.041	-0.052	-0.035	-0.016
	(-0.716)	(-0.688)	(-0.714)	(-0.465)	(-0.186)
BusFreed		0.001	0.008		
		(0.142)	(1.025)		
TradFreed	0.003			0.001	0.012
	(0.453)			(0.082)	(0.830)
Change	0.278***	-0.417	0.011	0.363	0.321
	(3.008)	(-0.887)	(0.012)	(0.419)	(1.567)
Constant	-0.335	0.652	-2.093	-2.336	-4.506
	(-0.109)	(0.252)	(-0.741)	(-0.733)	(-1.172)
Observations	501	501	501	507	415
Countries	61	61	61	61	59
AR1	-3.509	-3.696	-3.543	-3.348	-2.680
p-value	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
AR2	-0.630	-0.335	-0.615	-0.719	0.162
p-value	[0.529]	[0.738]	[0.539]	[0.472]	[0.871]
Instruments	51	51	51	51	50
Sargan	75.79	74.86	63.56	73.20	61.96
p-value	[0.000]	[0.000]	[0.001]	[0.000]	[0.001]
Hansen	35.39	35.21	35.49	36.49	35.64
p-value	[0.402]	[0.364]	[0.352]	[0.310]	[0.301]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. . Lags 1 through 3 were used (columns 46 to 50).

Table 3.12 Two-Step System GMM for Losses per GDP (cont.)

Variables	51	52	53	54	55
L.ln(Losses/GDP)	0.644***	0.680***	0.571***	0.614***	0.612***
	(6.213)	(7.534)	(5.959)	(4.504)	(4.489)
ln(Mobile)	0.028	0.155	0.180	0.224	0.202
	(0.213)	(1.329)	(1.078)	(1.005)	(0.968)
*ln(Mobile)*Change*	0.094	0.016	0.069		0.061
	(0.534)	(0.109)	(0.602)		(0.334)
ln(Fbis)	-0.025	-0.052*	-0.057*	-0.025	-0.020
	(-0.617)	(-1.757)	(-1.843)	(-0.535)	(-0.409)
Unemp	0.004	0.001	0.017		
	(0.160)	(0.051)	(0.892)		
Unempyouth				0.016	0.016
				(1.521)	(1.548)
School	0.005	-0.066	-0.033	-0.047	-0.061
	(0.052)	(-0.799)	(-0.322)	(-0.266)	(-0.350)
R&D	-0.152*	-0.034	0.067	-0.208	-0.221
	(-1.853)	(-0.393)	(0.476)	(-1.627)	(-1.539)
ln(Patres)	0.052				
	(1.569)				
ln(Patnon)	0.001				
	(0.062)				
ln(Tradres)		0.054	0.009		
		(0.972)	(0.116)		
ln(Tradnon)		-0.038	0.005		
		(-0.589)	(0.057)		
ln(Patents)				0.047	0.049
				(1.588)	(1.613)
ln(Trademarks)				-0.047	-0.051
				(-1.137)	(-1.215)
TradFreed	-0.000			0.002	0.001
	(-0.005)			(0.193)	(0.079)
CorrFreed			-0.005		
			(-1.048)		
Change	-0.125	0.200	0.083	0.218	-0.042
	(-0.180)	(0.332)	(0.181)	(1.588)	(-0.054)
Constant	-3.141**	-2.487	-3.740**	-3.286	-2.911
	(-1.986)	(-1.597)	(-2.076)	(-1.406)	(-1.284)
Observations	478	473	472	411	411
Countries	75	75	75	66	66
AR1	-3.193	-3.516	-3.279	-2.495	-2.465
p-value	[0.001]	[0.000]	[0.001]	[0.013]	[0.014]
AR2	0.344	0.314	0.480	-0.219	-0.224
p-value	[0.731]	[0.753]	[0.631]	[0.827]	[0.823]
Instruments	50	61	61	50	50
Sargan	75.71	91.85	88.29	57.51	57.90
p-value	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
Hansen	46.08	54.98	50.35	38.83	38.20
p-value	[0.081]	[0.171]	[0.270]	[0.301]	[0.284]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. Lags 1 through 3 were used (column 51, 54 and 55) and lags 1 through 4 were used in column 52 and 53.

Table 3.13 Two-Step System GMM for Losses per GDP (Cont.)

Variables	56	57	58	59	60
L.ln(Losses/GDP)	0.593***	0.609***	0.538***	0.644***	0.694***
	(4.012)	(4.887)	(4.375)	(4.835)	(5.021)
ln(Mobile)	-0.006	-0.031	-0.024		0.036
	(-0.156)	(-0.833)	(-0.536)		(0.209)
*ln(Mobile)*Change*					0.339*
					(1.726)
ln(Net)				-0.098**	-0.192
				(-2.328)	(-1.218)
R&D				-0.011	-0.125
				(-0.103)	(-1.204)
Yschoolpri	-0.176	-0.001	-0.129		
	(-0.754)	(-0.009)	(-0.686)		
Yschoolsec	0.072	0.153	0.151		
	(0.364)	(0.915)	(0.710)		
Pubexp				0.139	0.174
				(1.618)	(1.227)
Labp	-0.013	0.003			
	(-1.356)	(0.505)			
Labs	-0.023**		-0.011		
	(-2.111)		(-1.589)		
Labt		0.015	0.013		
		(1.518)	(1.228)		
Unemp	0.030**	0.020*	0.025**	0.015	0.031
	(2.233)	(1.666)	(2.035)	(0.885)	(1.409)
ln(Legal)	0.013	0.012	0.025	0.012	0.030
	(0.455)	(0.473)	(0.745)	(0.533)	(0.923)
CorrFreed	0.002			-0.003	
	(0.375)			(-0.739)	
TradFreed		-0.002	0.004		
		(-0.222)	(0.373)		
FinFreed					-0.003
					(-0.433)
Change	0.354***	0.310***	0.364***	0.364***	-1.028
	(2.650)	(3.027)	(3.053)	(3.016)	(-1.280)
Constant	-1.904	-4.642*	-4.550*	-3.301***	-3.286***
	(-1.000)	(-1.930)	(-1.713)	(-3.380)	(-3.585)
Observations	515	521	515	441	441
Countries	64	64	64	66	66
AR1	-3.261	-3.282	-3.229	-3.166	-2.736
p-value	[0.001]	[0.001]	[0.001]	[0.002]	[0.006]
AR2	-0.313	-0.338	-0.305	-1.058	-0.694
p-value	[0.755]	[0.735]	[0.760]	[0.290]	[0.488]
Instruments	53	53	53	57	46
Sargan	79.42	93.71	84.29	63.31	46.60
p-value	[0.000]	[0.000]	[0.000]	[0.030]	[0.036]
Hansen	47.10	44.32	43.84	53.65	40.73
p-value	[0.148]	[0.222]	[0.238]	[0.151]	[0.113]

Notes: Dependent variable is *ln(losses/GDP)*. Robust t-statistics in parentheses; *, ** and *** represent statistical significance at 10%, 5% and 1% respectively. *L.ln(Losses/GDP)* was considered as an endogenous instruments. Lags 1 through 3 were used (columns 56, 57, 58 and 60) and lags 1 through 4 (column 59).

Annex IV List of countries in the sample

Table 3.14 List of countries in the sample

Western Europe	Eastern Europe	America	Middle East and Africa	Asia Pacific
Austria	Albania	Argentina	Algeria	Australia
Belgium	Armenia	Bolivia	Egypt	China
Denmark	Azerbaijan	Brazil	Israel	Hong Kong
Finland	Bosnia and Herzegovina	Canada	Jordan	India
France	Bulgaria	Chile	South Africa	Indonesia
Germany	Croatia	Colombia	Morocco	Japan
Greece	Czech Republic	Costa Rica	Tunisia	New Zealand
Iceland	Estonia	Ecuador	Turkey	The Philippines
Ireland	Hungary	Guatemala	Mauritius	Saudi Arabia
Italy	Romania	Panama		Vietnam
Norway	Russia	Paraguay		South Korea
The Netherlands	Latvia	Peru		Pakistan
Poland	Lithuania	United States		Singapore
Portugal	Slovakia	Nicaragua		Sri Lanka
Cyprus	Slovenia	Uruguay		Thailand
Malta	Ukraine	Mexico		Malaysia
Luxembourg	Kazakhstan			
Spain	Serbia			
United Kingdom	Moldova			
Sweden				
Switzerland				

Chapter 4 Effects of taxation on software piracy across the European Union

*A first version of this chapter was presented at the 16th annual Infer Conference, Pescara, May 28-31, 2014.

4.1 Introduction

European Union is characterized by a high level of personal taxation and, at the same time, countries in the Euro Area face budgetary restrictions that prevent lowering this tax. Taxation will affect household disposable income. This will reflect in its purchase decision towards the acquisition of consumer goods such as software. Due to this we will analyze the impact that *personal income tax* (PIT) has on software piracy levels, as household taxation can contribute to the shadow economy (Schneider, Buehn, & Montenegro, 2010).

Being able to disaggregate the different taxation levels among different incomes that represent households we try to answer the following questions:

i) Reducing taxation can prevent the software piracy phenomenon?

ii) If yes, how to implement this reduction on the different households that represent potential software buyers.

iii) Finally we will try to ask if this reduction must be differentiated based on the different EU regions that also represent different levels of development.

The personal income tax is very heterogeneous among countries; it is progressive and in some cases can exceed 50% of annual income.

Levels of household income can affect their purchasing decisions; as their incomes increase non-essential goods such as video games will be sought. On the other side we have households with low income that cannot afford these types of goods. Being the personal income tax progressive, households with higher income will be more affected by taxes. With the disposable income that remains after taxes, they will face the decision on what type of goods to purchase. It can happen that more taxes will shift the consumption from legal to illicit software.

Up to our knowledge the effects of taxation on software piracy were not studied on previous empirical research. This work attempts to see the relationship between the level of taxation of workers and the level of software piracy in a country. Additionally, other taxes will be considered, reflecting indirect taxation and social security contributions made by households. We will use Eurostat data which provides estimates from different levels of income that represent different types of households. With this division it’s possible to measure thirteen types of households that vary according to marital status and number of children's. Households represent potential buyers or pirates of software. Our sample is constituted by the European Union over the period of 1996 to 2010.

The level of personal income tax in a country is an aggregated variable, measuring only the overall tax rate, e.g. the rates applied. This variable is aggregated and, to understand better the effects of taxation on households, we introduce the effective levels of direct taxation on these households that include both the personal income tax and social security contributions. Another important variable introduced was the relative importance of these taxes on total taxation[72].

We found that the weight of taxation on *GDP*, namely the taxes on consumption, increase piracy. The results suggest that there is room to increase the importance of corporate taxation, while an increase on indirect taxation leads to more piracy.

Section 4.2 describes the structure of taxes in the European Union and briefly describes the personal income tax, value added tax and corporate income tax. Section 4.3 describes the variables used and presents some summary statistics. In section 4.4 we test the presence of unit roots of the variables; we provide the econometric specification and present the effects of taxation on the different types of households. Furthermore we also consider the relative importance of the three main taxes analyzed in section 4.2 as a share of total taxation. Finally, section 4.5 concludes.

[72] We also compared the different regions of the European Union, namely the New Countries and Countries outside the Euro Zone and the results were maintained and were significant.

4.2 The structure of taxes in the European Union

This section describes the general tax policy of the European Union focusing essentially on three taxes; *value added tax* (VAT), *corporate income tax* (CIT) and *personal income tax* (PIT). This tax policy derives from the treaty establishing the European Community, namely, the article 3, which eliminates "Customs duties (…) and of all other measures having equivalent effect" between Member States, and try to "ensuring that competition in the common market is not distorted"; article 93 which deals with indirect taxation; other taxes have their base legislation on articles 94, 96 and 97, which includes corporate income tax and personal income tax.

The Community pursues general objectives due to the creation of the single market and the monetary union. These are: (i) preventing huge differences in indirect taxation to prevent distorting competition within the single market; (ii) to fill the gaps in the legislation that sometimes permit tax evasion and to prevent or mitigate double taxation; (iii) to prevent the harmful effect of tax competition, namely the migration of both firms and persons to countries with lower taxation.

The final objective of this tax policy is to not distort competition among Member States and, at the same time, promote financial sustainability. The Maastricht treaty introduced some important aspects, such as the limitation of Government's ability to finance public expenditure by borrowing.

The Stability and Growth Pact imposes to the participating Member States of the European Union a budget deficit lower than 3% of GDP. During the process of integration towards the Euro, countries had to prevent movements above 2.25% relative to ECU[73] (European Currency Unit) which was a fictional currency composed by the currencies of the Member States. Later on, in 1993, the bandwidth increased to 15% as a result of the 1992 crisis of the European Monetary System. Another important rule is that the annual average inflation should be no more than 1.5% above than the verified in the three EU Member States with the lowest inflation rate. Public debt must be lower than 60% or presenting a declining pattern. The final criteria stated that the long-term interest rates should not be more than

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[73]Europa.eu/legislation_summaries/economic_and_monetary_affairs/introducing_euro_practical_aspects/I25007_pt.htm

2.0% above than the average of the 3 EU Member States with the lowest ones. The next subsections describe these taxes in detail.

4.2.1 The Value Added Tax in the EU

In May 2001 the Commission published the “Tax policy in the European Union - Priorities for the years ahead”. The main conclusion of the report is that a “high degree of harmonization is essential in the indirect tax field”. The transitory system of VAT was “complicated susceptible to fraud and out of date”.

The treaty establishing the European Community, art 93, provides the basis for the harmonization of indirect taxation (VAT). In 11 April of 1967 was published the first directive of VAT, which stated that all Member States must replace their whole indirect taxation by a common system. The goal of this publication was of “de-taxing” of exports and “re-taxing” of imports.

More recently, in 2006, was published the VAT directive (see Council Directive (2006/112/EC)). This directive amended the sixth VAT directive of 1977 (see Sixth Council Directive (77/388/EEC)) of 17 May, combining in a single document all the relevant legislation that was previously scattered.

With respect to the rate of VAT, Member States must apply rates within a predetermined band. The minimum standard rate is 15%, subject to review every two years. Member States have the option to apply one or two rates called “reduced rates” that must be over 5%; the goods in which the reduced rates are applied are listed in Annex H of the amended sixth VAT directive.

Member States must abolish “luxury” or higher rates. Due to the fact that we are in a transitional system of VAT, there exist derogations for certain Member States; they can apply a “zero rate”, a “super-reduced” rate or a “parking” rate. The maximum standard rate allowed is 25%, which is in vigor on Denmark and Sweden (see COM (331)). Table 4.1 presents the Standard VAT rate. Overall, small variations on VAT are verified, being the minimum standard rate applied in Luxembourg. On average in the European Union, the average VAT rate is around 21%.

Table 4.1 Standard VAT rate applied in 2012

Country	VAT
Belgium	21
Bulgaria	20
Czech Republic	20
Denmark	25
Cyprus	17
Germany	19
Estonia	20
Ireland	23
Greece	23
Spain	18
France	21.2
Italy	21
Latvia	22
Lithuania	21
Luxembourg	15
Hungary	27
Malta	18
Netherlands	19
Austria	20
Poland	23
Portugal	23
Romania	24
Slovenia	20
Slovakia	20
Finland	23
Sweden	25
UK	17.5
EU Average	21,08

Notes: Standard tax rate is reported. Results are based on Taxation trends in European Union 2012 edition. EU Average is a simple mean of the European Union Countries.

4.2.2 Corporate Income Tax in the EU

Taxation of Companies is generally described in art. 94. The treaty doesn't impose rules directly. Instead, there are bilateral tax treaties involving both Member States and third countries that fill this gap in legislation. The main goal of this legislation is to prevent tax evasion and elimination of double taxation. In 1990 it was published the "Guidelines for company taxation" (SEC (90) 601, 1990) which focused on the mergers directive (see Council Directive (90/434/EEC)), the parent companies and subsidiaries directive (see Corrigendum to Council Directive (90/435/EEC)) and the arbitration procedure convention (90/436/EEC).

Over the years it was proposed that the rates were placed within a band. Initially, in 1975, the Commission published a draft in which the rates were placed between 45% and 55%. In 1999 the “Report of the Committee of independent Experts on Company Taxation” recommended a harmonization of corporate taxation, being the rates between 30% and 40%.

Table 4.2 presents the corporate income tax (CIT) applied to firms’ profits. The CIT correspond in many countries to one quarter of the taxable profit. We also have that on average 20% of profits are taxed.

Table 4.2 Corporate Income Tax rate applied in 2012

Country	CIT
Belgium	33.99
Bulgaria	10
Czech Republic	19
Denmark	25
Cyprus	10
Germany	15
Estonia	21
Ireland	12.5
Greece	20
Spain	20
France	33.33
Italy	27.5
Latvia	15
Lithuania	15
Luxembourg	28.8
Hungary	19
Malta	35
Netherlands	25
Austria	25
Poland	19
Portugal	25
Romania	16
Slovenia	20
Slovakia	19
Finland	24.5
Sweden	26.3
UK	24
EU Average	19,85

Notes: Nominal tax applied to CIT. Results based on Taxation trends in European Union 2012 edition. EU Average is a simple mean of the European Union Countries.

4.2.3 The Personal Income Tax in the EU

Personal income tax was left to the Member States to legislate, even in the situation of full integration[74]. Nevertheless, this tax policy established some actions, namely elimination of tax obstacles to cross-border activities (e.g. elimination or at least mitigation of double taxation). In the absence of harmonization, the European Court of Justice stated that the fundamental Treaty principles must be respected on the free movement of workers, services and capital, and the freedom of establishment (Articles 39, 43, 49 and 56 of the EC Treaty). Discrimination on the basis of nationality is forbidden. The treaty also states that every citizen of the Union has the right to move and reside freely within the territory of the Member States (Article 18 of the Treaty). The personal income tax is legislated by each country central authority (Central Governments), and in some cases such as in Germany, the local authorities receive a large share of this tax (the federal government and Länder Government receives 45% each and municipalities receives 15% of total taxation). Due to the large heterogeneity of legislation and rates applied across the European Union, we will only discuss some important aspects of this tax.

We can classify the personal income tax on three groups[75] on the basis on the tax complexity. The first group of countries has a flat tax rate (Bulgaria, Czech Republic, Denmark, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia and Sweden). The second group of countries is where the top rate is 50% or more (Austria, Belgium, Denmark, Netherlands, Sweden and UK). Finally the third group of countries is characterized by a large number of brackets or "special cases" (Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Malta, Poland, Portugal, Slovenia, Finland and Cyprus).

In the third group referred, an important characteristic of this tax is the amount of taxable income within each bracket. Sometimes the difference of taxable income between the lowest tax rate and the highest tax bracket is high, like, for instance in France. In Belgium this gap is lower. Another feature of this tax is the taxable income within each bracket. To understand these characteristics we provide some examples for 2010.

France had 5 brackets; in the fourth, the applicable rate was 30% for an income that range from 26 420 to 70 829 euros; a total amount of 44 409 euros was taxed at this rate.

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[74] See "Tax Policy in the European Union - Priorities for the years ahead" (COM, 2001 (260) 260) of 23 May 2001

[75] This classification was based on "Taxation trends in the European Union" 2011 edition

Portugal had 8 brackets; the equivalent one was the fourth at 35,5% from an income ranging from 18 375 to 42 259 euros; a total of 23 884 euros was taxed at this rate. In Belgium, with 5 brackets, the equivalent one was the second at 30%; it ranged from 7 900 to 11 240 euros; only 3 340 euros were taxed at this rate. From these three examples it can be seen that taxes are heterogeneous. For Belgium a rate of 50% was applicable to income higher than 34 330€. France had a tax of 41% applicable to income more than 70 830€ and Portugal had a tax of 46,5% for income higher than 153 300€.

4.2.3.1 The Effective taxation level on households

Although the taxes shown until now appear to be high, the final tax that households pay also includes the social security contribution. Higher levels of taxation can also mean higher social protection, so people are willing to accept such fact and obey social norms. To the personal income tax we must sum the contributions to social security that are mandatory; they can range from 10% in case of employees, to more than 20% in the case of employers but also we must subtract deductions that the different tax legal systems allow. This will result in the effective taxation levels of households that will be used in the empirical analysis. Contributions to social security vary greatly among countries. In some situations employees must pay more than 20% related to contributions to social security systems; Germany, Slovenia and Slovakia are some examples[76]. Rates paid by employers are even bigger, accounting to more than 30%, in Slovakia, Czech Republic and Estonia.

Deductions play an important role in order to mitigate the levels of taxation; they differ across countries. Some of these deductions include education and health care expenses, and they can represent a percentage spend within a certain limit or a fixed value. Information on deductions are only available since 2000[77].

Table 4.3 shows the average wage in the European Union. It shows that having childrens affect the level of taxes and social security contributions. These values are a simple mean of all countries; they hide huge differences among them. To show these differences table 4.4 presents the net earnings for each type of household and for each country in 2010.

[76] This information was based on the "Taxation Trends in The European Union, 2011 edition".
[77] Information was obtained from http://ec.europa.eu/taxation_customs/tedb/taxSearch.html

Among the countries with the highest net earnings, for single parent with 100% of the average wage, are Denmark (31 043€), Luxembourg (35 738€), Finland (27 257€) and UK (30 565€). When Portugal and Slovenia are compared, differences on net earnings are small, for the case of single parent with 100% of average wage; in Portugal the net earning is (13 528€) and in Slovenia (11 078€). Differences in income from the newly entered countries are big when compared with the 15 European Countries.

Table 4.3 Average earnings on the EU in 2010

	children	Av. wage	Taxes	Social Security	Net Earn.
Single parent	0	50%	1 071€	1 475€	10 024€
	0	67%	2 019€	2 113€	12 612€
	0	80%	2 862€	2 502€	14 721€
	0	100%	4 253€	3 064€	17787€
	0	125%	6 320€	3 704€	21 347€
	0	167%	10 256€	4 577€	27 002€
	2	67%	1 111€	1 988€	16 027€
Couples	2	100%0%	2 736€	3 004€	21 225€
	2	100%33%	3 815€	3 943€	27 482€
	2	100%67%	5 630€	5 174€	32 838€
	2	100%100%	7 927€	6 128€	37 957€
	0	100%33%	4 391€	3 968€	25 195€
	0	100%100%	8 460€	6 149€	35 733€

Notes: Source Eurostat. In column 1 of table 3 are the types of households, column 2 the number of children's and in column 3 the percentage of the average wage earned (for the case of couples the first percentage is referring to the head of the household and the second to the other household). For example a couple that earn 100%67% means that the head of the household earn 100% and the other earns 67% of the average wage. Table 4.3 shows the average value of taxes in column 4, social security contributions in column 5 and net earnings for the different types of households in column 6 for 2010. Unfortunately data was not available for Cyprus.

Net incomes in households in which both men and woman earn 100% of the average wage are higher in Luxembourg (80 719€), Ireland (65 500€), Denmark (65 392€) and UK (63 179€). Among the 15 European Countries, Portugal (28 023€), Greece (33 630€) and Spain (39 238€) have the lowest net earnings.

4.2.4 Brief Summary

In conclusion, although the EU Commission have provided tools for the harmonization of taxes, there are still huge discrepancies in their respective levels. We have covered only three taxes, but there are others equally important. There exist 27 Member States; from these, 17 are in the Euro Area. There are 27 different legislations. Commission has provided basic tools for harmonization, but seeing the current level of indirect taxes, personal and corporate income tax, “Richer” economies like Germany have a lower or equal level of taxation on personal income tax that some “poor” economies like Portugal.

Table 4.4 Net earnings in 2010

	Single Parent							Couple					
# Children's	None						Two	None		Two			
Average wage	50%	67%	80%	100%	125%	167%	67%	100%33%	100%100%	100%	100%33%	100%67%	100%100%
Belgium	15 298€	17 837€	20 256€	23 989€	28 254€	35 229€	23 000€	36 074€	48 006€	32 460€	40 745€	46 447€	52 678€
Bulgaria	1 536€	2 058€	2 458€	3 072€	3 840€	5 130€	2 488€	4 086€	6 144€	3 502€	4 515€	5 560€	6 574€
Czech Republic	4 913€	6 223€	7 272€	8 844€	10 809€	14 085€	8 590€	12 229€	17 688€	12 042€	14 189€	16 726€	19 185€
Denmark	16 282€	21 237€	25 201€	31 043€	37 323€	46 533€	29 856€	42 369€	62 085€	36 673€	45 676€	55 587€	65 392€
Germany	14 533€	18 315€	21 227€	25 381€	30 614€	39 119€	23 349€	36 631€	50 762€	33 564€	41 351€	48 636€	55 697€
Estonia	3 984€	5 192€	6 157€	7 606€	9 417€	12 435€	6 474€	10 383€	15 212€	8 429€	11 206€	13 620€	16 035€
Ireland	18 559€	22 383€	26 075€	30 950€	35 795€	43 871€	31 981€	45 820€	61 900€	37 942€	49 420€	57 596€	65 500€
Greece	7 360€	9 813€	11 776€	14 231€	17 104€	21 715€	10 795€	20 823€	30 852€	17 085€	22 973€	28 861€	33 630€
Spain	11 102€	13 460€	15 778€	19 154€	23 270€	30 003€	15 062€	26 777€	38 307€	21 000€	27 242€	33 544€	39 238€
France	13 818€	16 739€	19 823€	24 449€	29 524€	37 668€	19 294€	33 479€	48 899€	27 930€	36 986€	43 995€	51 705€
Italy	10 968€	13 816€	16 092€	19 527€	23 388€	29 321€	17 842€	27 643€	39 054€	23 068€	29 807€	35 496€	40 905€
Latvia	2 919€	3 860€	4 579€	5 685€	7 067€	9 390€	4 685€	7 664€	11 369€	6 788€	8 489€	10 370€	12 195€
Lithuania	2 798€	3 638€	4 280€	5 268€	6 503€	8 589€	5 511€	7 210€	10 537€	5 786€	7 367€	9 063€	10 693€
Luxembourg	20 581€	26 188€	30 276€	35 738€	42 173€	52 879€	35 971€	53 426€	73 197€	48 078€	60 948€	71 404€	80 719€
Hungary	3 383€	4 292€	5 018€	6 109€	7 169€	8 989€	5 581€	8 564€	12 217€	7 267€	9 723€	11 559€	13 376€
Malta	8 224€	10 587€	12 394€	14 914€	17 986€	22 885€	12 634€	20 389€	29 828€	16 639€	20 889€	26 001€	30 328€
Netherlands	17 527€	21 618€	24 981€	30 130€	36 579€	45 864€	28 042€	42 950€	60 260€	34 297€	45 785€	54 583€	63 095€
Austria	15 693€	19 435€	22 429€	26 789€	31 946€	41 529€	25 236€	38 176€	53 578€	32 619€	43 337€	51 406€	58 777€
Poland	3 656€	4 809€	5 731€	7 113€	8 842€	11 723€	5 165€	9 617€	14 227€	7 748€	10 174€	12 479€	14 784€
Portugal	7 556€	9 729€	11 249€	13 528€	16 377€	20 351€	11 358€	19 458€	27 056€	15 882€	20 528€	24 224€	28 023€
Romania	2 068€	2 719€	3 209€	3 972€	4 918€	6 527€	3 264€	5 246€	7 945€	4 451€	5 576€	7 008€	8 229€
Slovenia	6 395€	7 884€	9 161€	11 078€	13 431€	16 886€	11 296€	15 375€	22 155€	14 911€	17 889€	21 216€	23 986€
Slovakia	3 973€	5 042€	5 898€	7 182€	8 786€	11 483€	6 051€	10 243€	14 364€	8 930€	112 501€	13 233€	15 372€
Finland	15 701€	19 949€	22 895€	27 257€	32 354€	40 767€	23 593€	38 463€	54 514€	29 783€	40 989€	49 732€	57 040€
Sweden	15 399€	19 969€	23 625€	28 893€	33 935€	41 350€	22 800€	39 722€	57 786€	31 724€	42 553€	51 694€	60 617€
UK	16 404€	21 124€	24 901€	30 565€	37 629€	47 720€	26 797€	42 248€	61 130€	33 252€	44 935€	53 738€	63 179€

Notes: Cyprus was missing. Source Eurostat. Line 1 of table 4.4 shows the type of households, line 2 shows the number of children's and line 3 the average wage.

4.3 Data and description of the variables

Our dataset was constructed using the official publications provided by the *Business Software Alliance* and the Eurostat.

4.3.1 Dependent Variable

The dependent variable is the software piracy losses at current prices[78] from 1996 to 2010 BSA (2012). Software piracy can be defined as the unauthorized use of software that is protected by nationals or international Intellectual Property Rights. Some of this use can be a result of lack of enforcement of these laws. The software piracy losses measures the commercial value of the software that is currently being used trough illicit means and is a result of extensive surveys done over the years by the *Business Software Alliance* (BSA) with the help of International Data Corporation (IDC) and IPSOS BSA (2012). A total of 33 observations were missing for Estonia, Latvia, Lithuania and Luxembourg. Png (2010) found that when surveys are not applied, the software piracy rates are based on national income; it also found that the yearly rate of decrease of the piracy rates before 2003 were 2.0 (p.p), while the period after 2003 this rate of decrease fell to 1.1 (p.p) for the non-survey countries. With this in mind we will introduce a variable that will reflect this change[79]. More formally, software piracy can be defined as the unauthorized use of software that is protected by nationals or international Intellectual Property Rights. Some of this use can be a result of lack of enforcement of these laws.

4.3.2 Economic Dimension

Following Goel and Nelson (2009) and Andrés and Goel (2011) we will use the logarithm of real *GDPpc*[80] as a measure of national income. GDP measures the income of a

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78 We will introduce a variable, the HICP that reflects the change in prices of products at current prices
79 Piracy rates have a decreasing pattern while the piracy losses are increasing over the years. This dummy variable reflects the break in the series, as the Business Software alliance change its consultant and methodology in this period.
80 *GDPpc* takes into account Purchasing Power Parity and is measured at current prices.

country and also the ability to purchase goods such as software products. The higher the *GDP*, the higher households have the ability to purchase consumer goods. This is a control variable and is expected to have a negative effect as a result of increased disposable income that allows to purchase goods.

4.3.3 HICPH as a proxy of software price

Software's prices can affect the decisions to purchase or to use illegal software. A good choice would be based upon the prices of both hardware and software. Unfortunately that information can be misleading as in certain cases, such as the Microsoft Office or the prices of computers are almost the same across the countries. We used the Harmonized indices of consumer prices (*HICPH)* as a proxy for these prices but also due to the fact that piracy losses are at current prices. We will introduce three measures that reflect the overall costs of living; i) costs of communications - examples of these costs are the price of phone calls and prices of telephones (*HICPHgcomm)*; ii) costs of cultural services - examples are price of music, films, games, books and newspapers (*HICPHgculture*[81]) and iii) overall costs of products (*HICPHgall)*. Harmonized indices of consumer prices (*HICPHs*) give comparable measures of inflation for the countries and country groups where they are produced. They are economic indicators that measure the change over time of the prices of consumer goods and services acquired by households. These variables are expected to have a positive impact (increase piracy) as a result of increase of price on goods, in which software is included.

4.3.4 Tax dimension

4.3.4.1 Household taxation

Labor costs include several dimensions such as social security contributions and family allowances that are captured by this variable. One of the independent variables will be the different tax rates applied to different types of households. It represents only one

[81] These variables were retrieved in the official web site of the Eurostat and describe the rate of change from one year to another.

variable that can be decomposed into several tax levels. We will consider several hypotheses that vary according to the marital status, the existence of children in the constitution of the household and the percentage of the average wage that is earned. Several alternative types of households will be analyzed as independent variables:

- Single person with no children and 50%, 67%, 80%, 100%, 125% and 167% of the average wage (AW) respectively;
- Single person with two children and 67% of the AW;
- Married couple with two children and the following levels of the AW: husband 100% / wife 0%, husband 100% / wife 33%, husband 100% / wife 67% and husband 100% / wife 100%;
- Married couple with no children and 100% of the AW for the husband and 33% for the wife and husband 100% / wife 100%;

Hereafter we will use "*SP*" to denote single parent, "*C*" to denote couples; the number of children's will be "*t*" for two children's and "*n*" for no children's. *SPn67* represents a single parent household that earns 67% of the average wage and do not have children, *SPt67* represents a similar household with the same income but with two children. Another example is C*n10033*, where 100% represents the income that the head of the household earn and 33% represents the income that the other member of the household earns in comparison to the average wage - they do not have children; *Ct100100* represents couples that have two children and both households earn 100% of the average wage.

On each of these dimensions (representative households) we will consider the average tax rate that is defined as the income tax on gross wage earnings plus the employee's social security contributions, less universal cash benefits, expressed as a percentage of gross wage earnings[82]. We expect that this variable will increase software piracy, although with the harmonization that the European Union has set over the years, this positive impact may become marginal.

[82] http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/earn_net_esms.htm

4.3.4.2 Relative importance of taxes

We will introduce the relative importance of taxes on labor and consumption relative to *GDP*[83]. The impact of these taxes is expected to be positive, although they do not measure the direct level of taxation, e.g., they do not measure the actual rate but the importance of the tax on the economy.

4.3.5 Summary Statistics

Table 4.5 presents the summary statistics for each variable that will be analyzed. These results show that, in some circumstances, some households don't pay any type of tax, as in the case of *SPt67* and *Ct100.* Family allowances in these households is higher than the actual tax, which explains this negative impact. The negative value of taxes on *SPt67* and *Ct100* indicates that these households not only do not pay taxes but receive a net subsidy from the Government. Higher values of taxes are present when there are no children's. Additional to these statistics we also provide the graphs of software piracy rates and losses for each country. The maximum piracy rate of 98% was in 1997 in Bulgaria. Since then, these rates have been decreasing in all countries. Figure 4.1 presents this decrease on all European Union Countries. Figure 4.2 presents the evolution of software piracy losses.

[83] They comprise detailed tax and social contribution receipts for the general government sector as a share of GDP or as a share of total taxation (we have information on VAT, labor and capital taxes)

Table 4.5 Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Losses	372	318.86	575.03	0.97	3191
SPn50	402	19.72	7.58	0.15	39.26
SPn100	402	27.20	8.00	6.30	44.95
SPn125	402	29.67	8.26	8.46	48.37
SPn167	402	32.60	8.56	12.67	52.58
SPt67	402	5.29	10.24	-21.56	24.69
SPn67	402	23.04	7.81	3.52	41.39
SPn80	402	24.90	7.94	4.8	43.17
Cn100100	402	27.20	7.92	6.3	44.95
Cn10033	402	23.84	7.59	5.68	41.39
Ct100	402	14.83	8.58	-8.6	31.11
Ct100100	402	23.15	7.52	0.46	41.68
Ct10033	402	17.44	7.59	0.6	36.48
Ct10067	402	20.41	7.63	5.4	39.6
lGDPpc	405	9.77	0.52	8.37	11.15
GDPg	378	4.26	5.82	-18.49	15.91
HICPHall	405	94.55	16.63	5.01	139.62
HICPHgall	377	4.25	9.50	-1.7	154.8
HICPHcommu	404	100.24	21.72	1.81	206.34
HICPHgcommu	377	2.04	18.25	-14	237.5
HICPHculture	404	95.72	12.52	5.74	120.09
HICPHgculture	377	2.83	9.71	-4.9	146.6
Itaxcons	401	21.05	4.47	11.1	34.2
Itaxlab	401	34.66	6.74	18.8	49.3
TaxconsGDP	405	12	1.66	7.3	17.2
TaxconsTotal	405	33.63	6.09	22.8	54
TaxlabGDP	405	17.44	5.31	9	32
TaxlabTotal	405	46.99	7.89	27	62.5
TaxcapTotal	405	19.51	6.71	5.2	35

Notes: Std. Dev. represents the standard deviation; Min the minimum and Max the maximum.

Figure 4.1 Evolution of Software Piracy rates on the European Union

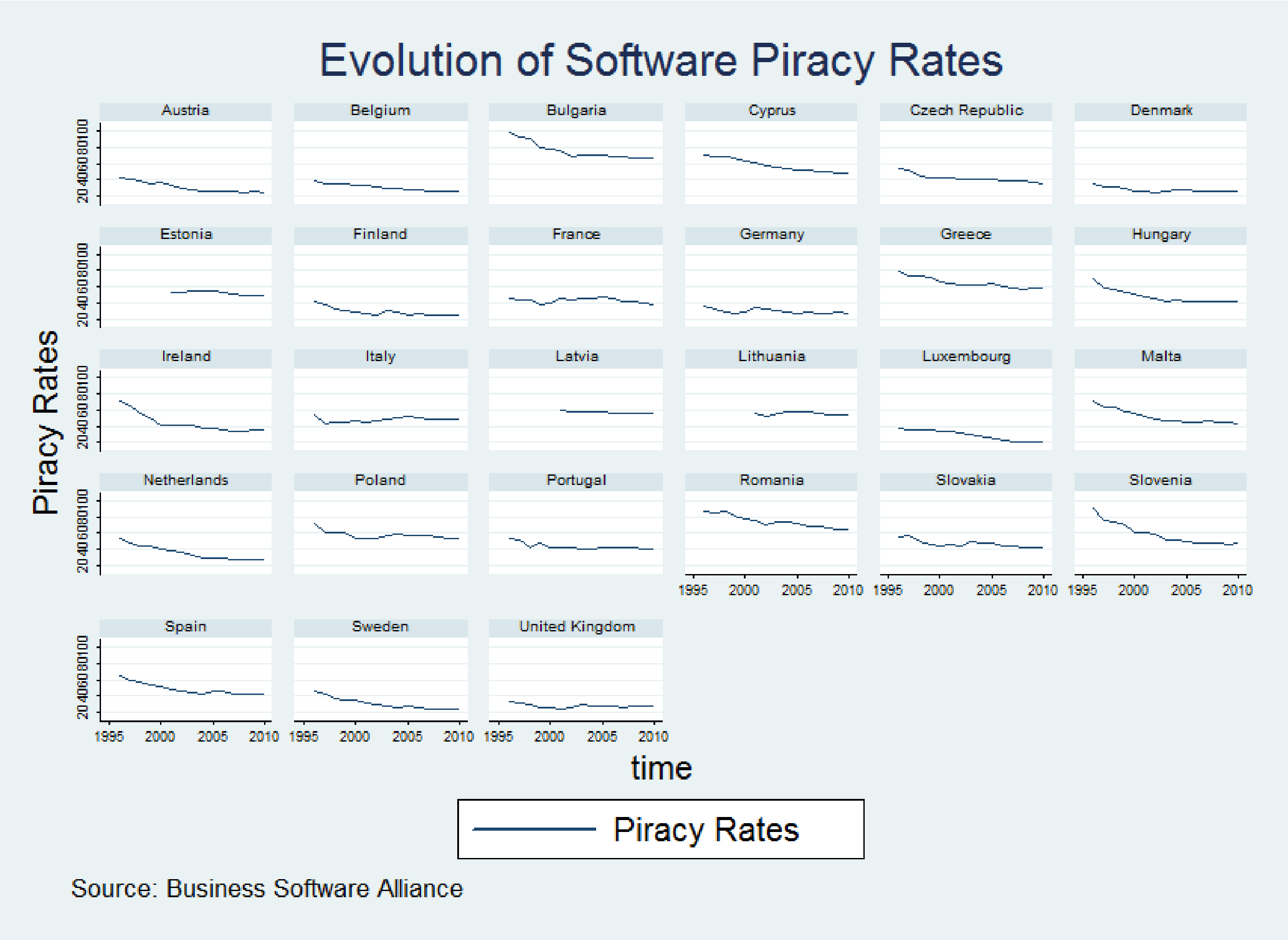
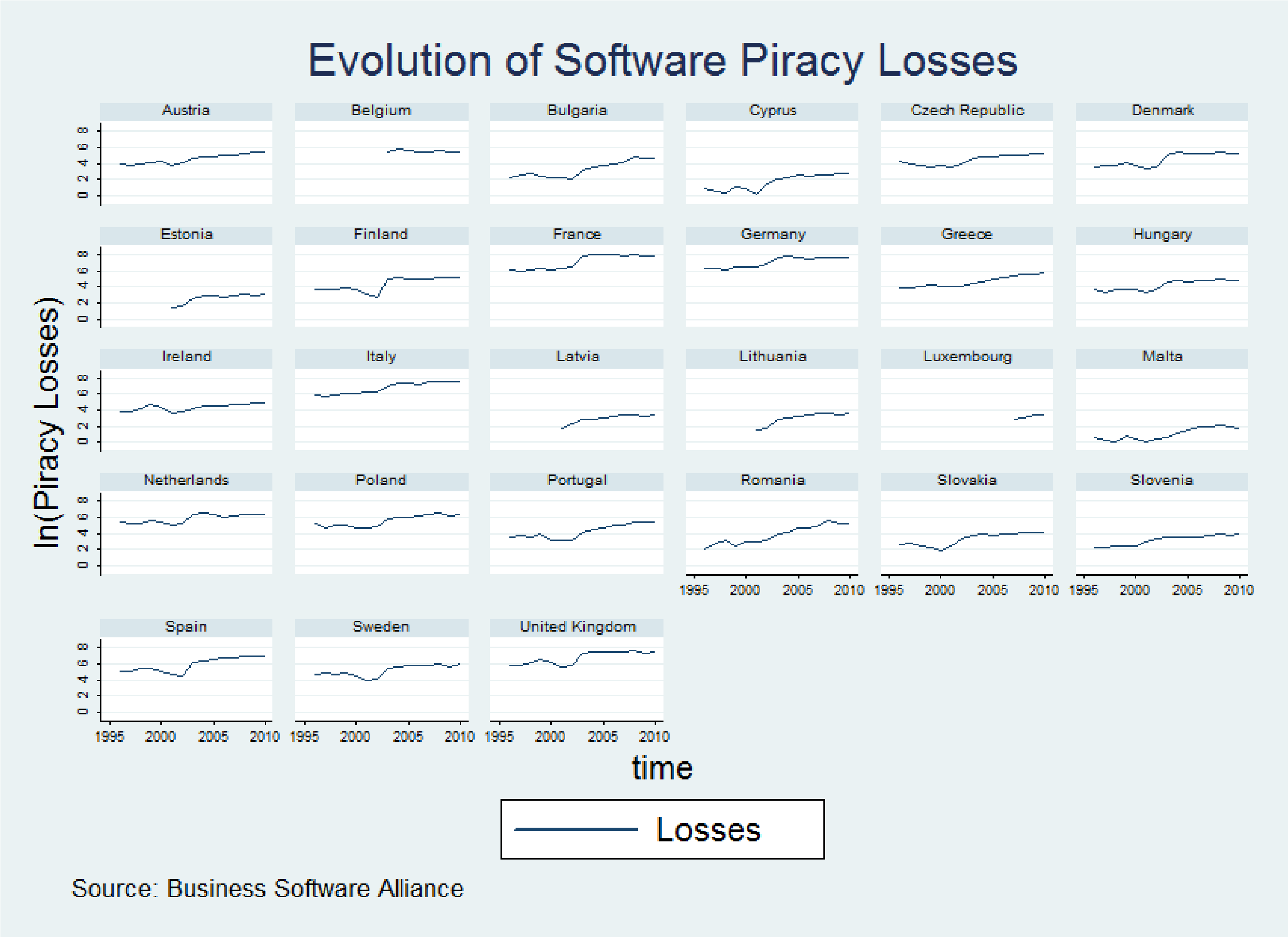


Figure 4.2 Evolution of Software Piracy Losses on the European Union



4.4 Empirical Study

When dealing with a panel-data analysis, we must choose the appropriate estimator but also ensure that our variables produce the best results. One problem that can occur in a panel of countries is the existence of one or more non-stationary variables. The existence of such variables can be problematic resulting in spurious regressions (Granger & Newbold, 1974). We start by testing the stationarity of the variables using unit-root tests. Next we empirically estimate our model using the fixed effect model following Andrés (2006a); Chen et al. (2010) and Boyce (2011), that showed that based on Hausman tests (Hausman, 1978) the fixed effect was the most appropriate for the analysis.

4.4.1 Testing the presence of unit roots

To check if our series are stationary we implemented a procedure proposed by Im, Pesaran, and Shin (2003), henceforth IPS. Other tests are available but rely on balanced panels which is not the case. Equation 4.1 shows a model with a first order autoregressive component:

$$\Delta y_{it} = \alpha_{it} + \phi_i y_{i,t-1} + \epsilon_{it} \tag{4.1}$$

where $i = 1, \dots, N$ represents the Member States; $t = 1, \dots, T_i$ indexes time; y_{it} is the variables that we want to test; ϵ_{it} is independently distributed normal for all *i* and *t* and has heterogeneous variance σ_i^2. This test assumes that all the panel dataset is non-stationary under the null hypothesis $H_0: \phi_i = 0$ against the alternative hypothesis that some panels are stationary $H_a: \phi_i < 0$. To be able to get significance it is necessary at least 10 observations per country, which is not the case on software piracy losses. In this variable we performed the Fisher type tests I. Choi (2001) that has the same assumption of the IPS test. In this framework four tests are available: Inverse chi-squared; Inverse normal; Inverse logit and Modified inverse chi-squared. Based on I. Choi (2001) simulations results, the inverse normal Z statistic offers the best trade-off between size and power. The IPS test is performed on the independent variables.

Table 4.6 presents the result of these tests for each variable. It can be seen that almost all the variables seem to be stationary or integrated of order zero *I(0)*. The exception goes to the natural logarithm of Gross Domestic Product per capita at Purchasing Power Parity and the Harmonized indices of consumer prices that may be considered as having unit roots. To prevent this problem we introduce the real GDP growth and the inflation rate (*HICPHg*). Both variables are stationary.

After establishing that our regressors are stationary, we can proceed with the fixed effect model.

Table 4.6 IPS and Fisher type Unit root tests

	Level	1stdifference
Dependent Variable		
ln(Losses)	-1.336*	-12.105***
Independent Variables		
SPn50	-3.871***	-
SPn67	-3.584***	-
SPn80	-4.015***	-
SPn100	-3.349***	-
SPn125	-3.525***	-
SPn167	-3.456***	-
SPt67	-4.637***	-
Cn10033	-3.165***	-
Cn100100	-3.694***	-
Ct100	-4.060***	-
Ct10033	-3.817***	-
Ct10067	-3.428***	-
Ct100100	-3.654***	-
lGDPpc	-0.278	-6.628***
Itaxlab	-3.313***	-
Itaxcons	-3.588***	-
HICPH	0.731	-4.826***
HICPHg	-6.783***	-
HICPHcomm	1.7637	-6.388***
HICPHgcomm	-4.455***	
HICPHculture	2.3157	-4.853***
HICPHgculture	-4.498***	-
TaxconsGDP	-3.620***	-
TaxconsTotal	-3.725***	-
TaxlabGDP	-2.770***	-
TaxlabTotal	-3.786***	-
TaxcapTotal	-4.333***	-

Notes: In the dependent variable we performed the Fisher type test presenting the inverse normal Z statistic. In the Independent variables the IPS test is used and the $Z_{\tilde{t}-bar}$ statistics is presented. It was included a trend and subtracted cross-sectional mean. It was tested under the null hypothesis that all panels contain unit roots against the alternative that some panels are stationary. *** and * corresponds to a significance level of 1% and 10% respectively.

4.4.2 Empirical results

4.4.2.1 Effects of taxation on software piracy losses

We start our analysis by introducing the different tax rates on labor applied to households as well as the importance of direct and indirect taxes as a share of GDP. The different regions of Europe will be analyzed when they present significance.

We can specify our dependent variable, software piracy losses *ln(Losses)* as a function of: i) the importance of taxation on labor as a share of GDP (*TaxlabGDP*); ii) the importance of taxation on consumption as a share of GDP (*TaxconsGDP*); iii) the growth rate of harmonized index of consumer prices index for all products (*HICPHg*); iv) growth of real gross domestic product per capita (*GDPg*); and v) the variable *tax* will assume thirteen different types of households. $tax(h_l)$ will assume the different levels of taxation that each of these households incur. $h_l = 1, \dots, 13$ represents the different types of households that are: *SPn50, SPn67, SPn80, SPn100, SPn125, SPn167, SPt67, Cn10033, Cn100100, Ct100, Ct10033, Ct10067, Ct100100.* Additional to this we include a dummy variable that reflects the change in methodology used by the *Business software alliance* occurred in 2002 *(change)*. The dependent variable is in natural logarithms.

Equation 4.2 and 4.3 summarizes the estimated model

$$\ln(Losses) = \theta_{0i} + \theta_{1t}GDPg_{it} + \theta_{2t}HICPHg_{it} + \theta_{3t}TaxconsGDP_{it} + \theta_{4t}TaxlabGDP_{it} + +\theta_5 tax(h_l)_{it} + \theta_6 change_i + \varepsilon_{it} \tag{4.2}$$

where

$$HICPHg_{it} = \theta_{21t}HICPHgall_{it} + \theta_{22t}HICPHgcomm_{it} + \theta_{23t}HICPHgculture_{it} \tag{4.3}$$

where *i=1,…27* represents the Member States, *t=1996,…,2010* represents the time, ε_{it} represents the error term. *HICPHgall* is the growth of all the prices, *HICPHgcomm* is the growth of prices in telecommunications and *HICPHgculture* is the growth of prices in products such as movies, culture or books.

Estimates of the piracy rates are projected from national income in the non-survey countries. Initially, the surveys only covered 15 countries. From these, only one country of the European Union was present: Spain (*First Annual BSA and IDC Global Software*). In the report of 2010, 32 countries were present in the surveys. From those countries, Czech Republic, Poland, France, Germany, Italy, Netherland, Spain, Sweden and United Kingdom make part of the European Union (*Eight annual BSA and IDC global software piracy study)*.

In each of the regressions reported we present the Hansen-test statistic that is a robust version of the Hausman test (Schaffer & Stillman, 2010). The Hausman test assumes under the null hypothesis that the random effect (RE) estimates is consistent. The fixed effects estimator uses the orthogonally conditions that the regressors are uncorrelated with the idiosyncratic error. Furthermore, one of the assumptions of the random effect is that it uses the additional orthogonally conditions that the regressors are uncorrelated with the group-specific error; the Hansen-test[84] treats this assumption as additional orthogonally conditions (it is a test of over identifying restrictions). Rejecting the null hypothesis favors the fixed effect model.

Table 4.7 presents the results for the entire sample (EU27). The impact of prices is similar in the different categories of products; we only report the results for the inflation of overall products (In Annex VI we report the remaining possibilities). We dropped taxation of households that were not significant (in Annex VII we report the remaining cases). Column 2 through 5 shows the estimates for the different types of households, as with previous studies (Chen et al., 2010); the *GDPg* is not significant in the majority of regressions.

We can observe a negative and marginal impact of inflation on overall products. Many software prices, such as productivity suits, are constant over the years, not suffering with the inflation of a Country. In fact some software prices decreases over the years; examples are games and movies. In many software products, Companies internalize the value of VAT, making software prices almost the same across European Countries. These variables were always significant at 1%.

[84] These additional orthogonality conditions are overidentifying restrictions. The test is implemented by xtoverid using the artificial regression approach described by Arellano (1993) and Wooldridge (2010, pp. 290-291), in which a random effects equation is reestimated, augmented with additional variables consisting of the original regressors transformed into deviations-from-mean form. The test statistic is a Wald test of the significance of these additional regressors. Under conditional homoskedasticity, this test statistic is asymptotically equivalent to the usual Hausman fixed-vs-random effects test; with a balanced panel, the artificial regression and Hausman test statistics are numerically equal. See Arellano (1993) for an exact statement.

Another important variable introduced was the relative importance of taxes; the positive effect of *TaxconsGDP* indicates that all the different types of indirect taxation play an important role in explaining software piracy. Changing these taxes determines the behavior of consumers when facing choices of purchasing goods. This variable was significant, which indicates that reducing indirect taxation could be beneficial for reducing piracy, because more disposable income is available to households to spend on goods.

Table 4.7 Tax rate on labor on different households in EU27

Variables	1	2	3	4	5
GDPg	0.009	0.009	0.009	0.010*	0.008
	(1.386)	(1.421)	(1.419)	(1.904)	(1.366)
TaxconsGDP	0.065**	0.056**	0.059**	0.068***	0.071**
	(2.402)	(2.303)	(2.304)	(2.628)	(2.514)
HICPHgall	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***
	(-3.756)	(-3.333)	(-3.111)	(-3.735)	(-3.541)
SPn50		0.021**			
		(2.070)			
SPn67			0.021*		
			(1.876)		
SPn80				0.019*	
				(1.671)	
Cn10033					0.018*
					(1.680)
Change	0.991***	1.000***	0.995***	1.056***	0.952***
	(14.113)	(14.028)	(13.870)	(15.061)	(14.538)
Constant	2.914***	2.628***	2.515***	2.455***	2.484***
	(8.796)	(6.448)	(5.381)	(4.936)	(4.738)
Observations	349	346	346	346	346
R^2	0.880	0.882	0.881	0.875	0.877
$\bar{R}^2$	0.875	0.877	0.876	0.871	0.872
Countries	27	27	27	27	27
Hansen-Test	4.9e+04	1543.99	628.96	606.66	471.79
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses).* All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. Degrees of freedom of t-distribution for n>120 are: critical values at 10% are 1.645; at 5% is 1.960 and at 1% are 2.576. *, ** and *** represent significance at 10%, 5% and 1% respectively. All EU represent the 27 Member states of the European Union

The additional variables that represent taxation of the different households have the expected positive impact, which indicates that they affect negatively the final disposable income that will be used to purchase these types of products. Only on those households that do not have children and earn less than 100% of the average wage are positively and significantly affected.

The positive effect of taxation on Single parents is more severe on households that earn less and this positive value decreases as households earn more. This result indicates that households can allocate more of their disposable income on digital content as their income increases (Shin et al., 2004). The same pattern applies to Couples that do not have children; only on households that earn less than 100% of the average wage, significance is present.

Knowing the main results including the EU27, we provide additional regressions in which we compare "Euro" and "Not Euro" zone, and the 15 original countries of the EU ("Old") and the "New Countries". Results on household taxation were only significant on "Not Euro" and "New" countries[85]. Table 5.8 presents the results.

In these regions we also observe the lack of significance of *GDPg* across many regressions. One of the main differences resides in the significance of household taxation across the different regions. In the countries not belonging to the Euro Zone household taxation has a strong coefficient, being significant (column 7 to 10). When the "Euro" Zone is examined (see Annex D), the coefficients are marginal and close to zero. This can be a result of the fact that countries in the sample belongs to the North of Europe that is characterized by a high level of taxation.

Table 4.8, columns 12 to 15 shows the "New" countries; many of these countries have a low flat rate (Bulgaria and Estonia are some examples). Since 2008 Bulgaria has a 10% flat rate tax system (Commission, 2012, p. 66). The region that represents the "Old" countries doesn't have significance, although with similar coefficient sizes (see Annex VIII).

In all regressions the Hansen-test favors the fixed effect model with a significance of 1%. The dummy variable that represented the change in methodology is positive which indicates that software piracy losses have increased over the years. Also as Figure 4.2 presented, a dramatic change occurred in 2002/2003, which was captures by this variable.

[85] The remaining regions are reported in annex.

Table 4.8 Tax rates on NOT EURO VS NEW Countries

	NOT EURO					NEW				
Variables	6	7	8	9	10	11	12	13	14	15
GDPg	0.008	0.005	0.004	0.008	0.008	0.009*	0.009	0.008	0.011**	0.010*
	(1.361)	(0.868)	(0.710)	(1.194)	(1.184)	(1.656)	(1.634)	(1.578)	(2.025)	(1.912)
TaxconsGDP	0.099**	0.051*	0.058*	0.058	0.073	0.067**	0.060**	0.063**	0.071**	0.074**
	(2.554)	(1.725)	(1.712)	(1.509)	(1.552)	(2.303)	(2.196)	(2.281)	(2.287)	(2.113)
HICPHgall	-0.003***	-0.004***	-0.004***	-0.004***	-0.004***	-0.005***	-0.005***	-0.005***	-0.004***	-0.004***
	(-2.871)	(-4.100)	(-3.524)	(-3.471)	(-3.395)	(-4.818)	(-5.317)	(-4.965)	(-3.933)	(-3.823)
SPn50		0.025**					0.025**			
		(2.408)					(2.685)			
SPn67			0.023*					0.020*		
			(1.818)					(1.720)		
SPn80				0.022*					0.013	
				(1.694)					(0.951)	
Cn10033					0.022*					0.013
					(1.908)					(0.969)
Change	1.240***	0.948***	0.951***	1.084***	1.078***	0.809***	0.790***	0.783***	0.891***	0.924***
	(16.673)	(8.011)	(7.906)	(12.227)	(13.106)	(12.585)	(12.459)	(12.548)	(12.358)	(11.877)
Constant	2.403***	2.557***	2.446***	2.364***	2.198**	1.747***	1.440***	1.449***	1.434**	1.355*
	(5.153)	(5.135)	(3.814)	(3.331)	(2.691)	(5.261)	(3.871)	(3.169)	(2.426)	(2.064)
Observations	131	131	131	131	131	155	152	152	152	152
R^2	0.895	0.929	0.925	0.922	0.923	0.902	0.908	0.903	0.898	0.896
$\bar{R}^2$	0.885	0.919	0.916	0.913	0.914	0.893	0.898	0.893	0.888	0.886
Countries	10	10	10	10	10	12	12	12	12	12
Hansen-Test	1039.47	5.7e+08	2605.19	3178.44	2015.02	753.247	8257.18	8283.31	78.65	227.09
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is ln(Losses). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. “Not Euro” represents the countries that are outside the Euro Area. “NEW” represents the 10 countries that recently entered in 2004 and 2007.

4.4.2.2 Additional Results

After establishing that both indirect and direct taxation on households affect positively software piracy, we examine if the relative importance in the Economy of these taxes can also affect this phenomenon. The relative importance of these taxes can be measured as a percentage of total taxation. In many countries, the importance of Capital, Labor and Consumption taxes accounts for almost one hundred percent of all taxes existing in a country.

Equation 4.4 describes the general econometric specification that will be used

$$\ln(Losses)_{it} = \theta_{0i} + \theta_1 GDPg_{it} + \theta_2 HICPHgall_{it} + \theta_3 TaxcapTot_{it} + \theta_4 TaxlabTot_{it} + \theta_5 TaxconsTot_{it} + \theta_6 change + \varepsilon_{it} \quad (4.4)$$

where *TaxcapTot, TaxlabTot* and *TaxconsTot* are the importance of taxes on capital, labor and consumption respectively as a share of total taxation. These three variables cannot be present at the same time as the sum of them represents almost 100% of total taxation.

So as:

$$TaxcapTot_{it} + TaxlabTot_{it} + TaxconsTot_{it} \cong 1 \quad (4.5)$$

To prevent a high level of multicolinearity we omit one variable at a time that will serve as a base tax level. For instance if we omit the $TaxconsTot_{it}$, solving the above equation relatively to that variable and replacing in equation 5.4 we get:

$$\ln(Losses)_{it} = (\theta_{0i} + \theta_5) + \theta_1 GDPg_{it} + \theta_2 HICPHgall_{it} + (\theta_3 - \theta_5) TaxcapTot_{it} + (\theta_4 - \theta_5) TaxlabTot_{it} + \theta_6 change + \varepsilon_{it} \quad (4.6)$$

From equation (4.6) is easy to check the interpretation of the coefficient as a 1 pp. increase in the share of the respective tax with an associate decrease of 1 pp. in the share of the Consumption Tax (the base case).

Anyway, we report all possible combinations in the regressions that serve as a robustness check. With this omission we can interpret the coefficients of the remaining taxes as the differential impact between a specific tax and the base one. The control variables (*GDPg* and *HICPHgall*) maintained the coefficients.

Table 4.9 presents the results for the entire sample. Columns 16 to 18 show the different combinations of these taxes. Significance on the variables that represent the importance of taxes was only present when taxation of labor and capital were considered together (column 16); the negative impact of *TaxcapTot*[86] indicates that an increase of the relative importance of capital taxation and a reduction of consumption taxation, will lead to less piracy (substitution effect). In spite of this statistical significance, column 18 shows that this result is not strong, which can be a result of the complex tax systems and the difficulty in reducing direct taxation.

Table 4.9 Relative importance of taxation in the EU27

Variables	16	17	18
GDPg	0.012*	0.013*	0.013*
	(1.646)	(1.685)	(1.657)
HICHgall	-0.003**	-0.003**	-0.003**
	(-2.595)	(-2.530)	(-2.558)
TaxcapTot	-0.027*	0.003	
	(-1.667)	(0.172)	
TaxlabTot	-0.030		-0.004
	(-1.556)		(-0.229)
TaxconsTot		0.029	0.026
		(1.508)	(1.599)
Change	1.265***	1.266***	1.266***
	(20.785)	(20.889)	(20.833)
Constant	5.592***	2.615***	2.942***
	(4.836)	(3.128)	(2.845)
Observations	349	349	349
R^2	0.845	0.845	0.845
$\bar{R}^2$	0.840	0.840	0.840
Countries	27	27	27
Hansen-Test	3.5e+04	1.1e+04	9853.72
p-value	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is ln(Losses). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses.

[86] In the European Union, this tax represents on average 19.51% of total taxation. The personal taxation represents, on average, 47% of total taxation, which indicates that the rates applied are high. On the other side, the rates applied to capital are relatively low.

Table 4.10 presents the results for the different EU regions that were significant; the “Not Euro” and “Euro” zone.

Table 4.10. Relative importance of taxation in the Not Euro and EURO Countries

	NOT EURO			EURO		
VARIABLES	19	20	21	22	23	24
GDPg	0.000	0.001	0.000	0.022**	0.022**	0.022**
	(0.047)	(0.172)	(0.064)	(2.142)	(2.149)	(2.137)
HICHgall	-0.006***	-0.006***	-0.007***	-0.046***	-0.046***	-0.046***
	(-3.985)	(-3.922)	(-4.107)	(-2.680)	(-2.660)	(-2.629)
TaxcapTot	-0.013	0.041		-0.032*	-0.023	
	(-0.614)	(1.579)		(-1.775)	(-1.209)	
TaxlabTot	-0.054**		-0.044*	-0.010		0.022
	(-2.447)		(-1.707)	(-0.485)		(1.196)
TaxconsTot		0.052**	0.010		0.009	0.031*
		(2.299)	(0.495)		(0.434)	(1.710)
Change	1.214***	1.220***	1.214***	1.201***	1.202***	1.203***
	(13.781)	(13.972)	(13.864)	(12.948)	(12.970)	(12.935)
Constant	6.567***	1.181	5.488**	4.840***	3.904***	1.670
	(5.186)	(1.092)	(3.144)	(4.042)	(4.243)	(1.343)
Observations	131	131	131	218	218	218
R^2	0.894	0.893	0.894	0.835	0.835	0.835
$\bar{R}^2$	0.884	0.883	0.884	17	17	17
Countries	10	10	10	0.827	0.826	0.826
Hansen-Test	1095.60	862.59	828.46	904.727	1072.968	1150.520
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is ln(Losses). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. “Not Euro” represents the countries that are outside the Euro Area.

Columns 19 to 21 present the results for the “Not Euro” Zone. *TaxlabTot* is significant at 5% with a negative impact on piracy which indicates that if we increase the importance of this tax and at the same time decrease the importance of consumption tax (base tax), this will decrease piracy. If we consider the capital tax as the base tax, we observe that *TaxlabTot* maintains its coefficient, being significant at 10%. In this case an increase of labor tax and, at the same time, a decrease of capital taxation (the base tax) will also lead to less piracy. *TaxconsTot* is significant at 5% with a positive impact (increases piracy) when we omit labor tax. In this case an increase of consumption tax and a decrease of labor tax (base tax) will increase piracy although this result is not robust.

Columns 22 to 24 shows the “Euro” Zone; in this situation *TaxlabTot* loses significance. This is an unexpected result as in the Euro Zone the importance of this tax is smaller than those outside the Euro Zone, although this difference is marginal[87].

Table 4.11 presents the results for the “New” and “Old” countries. Columns 25 to 27 presents the “New” Countries. When we consider the consumption tax as the base one, we can observe that it is possible to reduce piracy choosing capital or labor tax. Both variables are significant with a negative impact. If we increase *TaxlabTot* and reduce consumption taxation (base tax), this will decrease piracy; we can also, in alternative, increase *TaxcapToT* and reduce consumption tax. Although this will depend of the advantages and disadvantages of changing one of these taxes.

When we consider both *TaxcapTot* and *TaxconTot, TaxconTot* is positive and significant which indicates that if we increase this tax and decrease the base tax (labor tax), this will increase piracy. Also when the base tax is the capital tax, *TaxconsTot* maintain the significance with a positive impact; an increase of this tax and a decrease of capital tax (the base tax) will increase piracy. Columns 28 to 30 shows the “Old” countries; in this case none of the variables are significant.

[87] On average in the Euro Zone this tax represents 47.7% of total taxation while on the remaining countries this value is of 46.6%.

Table 4.11 Relative importance of taxation in the New and Old Countries

	NEW			OLD		
Variables	25	26	27	28	29	30
GDPg	-0.001	0.000	-0.000	0.026*	0.026*	0.026*
	(-0.088)	(0.052)	(-0.029)	(1.836)	(1.842)	(1.832)
HICHgall	-0.004***	-0.004***	-0.004***	-0.054*	-0.053	-0.053*
	(-3.097)	(-2.985)	(-3.061)	(-1.671)	(-1.636)	(-1.653)
TaxcapTot	-0.036***	0.019		-0.016	-0.022	
	(-3.130)	(0.846)		(-0.455)	(-0.844)	
TaxlabTot	-0.056**		-0.022	0.006		0.021
	(-2.496)		(-0.974)	(0.204)		(0.821)
TaxconsTot		0.054**	0.034***		-0.008	0.014
		(2.316)	(2.794)		(-0.267)	(0.395)
Change	1.216***	1.223***	1.216***	1.225***	1.225***	1.227***
	(12.265)	(12.186)	(12.077)	(13.372)	(13.498)	(13.540)
Constant	5.657***	0.122	2.204	4.716**	5.391***	3.256
	(4.840)	(0.106)	(1.768)	(2.337)	(4.681)	(1.627)
Observations	155	155	155	194	194	194
R^2	0.871	0.870	0.871	0.858	0.858	0.858
$\bar{R}^2$	0.861	0.860	0.861	15	15	15
Countries	12	12	12	0.850	0.850	0.849
Hansen-Test	703.36	567.91	587.98	1054.141	1061.812	1201.264
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is ln(Losses). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. “New” represents the 10 countries that recently entered in 2004 and 2007.

4.5 Conclusion

This chapter analyzed the impact that levels of taxation have on software piracy. Previous econometric studies have relied on cross-sectional and panel data studies. Our contribution to the empirical literature is in the fact that we introduce a new analysis that studies the effect of taxation on different households types as well as introducing a large panel dataset for the European Union and its different regions. Results are valuable for policymakers, especially within the common market of the European Union.

Results indicate that personal taxation affects differently the households. An increase in taxation on households that have smaller income appears to increase piracy, being this impact more pronounced on these households than those that earn more. These results were also founded when the different regions of the EU were considered, although only significant on "Not Euro" and the "New" countries. Having more access to digital content combined with reduced incomes may result on using illegal software, for example downloading illegal music instead of purchasing them.

Further analysis was conducted with the relative importance of personal tax, capital tax and consumption tax as a share of total taxation. Results showed that even if its not possible to reduce the number of taxes or the actual rates applied, there appear to be some benefit in reducing the impact of taxation on consumption. These results were heterogeneous among the different regions. To promote effective measures to prevent piracy, effective policies are necessary targeting each group of countries and the different tax types (PIT, CIT and CIT).

Annex V Additional Summary Statistics

Table 4.12 Detailed summary statistics for Euro and Non Euro Zone

	Euro Area					Not Euro Area				
Variable	Obs.	Mean	S. D.	Min	Max	Obs.	Mean	S. D.	Min	Max
Losses	232	371.22	647.08	0.969	3191	140	232.10	417.77	4.843	2181
SPn50	252	18.10	7.39	4.62	36.66	150	22.46	7.11	0.15	39.26
SPn100	252	26.58	8.69	6.3	43.37	150	28.23	6.55	8.83	44.95
SPn125	252	29.36	8.73	8.46	47.71	150	30.17	7.40	11.37	48.37
SPn167	252	32.66	8.69	12.67	50.03	150	32.51	8.34	14.36	52.58
SPt67	252	4.32	9.92	-21.28	24	150	6.92	10.57	-21.56	24.69
SPn67	252	21.86	8.25	4.5	36.92	150	25.01	6.56	3.52	41.39
SPn80	252	23.97	8.61	4.8	42.28	150	26.44	6.39	6.12	43.17
Cn100100	252	26.63	8.56	6.30	44.28	150	28.16	6.61	12.93	44.95
Cn100333	252	22.74	7.97	5.68	38.09	150	25.69	6.53	9.35	41.39
Ct100	252	13.35	7.99	-8.6	28.05	150	17.32	8.98	-6.91	31.11
Ct100100	252	22.57	7.84	0.46	38.66	150	24.12	6.87	7.31	41.68
Ct10033	252	16.40	7.43	0.6	31.03	150	19.18	7.55	4.79	36.48
Ct10067	252	19.60	7.77	5.4	35.28	150	21.77	7.22	5.62	39.6
lGDPpc	255	9.95	0.39	8.67	11.15	150	9.47	0.57	8.37	10.35
HICPHall	255	94.87	12.30	53.71	126.95	150	93.99	22.17	5.01	139.62
HICPHgall	238	2.76	2.01	-1.7	12.2	139	6.82	15.11	-1.2	154.8
HICPHcultture	255	96.53	8.14	60.23	112.56	149	94.34	17.60	5.74	120.09
HICPHgcultute	238	1.46	2.17	-2.6	12.4	139	5.17	15.49	-4.9	146.6
HICPHcomm	255	104.37	21.30	38.86	206.34	149	93.17	20.63	1.81	124.6
HICPHgcomm	238	-.67	5.66	-14	41.4	139	6.69	28.61	-10.7	237.5
Itaxcons	251	20.66	3.84	11.1	29.3	150	21.71	5.30	11.7	34.2
Itaxlab	251	34.09	7.22	18.8	45.3	150	35.63	5.81	34.4	49.3
TaxlabGDP	255	17.47	5.00	9.4	26	150	17.39	5.83	9	32
TaxlabTotT	255	46.58	8.21	27	60.7	150	47.71	7.28	30.2	62.5
TaxlconsGDP	255	11.69	1.40	7.3	15.2	150	12.53	1.93	8.5	17.2
TaxconsTotT	255	32.34	5.82	22.8	44	150	35.81	5.94	24	54
TaxcapTotT	255	21.22	6.56	5.2	35	150	16.62	5.95	6.9	32.9

Notes: S.D represents the standard deviation, Min. the minimum and Max. the maximum.

Table 4.13 Detailed Summary Statistics for Old and New Countries

	Old Countries					New Countries				
Variable	Obs.	Mean	S. D.	Min	Max	Obs.	Mean	S.D.	Min	Max
Losses	207	519.27	703.61	16	3191	165	67.44	108.90	0.969	648
SPn50	225	20.91	7.85	4.62	39.26	177	18.22	6.95	0.15	31.31
SPn100	225	29.73	7.79	16.49	44.95	177	23.97	7.04	6.3	38.81
SPn125	225	32.63	7.93	18.76	48.37	177	25.90	7.07	8.46	42.52
SPn167	225	36.15	8	21.47	52.58	177	28.09	6.97	12.67	45.14
SPt67	225	7.79	8.87	-21.28	21.41	177	2.12	10.98	-21.56	24.69
SPn67	225	25.01	7.79	11.47	41.39	177	20.53	7.09	3.52	32.32
SPn80	225	27.20	7.94	13.89	43.17	177	21.95	6.91	4.8	32.82
Cn100100	225	29.68	7.80	17.43	44.95	177	24.05	6.88	6.3	38.81
Cn100333	225	25.52	7.82	10.45	41.39	177	21.71	6.73	5.68	34.25
Ct100	225	17.23	7.64	-2.17	31.11	177	11.78	8.75	-8.6	28.97
Ct100100	225	25.63	7.42	11.14	41.68	177	19.99	6.40	0.46	31.74
Ct10033	225	19.50	7.79	2.02	36.48	177	14.82	6.44	0.6	27.8
Ct10067	225	22.77	7.77	6.23	39.6	177	17.41	6.29	5.4	30.84
lGDPpc	225	10.11	0.29	9.38	11.15	180	9.36	0.42	8.37	10.11
HICPHall	225	96.17	9.47	72.68	117.68	180	92.52	22.47	5.01	139.62
HICPHgall	210	2.21	1.13	-1.7	5.4	167	6.95	13.77	-1.2	154.8
HICPHcultture	225	97.90	5.55	76.84	109.43	179	93.00	17.39	5.74	120.09
HICPHgcultute	210	0.83	1.47	-2.6	6.5	167	5.34	14.12	-4.9	146.6
HICPHcomm	225	106.43	12.98	83.84	156.36	179	92.47	27.32	1.81	206.34
HICPHgcomm	210	-1.93	3.11	-14	7.1	167	7.05	26.41	-13.6	237.5
Itaxcons	221	22.10	4.86	12.6	34.2	180	19.77	3.54	11.1	28.2
Itaxlab	221	35.69	7.02	21.6	49.3	180	33.40	6.23	18.8	42.6
TaxlabGDP	225	19.59	5.60	9.7	32	180	14.74	3.38	9	20.8
TaxlabTotT	225	48.50	7.86	32.5	62.5	180	45.12	7.53	27	57.2
TaxlconsGDP	225	11.71	1.57	7.3	16.4	180	12.36	1.71	8.5	17.2
TaxconsTotT	225	29.99	4.66	22.8	41.3	180	38.17	4.38	27.9	54
TaxcapTotT	225	21.68	5.78	10.9	34.9	180	16.81	6.83	5.2	35

Notes: S.D represents the standard deviation, Min. the minimum and Max. the maximum.

Annex VI Additional regressions with different inflations

Table 4.14 Regressions with the different inflation types

Variables	31	32	33	34	35	36	37	38	39	40
GDPg	0.008	0.008	0.008	0.009*	0.007	0.008	0.007	0.007	0.009*	0.006
	(1.259)	(1.279)	(1.270)	(1.777)	(1.241)	(1.273)	(1.187)	(1.195)	(1.645)	(1.130)
TaxconsGDP	0.065**	0.055**	0.058**	0.068***	0.070**	0.065**	0.054**	0.058**	0.067***	0.070***
	(2.369)	(2.232)	(2.234)	(2.579)	(2.466)	(2.485)	(2.298)	(2.324)	(2.711)	(2.590)
HICPHgculture	-0.005***	-0.004**	-0.004**	-0.004**	-0.004**					
	(-2.927)	(-2.366)	(-2.454)	(-2.549)	(-2.544)					
HICPHgcomm						-0.002***	-0.003***	-0.003***	-0.002***	-0.003***
						(-4.944)	(-5.207)	(-4.845)	(-4.275)	(-4.738)
SPn50		0.021**					0.022**			
		(2.043)					(2.216)			
SPn67			0.021*					0.022**		
			(1.862)					(2.019)		
SPn80				0.019*					0.019*	
				(1.658)					(1.781)	
Cn10033					0.018*					0.019*
					(1.663)					(1.857)
Change	0.981***	0.991***	0.984***	1.048***	0.942***	0.982***	0.988***	0.982***	1.050***	0.940***
	(13.673)	(13.426)	(13.287)	(14.775)	(14.135)	(13.733)	(13.746)	(13.606)	(14.847)	(14.093)
Constant	2.926***	2.647***	2.536***	2.469***	2.503***	2.918***	2.640***	2.522***	2.452***	2.479***
	(8.664)	(6.333)	(5.323)	(4.890)	(4.708)	(9.436)	(6.982)	(5.841)	(5.302)	(5.124)
Observations	349	346	346	346	346	349	346	346	346	346
R^2	0.880	0.883	0.882	0.875	0.878	0.880	0.883	0.882	0.876	0.878
Countries	27	27	27	27	27	27	27	27	27	27
$\bar{R}^2$	0.875	0.877	0.876	0.871	0.873	0.875	0.878	0.877	0.871	0.873
Hansen-Test	4.9e+04	1642.431	596.044	629.708	464.450	7.3e+04	1412.206	590.781	586.600	479.283
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses)*. All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses.

Annex VII Regressions with the remaining households types

Table 4.15 Remaining households for EU 27

Variables	41	42	43	44	45	46	47	48	49
GDPg	0.011*	0.014**	-0.013***	0.013**	0.015**	0.015**	0.014**	0.015**	0.015**
	(1.817)	(2.440)	(-2.759)	(2.055)	(2.403)	(2.422)	(2.430)	(2.421)	(2.432)
TaxconsGDP	0.065**	0.065**	0.062*	0.062**	0.084***	0.078***	0.076***	0.082***	0.086***
	(2.252)	(2.157)	(1.717)	(2.044)	(2.948)	(3.058)	(3.220)	(3.034)	(2.991)
HICPHgall	-0.004***	-0.004***	-0.007***	-0.004***	-0.003**	-0.003***	-0.003***	-0.003*	-0.003**
	(-4.139)	(-4.160)	(-8.192)	(-3.433)	(-2.370)	(-2.857)	(-2.594)	(-2.031)	(-2.144)
SPn100	0.007								
	(0.589)								
SPn125		0.000							
		(0.033)							
SPn167			0.001						
			(0.063)						
SPt67				-0.001					
				(-0.180)					
Cn100100					0.012				
					(1.116)				
Ct100						0.003			
						(0.418)			
Ct10033							0.009		
							(1.011)		
Ct10067								0.011	
								(1.072)	
Ct100100									0.012
									(1.152)
Change	1.234***	1.259***	1.102***	1.286***	1.135***	1.134***	1.140***	1.134***	1.141***
	(20.537)	(21.341)	(20.553)	(21.783)	(18.888)	(18.887)	(18.665)	(19.009)	(18.692)
Constant	2.781***	2.938***	3.091***	2.961***	2.336***	2.697***	2.593***	2.449***	2.357***
	(4.801)	(4.978)	(4.284)	(7.933)	(4.060)	(7.522)	(7.009)	(5.024)	(4.401)
Observations	346	346	346	346	346	346	346	346	346
R^2	0.851	0.850	0.861	0.854	0.866	0.866	0.867	0.867	0.867
Countries	27	27	27	27	27	27	27	27	27
$\bar{R}^2$	0.846	0.845	0.855	0.848	0.862	0.861	0.861	0.862	0.862
Hansen-Test	1182.253	1108.583	1244.960	2.4e+04	251.157	1257.545	914.464	408.865	380.457
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses).* All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses.

Table 4.16 Remaining households for the countries outside the EURO Zone

Variables	50	51	52	53	54	55	56	57	58
GDPg	0.005	0.005	0.004	0.003	0.009	0.008	0.009	0.008	0.009
	(1.009)	(0.877)	(0.719)	(0.602)	(1.224)	(1.144)	(1.177)	(1.182)	(1.193)
TaxconsGDP	0.071**	0.074*	0.074*	0.076*	0.083*	0.077*	0.070*	0.085*	0.088*
	(1.961)	(1.808)	(1.667)	(1.724)	(1.730)	(1.794)	(1.756)	(1.820)	(1.818)
HICPHgall	-0.004***	-0.004***	-0.004***	-0.004***	-0.003***	-0.004***	-0.003***	-0.003**	-0.003**
	(-3.016)	(-3.465)	(-4.065)	(-3.478)	(-2.693)	(-3.136)	(-3.166)	(-2.120)	(-2.027)
SPn100	0.015								
	(1.162)								
SPn125		0.007							
		(0.620)							
SPn167			-0.002						
			(-0.213)						
SPt67				0.004					
				(0.583)					
Cn100100					0.014				
					(1.018)				
Ct100						0.009			
						(0.904)			
Ct10033							0.012		
							(1.260)		
Ct10067								0.013	
								(1.120)	
Ct100100									0.014
									(1.026)
Change	1.126***	1.117***	1.112***	1.113***	1.147***	1.128***	1.130***	1.140***	1.143***
	(10.767)	(11.051)	(11.227)	(11.343)	(18.085)	(16.799)	(17.156)	(17.440)	(17.977)
Constant	2.345***	2.546***	2.854***	2.715***	2.252**	2.569***	2.556***	2.315***	2.223**
	(3.053)	(3.184)	(3.452)	(4.490)	(2.499)	(4.478)	(4.939)	(3.024)	(2.615)
Observations	131	131	131	131	131	131	131	131	131
R^2	0.918	0.917	0.916	0.917	0.914	0.914	0.915	0.915	0.915
Countries	10	10	10	10	10	10	10	10	10
$\bar{R}^2$	0.909	0.906	0.906	0.907	0.905	0.905	0.906	0.906	0.905
Hansen-Test	3130.502	1.3e+07	3.9e+05	1191.196	6665.099	419.068	4145.801	1.1e+06	1.1e+05
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses).* All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses.

Table 4.17 Remaining households for the NEW countries

Variables	59	60	61	62	63	64	65	66	67
GDPg	-0.016***	-0.016***	-0.016***	-0.016***	-0.016***	-0.016***	-0.016***	-0.016***	-0.016***
	(-3.425)	(-3.269)	(-3.134)	(-2.742)	(-3.337)	(-3.081)	(-3.207)	(-3.143)	(-3.193)
TaxconsGDP	0.074*	0.070*	0.064	0.071**	0.078*	0.071**	0.071**	0.075**	0.079**
	(1.913)	(1.793)	(1.609)	(1.989)	(1.803)	(1.989)	(2.024)	(2.042)	(2.096)
HICPHgall	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***
	(-12.417)	(-14.285)	(-14.908)	(-15.217)	(-10.975)	(-15.299)	(-15.214)	(-11.960)	(-13.031)
SPn100	0.007								
	(0.488)								
SPn125		-0.001							
		(-0.105)							
SPn167			-0.011						
			(-1.097)						
SPt67				-0.001					
				(-0.163)					
Cn100100					0.010				
					(0.639)				
Ct100						-0.001			
						(-0.229)			
Ct10033							0.002		
							(0.288)		
Ct10067								0.008	
								(0.692)	
Ct100100									0.009
									(0.882)
Change	0.920***	0.923***	0.929***	0.924***	0.916***	0.924***	0.920***	0.911***	0.910***
	(18.832)	(18.198)	(17.989)	(19.599)	(17.614)	(19.408)	(19.712)	(18.507)	(18.774)
Constant	1.756**	1.984***	2.345***	1.947***	1.620*	1.956***	1.923***	1.775***	1.671***
	(2.488)	(2.892)	(3.426)	(4.554)	(1.930)	(4.665)	(4.537)	(3.313)	(2.970)
Observations	152	152	152	152	152	152	152	152	152
R^2	0.880	0.880	0.881	0.880	0.880	0.880	0.880	0.880	0.881
Countries	12	12	12	12	12	12	12	12	12
$\bar{R}^2$	0.868	0.867	0.869	0.867	0.868	0.867	0.867	0.868	0.869
Hansen-Test	6.0e+09	2218.358	979.056	361.686	1775.228	2.2e+08	2.7e+04	7663.393	8.2e+05
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses)*. All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses.

Annex VIII regressions with the remaining regions

Table 4.18 The different Households types for the OLD countries

Variables	68	69	70	71	72	73	74	75	76	77	78	79	80	81
GDPg	0.022*	0.022*	0.021*	0.021*	0.021*	0.021*	0.021*	0.019*	0.020*	0.021*	0.018*	0.018*	0.019*	0.020*
	(1.777)	(1.860)	(1.764)	(1.788)	(1.780)	(1.816)	(1.857)	(1.742)	(1.776)	(1.787)	(1.645)	(1.755)	(1.776)	(1.799)
TaxconsGDP	0.055	0.055	0.062	0.061	0.058	0.058	0.062	0.064	0.062	0.057	0.063	0.065	0.065	0.061
	(0.842)	(0.827)	(0.952)	(0.949)	(0.877)	(0.867)	(0.948)	(0.980)	(0.945)	(0.865)	(0.963)	(1.002)	(1.001)	(0.926)
HICPHgculture	-0.062**	-0.062**	-0.061**	-0.061*	-0.061**	-0.061**	-0.059*	-0.068**	-0.059*	-0.061**	-0.062**	-0.060**	-0.061**	-0.061**
	(-2.339)	(-2.303)	(-2.187)	(-2.132)	(-2.214)	(-2.163)	(-1.968)	(-2.908)	(-2.071)	(-2.185)	(-2.272)	(-2.246)	(-2.214)	(-2.235)
SPn50		-0.002												
		(-0.145)												
SPn67			0.009											
			(0.517)											
SPn80				0.013										
				(0.746)										
SPn100					0.008									
					(0.501)									
SPn125						0.007								
						(0.378)								
SPn167							0.015							
							(0.693)							
SPt67								0.008						
								(0.983)						
Cn10033									0.015					
									(0.794)					
Cn100100										0.007				
										(0.440)				
Ct100											0.020			
											(0.907)			
Ct10033												0.021		
												(1.019)		
Ct10067													0.018	
													(0.903)	
Ct100100														0.013
														(0.722)
Change	1.238***	1.236***	1.245***	1.249***	1.244***	1.243***	1.242***	1.237***	1.255***	1.242***	1.242***	1.259***	1.249***	1.242***
	(15.829)	(17.004)	(15.988)	(16.042)	(16.082)	(16.296)	(15.749)	(15.206)	(15.870)	(16.001)	(14.903)	(14.930)	(15.310)	(15.269)
Constant	4.025***	4.073***	3.725***	3.606***	3.755***	3.757***	3.402**	3.862***	3.566***	3.800***	3.601***	3.481***	3.505***	3.619***
	(5.115)	(4.605)	(4.002)	(3.786)	(3.714)	(3.267)	(2.876)	(4.819)	(3.532)	(3.835)	(3.799)	(3.594)	(3.512)	(3.549)
Observations	194	194	194	194	194	194	194	194	194	194	194	194	194	194
R^2	0.856	0.856	0.856	0.856	0.856	0.856	0.857	0.857	0.857	0.856	0.859	0.859	0.858	0.857
Countries	15	15	15	15	15	15	15	15	15	15	15	15	15	15
$\bar{R}^2$	0.849	0.849	0.849	0.849	0.849	0.849	0.850	0.850	0.850	0.849	0.852	0.852	0.851	0.850
Hansen-Test	1.2e+04	2613.756	1134.045	1526.225	1692.318	1773.026	1942.547	946.576	1230.159	1401.549	1051.507	580.610	525.371	635.569
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Table 4.19 The different Households types for the EURO Zone

Variables	82	83	84	85	86	87	88	89	90	91	92	93	94	95
GDPg	0.022**	0.023**	0.021**	0.020**	0.021**	0.021**	0.021**	0.022**	0.021**	0.020**	0.021**	0.021**	0.020**	0.020**
	(2.446)	(2.302)	(2.077)	(2.157)	(2.200)	(2.227)	(2.247)	(2.287)	(2.177)	(2.121)	(2.220)	(2.311)	(2.233)	(2.245)
TaxconsGDP	0.081***	0.075**	0.073**	0.074**	0.074**	0.074**	0.077**	0.073**	0.073**	0.077**	0.073**	0.073**	0.075**	0.076**
	(2.833)	(2.525)	(2.472)	(2.492)	(2.362)	(2.249)	(2.258)	(2.463)	(2.445)	(2.308)	(2.516)	(2.525)	(2.457)	(2.328)
HICPHgculture	-0.048**	-0.048**	-0.049**	-0.049**	-0.049**	-0.049**	-0.049**	-0.048**	-0.049**	-0.049**	-0.049**	-0.049**	-0.049**	-0.049**
	(-2.409)	(-2.376)	(-2.448)	(-2.389)	(-2.383)	(-2.391)	(-2.316)	(-2.241)	(-2.394)	(-2.353)	(-2.428)	(-2.405)	(-2.453)	(-2.368)
SPn50		-0.008												
		(-0.534)												
SPn67			0.006											
			(0.275)											
SPn80				0.009										
				(0.445)										
SPn100					0.002									
					(0.095)									
SPn125						0.001								
						(0.045)								
SPn167							0.007							
							(0.319)							
SPt67								-0.002						
								(-0.400)						
Cn10033									0.001					
									(0.045)					
Cn100100										0.010				
										(0.443)				
Ct100											0.000			
											(0.049)			
Ct10033												0.002		
												(0.096)		
Ct10067													0.008	
													(0.422)	
Ct100100														0.006
														(0.363)
Change	1.199***	1.174***	1.177***	1.178***	1.179***	1.179***	1.178***	1.181***	1.179***	1.179***	1.178***	1.179***	1.178***	1.179***
	(13.041)	(13.453)	(12.598)	(12.787)	(12.820)	(12.833)	(12.726)	(12.861)	(13.094)	(12.703)	(12.853)	(12.915)	(12.837)	(12.944)
Constant	2.827***	3.097***	2.845***	2.734***	2.910***	2.934***	2.703**	2.970***	2.939***	2.669***	2.958***	2.940***	2.792***	2.800***
	(8.893)	(6.833)	(5.511)	(4.198)	(4.220)	(3.697)	(2.911)	(8.727)	(4.382)	(3.303)	(7.915)	(6.278)	(4.737)	(4.374)
Observations	218	215	215	215	215	215	215	215	215	215	215	215	215	215
R^2	0.839	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836
Countries	17	17	17	17	17	17	17	17	17	17	17	17	17	17
$\bar{R}^2$	0.829	0.826	0.825	0.826	0.825	0.825	0.826	0.825	0.825	0.826	0.825	0.825	0.826	0.826
Hansen-Test	8626.827	1041.778	808.702	853.152	918.880	751.863	823.716	2.7e+04	530.353	732.485	4742.566	2869.755	930.655	975.902
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Annex IX Unit root Formulas

We present the mathematical expressions used to compute the unit root tests of section (4.1). In this chapter we presented $Z_{\tilde{t}-bar}$ in which the output has an asymptotic standard normal distribution.

We rewrite equation (1)

$$\Delta y_{it} = \alpha_{it} + \phi_i y_{i,t-1} + \epsilon_{it} \tag{IX.4.1}$$

Consider

$$\tilde{t}\_bar_{NT} = \frac{1}{N}\sum_{i=1}^{N} \tilde{t}_{iT} \tag{IX.4.2}$$

where

$$\tilde{t}_{iT} = \frac{\Delta y_i' M_\tau y_{i,-1}}{\tilde{\sigma}_{iT}\left(y_{i,-1}' M_\tau y_{i,-1}\right)^{\frac{1}{2}}} \tag{IX.4.3}$$

We have that $\Delta \boldsymbol{y_i} = (\Delta y_{i2}, \dots, \Delta y_{iT})'$, $\boldsymbol{y_{i,-1}} = \left(y_{i1}, \dots, y_{i,T-1}\right)'$ and $\boldsymbol{M_\tau} = \mathbf{I} - \tau_T(\tau_T'\tau_T)^{-1}\tau_T'$
and

$$\tilde{\sigma}_{it}^2 = \frac{\Delta \boldsymbol{y_i' M_\tau y_i}}{T-1} \tag{IX.4.4}$$

then

$$Z_{\tilde{t}-bar} = \frac{\sqrt{N}\{\tilde{t}_{bar_{NT}} - N^{-1}\sum_{i=1}^{N} E(\tilde{t}_{iT})\}}{\sqrt{N^{-1}\sum_i Var(\tilde{t}_{iT})}} \tag{IX.4.5}$$

Both $E(\tilde{t}_{iT})$ and $Var(\tilde{t}_{iT})$ are obtained by linearly interpolating the values shown in Im et al. (2003).

In the variable in which we performed the Fisher type test we presented the inverse normal Z statistics that has the following mathematical expression.

$$Z = \frac{1}{\sqrt{N}}\sum_{i=1}^{N} \Phi^{-1}(p_i) \tag{IX.4.6}$$

Were $\Phi^{-1}(p_i)$ is the inverse of the standard normal cumulative distribution function and $Z \sim N(0,1)$.

Annex X The different regions of the European Union

The regions of Europe that will be analyzed here show different stages of development, which can affect the enforcements of laws and Government effectiveness. European Union has grown since its original creation (1952) with the European Coal and Steel Community (ECSC) and the European Economic Community (EEC) formed by Belgium, France, Federal Republic of Germany, Italy, Luxembourg and Netherlands. In 1973 entered Denmark, Ireland and the United Kingdom; later on in 1981 Greece entered. Its geographical domain expanded including many countries, such as Portugal and Spain that entered in 1986. With the Maastricht Treaty (1993) it was established the current name "European Union". Austria, Sweden and Finland joined in 1995. In 2004 10 countries entered: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Malta and Cyprus. In 2007 two more entered, Romania and Bulgaria. They represent two distinct realities (level of economic development, culture and language). Some of the new countries (Estonia, Latvia and Lithuania) came from the Union of Soviet Socialist Republics (USSR).

The Euro Zone is constituted by 17 countries[88], some of which recently entered the European Union. Countries that entered the Euro Zone must obey certain rules that were set in order to prevent inflation. A deficit less than 3% of the GDP, a debt less or equal than 60%, are part of the third stage of European Economic and Monetary Union (EMU) to adopt the euro as their currency. Additional to these criteria they had to obey an inflation rate that had to be at most, 1.5% points above the average of the three best performing Member States of the EU and also the nominal long-term interest rate must not be more than 2 percentage points higher than in the three lowest Member States. The rule of Government debt was relaxed to allow more countries to enter. (For a detailed description see art 104, 121 and 122 of the EC Treaty)

These criteria obey a certain principle; they suppose an average growth rate of 2%, deficit can be above 3% in extraordinary circumstances such as crisis. Unfortunately the crises stroke the European Union with the sovereign debt crisis. The objective of excessive deficit procedures is to prevent and sanction countries that did not meet these criteria. Not

[88] Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain.

one or two countries failed to meet these criteria; almost all of them. Examples are Austria, Italy, Portugal, France, and Ireland. Instead of sanctions it was proposed deadlines to the Member States to meet these criteria. This can affect the use of fiscal policies in order to promote expansionary policies, for example reducing the VAT rate on software products.

Annex XI Robustness Check

Table 4.20 Additional Results

Variables	96	97	98
GDPg	0.008	0.008	0.010
	(1.349)	(1.266)	(1.585)
TaxconsGDP	0.068***	0.063**	0.061**
	(2.843)	(2.658)	(2.435)
HICPHgall	-0.010**	-0.010**	-0.004***
	(-2.477)	(-2.489)	(-3.320)
SPn50	0.024*	0.024*	0.021**
	(1.893)	(1.914)	(2.081)
School	-0.120	-0.119	
	(-1.287)	(-1.320)	
Net	0.003		0.003
	(0.901)		(1.032)
Change	0.932***	0.977***	0.945***
	(8.991)	(11.925)	(9.989)
Constant	3.863**	3.973***	2.505***
	(2.660)	(2.785)	(5.788)
Observations	324	324	346
R^2	0.880	0.880	0.883
Countries	27	27	27
$\bar{R}^2$	0.874	0.874	0.877
Hansen-test	2064.071	5560.705	1066.475
p-value	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *ln(Losses).* All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. School is the total years of schooling offered in a country and net is the internet users. Both variables were retrieved from the WDI of the World Bank.

Chapter 5 Education and Software piracy in the European Union

* A first version of this chapter was presented in the PhD student workshop; School of Economics and Management, University of Minho July 3rd 2014

5.1 Introduction

The problem of software piracy has been growing over the years as a result of the exponential development and dissemination of the Internet and Computers. Since original conception of WWW protocol by Tim Berners-Lee in 1989[89], Internet speeds have increased exponentially exceeding nowadays more than 100MBPS[90]. The ability to interact with the information society in its different interface types (Computers, Tablets, Smartphones, etc.) doesn't come with the individual; the required knowledge is acquired in many cases at school or at the workplace. Furthermore, to take advantages of some of the functionalities of these devices it is necessary to have a certain level of skills acquired on school or at the work place or even self-taught. With better education comes also the knowledge to download illegal software without being caught by national Intellectual Property authorities. Education can affect the use of software, nevertheless, books in which content is taught also shape the knowledge acquired at the different levels of education, introduction of moral concepts can affect student's perception of illicit behaviour.

The content relating to Intellectual Property Rights in schoolbooks can shape and prevent future use of illicit software. In a recent study MacDonald and Fougere (2003) analysed in what extent the software piracy phenomenon is present in MIS (Management Information Science) textbooks using Index Citation[91]. The main result found by these authors was that software piracy was present on 72%, ethics was present in 67%, software license in 50%, copyright in 50% and intellectual property in 39%.

Recent literature (Goel & Nelson, 2009) focused solely on the literacy rate indicator a factor that could explain this phenomenon, having established a positive effect between literacy and software piracy. There have been attempts to explain piracy rates with other variables such as the years of schooling of people with age 25 and over (see Andrés (2006b)); in this case more schooling years resulted in less piracy. In our opinion we must also understand what happens in each level of education, from pre-primary to university, in

[89] http://www.webfoundation.org/vision/history-of-the-web/

[90] Many Internet providers in the European Union such as VOO in Belgium, Vodafone in the different countries that operates, offer these speeds.

[91] They used a 5-point likert scale in which 5 represents a perfect coverage: software piracy obtained 1.4; software license 0.9; Intellectual Property 1.0; Ethics 1.3 and Copyright 1.2. These results show that software piracy must be better taught in the courses of MIS.

order to promote concrete measures that Governments can implement with the help of national Intellectual Property Offices and European Union authorities. To Know in what levels of education is necessary to act primarily to mitigate piracy is essential as well as set different approaches at each level.

This chapter departs from the empirical literature focusing on the financial aspects of education, for example, considering the expenditure that the Governments put in different levels of education (measured in percentage of *GDPpc* or *GDP*). This approach also allows us to analyse how this expenditure is made on the different ISCED (International Standard Classification of Education) levels from 0 to 6[92]. We also introduce non-financial dimensions that reflect years of education offered in a country. The International Standard Classification of Education (ISCED) was designed by UNESCO in the early 1970's to serve "as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally". The present classification, now known as ISCED 1997, was approved by the UNESCO General Conference at its 29th session in November 1997. With this method it is possible to compare statistics on education in different countries worldwide.

European Countries have different dimensions (sizes) and, depending on their budgetary restrictions and level of taxation, they can spend more or less on education. Students at different levels of education receive help to continue his/her studies; this help comes in several forms such as scholarships. Normally, the higher the level of education attained the more expenses students incur on. Governments carefully attribute this financial help to those students with less income in order for them to continue the studies. We will analyse if the financial aid to students can influence their behaviour towards using legal or illegal software.

Expenditure on education can go to public and/or private education institutions. We will analyse how these expenditure on both types of institutions can be used to mitigate or even prevent the software piracy phenomenon.

[92] ISCED 0- Pre-primary education; ISCED 1- Primary education or first stage of basic education; ISCED 2- Lower secondary or second stage of basic education; ISCED 3- Upper secondary education; ISCED 4- Post-secondary non-tertiary education; ISCED 5- First Stage of tertiary education; ISCED 6- Second Stage of tertiary education.

This work studies the effects of education on software piracy, focusing on non-financial and financial measures, namely the investment (or lack of) in education, as a factor that can explain piracy in the European Union.

The main questions that we try to answer are the following:

(i) More years of schooling offered in a country will reduce piracy?

(ii) More resources allocated to education can prevent software piracy?

(iii) In which levels the Governments must allocate more resources and in what type of institutions?

(iv) Financial aid to students can prevent or even make disappear software piracy?

This chapter is organized as follows: section 5.2 makes a cross-country comparison of the students distribution according to different types of educational institutions. Section 5.3 describes the dataset, variables and methodology used; section 5.4 presents the empirical work; finally, section 5.5 concludes.

5.2 Distribution of Students in Private and Public educational institutions

Education and its quality can affect a student as its future performance in the workplace depends on the skills learned in school; more time at school increases student's future income (Mulligan, 1999) and his perception of the reality, e.g. of social norms and a better understanding of the national legal system (Hoskins, D'Hombres, & Campbell, 2008).

From the earliest times that parents face the decision to choose in which type of educational institution should enroll their children. Several factors affect this decision such as the quality of the institution, the education of parents, their financial constraints, etc. These educational institutions can be classified into public and private. In the first case, they are controlled and managed directly by a public education authority or agency[93]; in the second case they are controlled and managed by a non-governmental organization (e.g. a Church, Trade Union or business enterprise)[94]. Both types usually provide additional curricular activities such as Music, Chess and different types of Sports. Governments can also provide financial help to private institutions by means of national education system specific protocols.

Within the European Union framework, there are several frameworks that promote the development of countries[95] where educational institutions are included. One example of a mechanism to develop the regions is the European Regional Development Fund (ERDF - see Council Regulation - EC (1783/1999)). The main objective is to promote regional development. These countries must promote policies to help fund allocation to education that in turn will lower piracy and promote economic growth. Another important fund is the European Social Fund (ESF - see Council Regulation - EC (1784/1999)**)**. This fund has the objective to promote active labour market policies and prevent unemployment. One of the objectives is the promotion of education and training for the individuals. These funds serve to promote the education in a country, among other things.

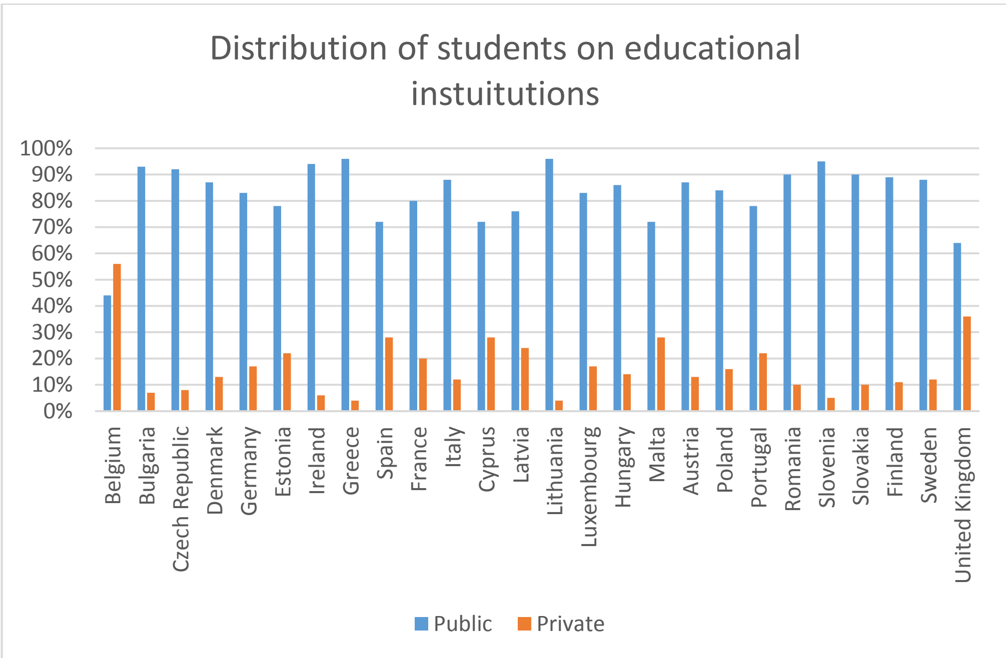
Figure 5.1 shows the percentage of students that are attending public and private educational institutions in all educational levels. All ISCED levels are jointly considered. To

[93] http://stats.oecd.org/glossary/detail.asp?ID=2194
[94] http://stats.oecd.org/glossary/detail.asp?ID=2123
[95] Countries receive structural funds in order to develop and promote growth (see Council Regulation (EC) **(1260/1999))**

obtain the percentage of students on public institutions, we divided the number of students and pupils on public institutions by the total student population (both public and private). In the same way to obtain the percentage of students on private institutions we divided the students and pupils in private institutions by the total student population.

Countries such as Belgium and United Kingdom have a great percentage of almost 50% of students on private educational institutions. Nevertheless, in the United Kingdom this percentage has declined over the years. Information on Netherlands was only available in 2000 and only 26% were in public institutions. In many countries the percentages of students on public institutions is declining over time in favour of private institutions. In 2010, the highest levels of students in public educational institutions were present on Greece (96%), Lithuania (96%), Slovenia (95%), Ireland (94%) and Bulgaria with 93%. The lowest student population on public institutions was on Belgium (44%) and United Kingdom (64%).

Figure 5.1 Distribution of students on public and private educational institutions in 2010



Notes: Source, Eurostat. Authors' calculations.

Table 5.1 and Table 5.2 present the different ISCED levels for public and private educational institutions. The ISCED 5 is a result of the sum of the ISCED 5A[96] and ISCED 5B[97]. It can be seen that Governments through public institutions play an important role in providing education for the young. The majority of countries have more than 90% of the student population in ISCED 1 through 6. Private institutions also play an important role on higher educational levels, namely ISCED 5 and 6 on Latvia. The distribution of students according to the type of institution varies among countries, and when the different levels of ISCED are considered, there are differences in each country.

[96] First stage of tertiary education - Syllabuses that are theoretically based, research preparatory or giving access to professions with high skills requirements (level 5A).
[97] First stage of tertiary education - Syllabuses practically oriented and occupationally specific (level 5B).

Table 5.1 Distribution of students on public and private educational institutions from ISCED 1 to ISCED 3

	ISCED 1						ISCED 2						ISCED 3					
	Public			Private			Public			Private			Public			Private		
Countries	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010
Belgium	46%	45%	46%	54%	55%	54%	42%	43%	40%	58%	57%	60%	40%	42%	43%	60%	58%	57%
Bulgaria	100%	100%	99%	0%	0%	1%	100%	99%	98%	0%	1%	2%	99%	98%	97%	1%	2%	3%
Czech Republic	99%	99%	98%	1%	1%	2%	98%	98%	97%	2%	2%	3%	90%	87%	86%	10%	13%	14%
Denmark	89%	88%	86%	11%	12%	14%	78%	76%	74%	22%	24%	26%	98%	98%	98%	2%	2%	2%
Germany	98%	97%	96%	2%	3%	4%	93%	92%	91%	7%	8%	9%	93%	92%	93%	7%	8%	7%
Estonia	99%	98%	96%	1%	2%	4%	99%	98%	97%	1%	2%	3%	99%	97%	97%	1%	3%	3%
Ireland	99%	99%	99%	1%	1%	1%	100%	100%	NA	0%	0%	NA	99%	99%	98%	1%	1%	2%
Greece	93%	93%	93%	7%	7%	7%	95%	95%	95%	5%	5%	5%	94%	94%	96%	6%	6%	4%
Spain	67%	68%	68%	33%	32%	32%	67%	68%	69%	33%	32%	31%	79%	78%	78%	21%	22%	22%
France	85%	85%	85%	15%	15%	15%	79%	79%	78%	21%	21%	22%	70%	70%	68%	30%	30%	32%
Italy	93%	93%	93%	7%	7%	7%	97%	96%	96%	3%	4%	4%	94%	95%	89%	6%	5%	11%
Cyprus	96%	94%	92%	4%	6%	8%	90%	87%	82%	10%	13%	18%	89%	87%	83%	11%	13%	17%
Latvia	99%	99%	99%	1%	1%	1%	99%	99%	99%	1%	1%	1%	99%	98%	98%	1%	2%	2%
Lithuania	100%	100%	99%	0%	0%	1%	100%	100%	99%	0%	0%	1%	100%	100%	99%	0%	0%	1%
Luxembourg	93%	93%	91%	7%	7%	9%	79%	80%	81%	21%	20%	19%	85%	84%	84%	15%	16%	16%
Hungary	95%	94%	91%	5%	6%	9%	95%	93%	91%	5%	7%	9%	91%	85%	79%	9%	15%	21%
Malta	64%	62%	59%	36%	38%	41%	70%	65%	62%	30%	35%	38%	89%	93%	92%	11%	7%	8%
Netherlands	31%	NA	NA	69%	NA	NA	25%	NA	NA	75%	NA	NA	8%	NA	NA	92%	NA	NA
Austria	96%	95%	94%	4%	5%	6%	93%	92%	91%	7%	8%	9%	91%	88%	89%	9%	12%	11%
Poland	99%	98%	97%	1%	2%	3%	99%	98%	96%	1%	2%	4%	94%	91%	86%	6%	9%	14%
Portugal	90%	90%	88%	10%	10%	12%	90%	88%	81%	10%	12%	19%	85%	82%	76%	15%	18%	24%
Romania	NA	100%	100%	NA	0%	0%	NA	100%	100%	NA	0%	0%	99%	99%	97%	1%	1%	3%
Slovenia	100%	100%	100%	0%	0%	0%	100%	100%	100%	0%	0%	0%	98%	96%	97%	2%	4%	3%
Slovakia	96%	95%	94%	4%	5%	6%	95%	94%	94%	5%	6%	6%	93%	89%	86%	7%	11%	14%
Finland	99%	99%	99%	1%	1%	1%	96%	96%	96%	4%	4%	4%	90%	86%	84%	10%	14%	16%
Sweden	97%	94%	92%	3%	6%	8%	97%	92%	88%	3%	7%	12%	98%	92%	84%	2%	8%	16%
United Kingdom	95%	95%	95%	5%	5%	5%	94%	94%	79%	6%	7%	21%	30%	25%	54%	70%	75%	46%

Table 5.2 Distribution of students on public and private educational institutions from ISCED 4 to ISCED 6

	ISCED 4						ISCED 5						ISCED 6					
	Public			Private			Public			Private			Public			Private		
GEO/TIME	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010	2000	2005	2010
Belgium	19%	17%	14%	81%	83%	86%	44%	45%	43%	56%	55%	57%	38%	44%	55%	62%	56%	45%
Bulgaria	81%	49%	20%	19%	51%	80%	89%	83%	78%	11%	17%	22%	100%	99%	98%	0%	1%	2%
Czech Republic	71%	71%	79%	29%	29%	21%	95%	90%	84%	5%	10%	16%	100%	100%	100%	0%	0%	0%
Denmark	NA	100%	NA	0%	0%	0%	NA	99%	98%	NA	1%	2%	NA	100%	NA	NA	0%	NA
Germany	96%	94%	92%	4%	6%	8%	NA	91%	88%	NA	9%	12%	NA	NA	NA	NA	NA	NA
Estonia	89%	92%	91%	11%	8%	9%	19%	18%	17%	81%	82%	83%	NA	NA	NA	NA	NA	NA
Ireland	100%	100%	100%	0%	0%	0%	95%	92%	95%	5%	8%	5%	98%	97%	98%	2%	3%	2%
Greece	77%	72%	NA	23%	28%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Spain	75%	NA	NA	25%	NA	NA	87%	86%	85%	13%	14%	15%	96%	95%	95%	4%	5%	5%
France	72%	66%	59%	28%	34%	41%	85%	83%	80%	15%	17%	20%	100%	100%	99%	0%	0%	1%
Italy	76%	79%	21%	24%	21%	79%	94%	94%	91%	6%	6%	9%	97%	96%	96%	3%	4%	4%
Cyprus	NA	NA	NA	NA	NA	NA	NA	NA	29%	NA	NA	71%	NA	NA	NA	NA	NA	NA
Latvia	98%	94%	86%	2%	6%	14%	2%	4%	6%	98%	96%	94%	0%	0%	NA	100%	100%	NA
Lithuania	NA	100%	100%	NA	0%	0%	96%	92%	88%	4%	8%	12%	NA	100%	99%	NA	0%	1%
Luxembourg	NA	100%	NA	NA	0%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hungary	95%	67%	61%	5%	33%	39%	87%	85%	83%	13%	15%	17%	98%	95%	93%	2%	5%	7%
Malta	100%	100%	100%	0%	0%	0%	100%	100%	100%	0%	0%	NA	100%	100%	NA	0%	0%	NA
Netherlands	NA	NA	NA	NA	NA	NA	31%	NA	NA	69%	NA	NA	79%	NA	NA	21%	NA	NA
Austria	85%	82%	81%	15%	18%	19%	92%	86%	83%	8%	14%	17%	100%	100%	98%	0%	0%	2%
Poland	45%	46%	23%	55%	54%	77%	72%	70%	67%	28%	30%	33%	92%	92%	93%	8%	8%	7%
Portugal	NA	28%	87%	NA	72%	13%	68%	73%	76%	32%	27%	24%	87%	89%	93%	13%	11%	7%
Romania	59%	49%	56%	41%	51%	44%	71%	77%	NA	29%	23%	NA	NA	100%	98%	NA	0%	2%
Slovenia	100%	98%	99%	0%	2%	1%	NA	92%	87%	NA	8%	13%	NA	88%	87%	NA	12%	13%
Slovakia	84%	75%	81%	16%	25%	19%	100%	98%	83%	0%	2%	17%	100%	99%	97%	0%	1%	3%
Finland	72%	87%	85%	28%	13%	15%	88%	89%	NA	12%	11%	NA	100%	100%	NA	0%	0%	NA
Sweden	94%	98%	49%	6%	14%	51%	94%	93%	91%	6%	7%	9%	93%	93%	93%	7%	7%	7%
United Kingdom	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5.3 Data and variable description

The construction of our dataset was based on the official statistics provided by the Eurostat website, from 2000 to 2011. Additional to this, the software piracy rates were retrieved from the official annual reports provided by the *Business Software Alliance* (BSA, 2003, 2004, 2005, 2010b, 2012). Data on the number of years of both primary and secondary education offered by each country were drawn from the *World Development Indicators* (WDI) provided by the World Bank.

5.3.1 Dependent Variable (Software Piracy)

Before a software product is released to the public it is necessary many hours of work (sometimes millions of euros in *R&D*), after of which the product is finalized and all bugs are eliminated. The feedback of possible software bugs is usually provided by testers[98] in early stages of software development (Alpha and Beta versions). Costs associated with software can vary; different categories of products (games, movies, productivity software) will have different mean prices. After a software product is finished the owner will seek copyright protection on a national or International Property Office. The software price will not reflect the actual hard copy but a license, and this price should take into account all previous costs devoted to its development. Not paying this license constitutes a crime (software piracy).

The dependent variable is the software piracy rates that represent the percentage of software that is illegally used. We can define Software Piracy as the unauthorized use of software, being for leisure or work, without paying a license to the owner. The *Business Software Alliance* provides an aggregate estimate of software piracy in a country and several categories of products are considered: General Productivity Applications[99], Professional

[98] http://www.istqb.org/
[99] 1. Databases, 2. Presentations Graphics, 3. Project Management, 4. Spreadsheets, 5. Word Processing.

Applications[100], and Utilities[101]. They also included operating systems, consumer-oriented software (games, personal finance and reference) and local-language software.

Software piracy can come in different forms: i) Softlifting, when we purchase a single licensed copy of the software and load it on multiple computers, contrary to the license terms; ii) Internet piracy occurs when we make unauthorized copies of copyrighted software available to others electronically, for example, lending to friends; iii) Software counterfeiting is the illegal duplication and distribution of copyrighted software in a form designed to make it appear to be legitimate; iv) OEM unbundling occurs when selling stand-alone software that was intended to be bundled with specific accompanying hardware; v) Hard disk loading installing consists of putting unauthorized copies of software onto the hard disks of personal computers, often as an incentive for the end user to buy the hardware from that particular hardware dealer; and vi) renting when unauthorized rental of software for temporary use is made similar to what occurs in Films.

5.3.2 Control Variables

This subsection describes variables, found by previous authors as affecting software piracy in a country. Variables affect the disposable income of households by means of personal income, taxation or inflation.

Previous authors found that the Gross Domestic per capita negatively affected the levels of software piracy (Goel & Nelson, 2009; Ram D. Gopal & Sanders, 1998; Marron & Steel, 2000). In Chapter 4 we found that, in the European Union, the impact of this variable was marginal. We will introduce a proxy variable that will represent the expenditure of households: household's final consumption expenditure per capita[102]. This variable is expected to have a negative impact on piracy, e.g., more expenditure on goods and services reduces piracy as they have more disposable income.

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[100] 6. Accounting, 7. Languages, 8. Curricular, 9. Desktop Publishing, 10. Other Languages, 11. Professional Drawing and Painting, 12. Programming Tools.

[101] 13. Application Utilities, 14. Calendar & Scheduling, 15. Clips, 16. Communications, 17. Education Administration & Productivity, 18. Electronic Mail, 19. Fonts, 20. Forms, 21. General Business, 22. Internet Access and Tools, 23. Personal and Business Productivity, 24. PIM's, 25. System Utilities and 26. Training.

[102] Final consumption expenditure (ESA95, 3.75-3.99) consists of expenditure incurred by residential institutional units on goods or services that are used for the direct satisfaction of the individual needs or wants or the collective needs of members of the community.

A measure of taxation in a country will be used (as with Chapter 4 The relative importance of consumption, corporate and labour taxation as a share of total GDP will be used. These taxes have a strong effect on an economy being households affected by them. The consumption taxation taxes their expenditure on goods and services, capital taxation taxes their income from deposits and labour taxation taxes their income. All taxes are expected to have a positive impact.

A control variable that measures the inflation of a country will be used; this variable allows a comparison of the evolution of prices across the European Union. Several dimensions can be considered here. In Chapter 4 we considered inflation of overall products, cultural products and communications. Results were similar in all categories of products. These variables were found to affect negatively software piracy losses, being this effect significant but marginal (values ranged from -0.004 to -0.006). Our analysis in this chapter focus on a different dependent variable, so these values may be different. Inflation may not affect software prices directly; nevertheless an increase on overall prices will affect the disposable income of households. This variable is expected to have a positive effect on software piracy.

5.3.3 Education dimension

This subsection introduces the education dimension, describing both non-financial and financial variables that can affect piracy. The non-financial measure of education will affect the future income of households as higher education can represent more job opportunities with better salaries. In the financial aspects, more resources allocated would provide better curricula and greater awareness by students about illicit content and about the consequences of their use. Resources could also be applied into the acquisition of software for personal use.

5.3.3.1 Non-financial educational dimension

We introduce a non-financial variable in the educational dimension that will reflect the education offered by a country in the primary and secondary levels. In Chapter 3 we studied this variable, analysing all countries present in the official publications provided by the *Business Software Alliance*. Both primary and secondary education had a negative impact on piracy, which indicates that more time spent at school reduces the risk of using illicit software. In our analysis we will consider the total schooling years offered by a country at both primary and secondary levels. This variable is expected to have a negative impact on piracy.

H1: More schooling years on primary and secondary education will lower piracy

5.3.3.2 Financial educational dimension

Expenditure on education can come from local Governments and Central Governments but usually the Central Government redistributes the income from taxes to the ministry of education that by turn will use it on schools and universities. Our main objective is to find if education plays an important role in deterring software piracy and, for that purpose, we will examine, when possible, the different ISCED levels.

Spending on education can come from different sources; one of these is the financial aid to students[103] as a percentage of total public expenditure on education. This variable is disaggregated into ISCED 1-4 and 5-6. This financial aid can come in the form of scholarships due to the low income of the parents, or can result from good grades and good behaviour. This variable is expected to have a negative effect. When considering the possible effect that this variable has on piracy we must consider the education of students, e.g. more education can also represent more knowledge of how to use and seek illegal software. This financial help can also provide resources to spend improving the access to digital content for example with the possibility to buy access to both Internet (at higher speeds) and a Personal Computer (of higher performance).

H2: Financial aid to students considering all ISCED levels has a negative effect on Software Piracy.

[103] Financial aid to pupils and students as % of total public expenditure on education, for all levels of education combined or on ISCED 1-4 and ISCED 5-6.

So far, previous authors only considered non-financial indicators such as literacy rates or years of schooling based on Barro and Lee (2013) dataset. To improve previous research we will introduce the annual expenditure on public and private[104] educational institutions per student/pupil compared to *GDPpc*. We will also consider the impact of public spending on education compared to GDP[105] (in both cases we expect the same results). Unfortunately the Eurostat don't provide a disaggregated analysis into public and private educational institutions. More spending on educational institutions can result in better curricula and also better resources to connect schools to the digital economy, for example offering higher Internet speeds and better computers for students. A disaggregated analysis using ISCED 0, ISCED 1, ISCED 2-4 and ISCED 5-6 will be considered.

H3: More spending on Education at all levels will reduce software piracy.

These resources must be made available to students and also increasing student's awareness when using software. Moreover, these resources also increase the potential for practicing software piracy. We expect that more educational expenditure on education will reduce piracy, although we expect a positive effect on higher educational levels as a result of better access to the digital world. We expect that the impact on the different educational levels may be different.

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[104] Annual expenditure on public and private educational institutions per pupil compared to GDP per capita for all levels of education combined based on full-time equivalents or on ISCED 1, ISCED 2-4 and ISCED 5-6.

[105] Total public expenditure on education as % of GDP, for all levels of education combined and on ISCED 1, ISCED 2-4 and ISCED 5-6

5.4 Empirical Evidence

5.4.1 Econometric Specification

In this section we provide the econometric specification that will be used. We can divide our analysis in two: one, considering the effects of public spending and other, analysing in what type of educational institutions expenditure is made. The main methodology used will be the fixed effect model as it was found by Andrés (2006a) and in Chapter 4 to be suited for the analysis within the European Union.

In model 6.1 we include the variables that will be used in the first analysis. The general econometric specification is given by:

$$PR_{it} = \alpha_1 \ln(HFCEpc)_{it} + \alpha_2 tax_{it} + \alpha_3 school_{it} + \alpha_4 HICPHg_{it} + \alpha_5 AIDall_{it} + \alpha_6 PubExpall_{it} + \alpha_7 change_t + \gamma_i + \vartheta_{it} \qquad (6.1)$$

where *PR* is the software piracy rate, *HFCEpc* is the consumption of households (both in natural logarithms); *tax* is the sum of tax on consumption as a share of GDP (*TaxConsGDP*), labour taxation as a share of GDP (*TaxlabGDP*) and capital taxation as a share of GDP (*TaxCapGDP*). $tax_{it} = TaxConsGDP + TaxLabGDP + TaxCapGDP$. School represents the total number of years of schooling offered by a country, which is the sum of both primary and secondary education. $school = primary + secondary$; *HICPHg* is the inflation for the overall products in a country.

PubExpall is the total public spending on education as a share of GDP; this variable can be decomposed into *PubExp0, PubExp1, PubExp24 and PubExp56*, which represent the ISCED 0, 1, 2-4 and 5-6 respectively. Financial aid to students is given by *AIDall*, which can also be decomposed into *AID14* and *AID56*, associated with ISCED 1-4 and ISCED 5-6 respectively. A variable that reflects the change in the methodology provided by the *Business Software Alliance* is introduced (*change*)[106]. ϑ_{it} represents the error term and γ_i is a panel specific component. *i* indexes the countries, i = 1,…,28 and t the time t = 2000,…,2010.

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[106] Based on the results of Png (2010).

In equation 6.2 and 6.3 we provide the econometric specification for the remaining analysis, e.g. assessing in what type of educational institution to invest in order to lower piracy and in what levels.

$$PR_{it} = \beta_1 \ln(HFCEpc)_{it} + \beta_2 tax_{it} + \beta_3 school_{it} + \beta_4 HICPHg_{it} + \beta_5 AIDall_{it} + \beta_6 PubPriall_{it} + \beta_7 change_t + \gamma_i + \vartheta_{it} \tag{6.2}$$

$$PR_{it} = \beta_1 \ln(HFCEpc)_{it} + \beta_2 tax_{it} + \beta_4 school_{it} + \beta_5 HICPHg_{it} + \beta_6 AIDall_{it} + \beta_7 Puball_{it} + \beta_8 change_t + \gamma_i + \vartheta_{it} \tag{6.3}$$

PubPriall is the expenditure on public and private educational institutions per student as a percentage of GDPpc. *Puball* is educational expenditure only on public institutions. The first variable can be decomposed into *PubPri1, PubPri24 and PubPri56*, representing expenditure on the different ISCED levels. The second variable can be decomposed into *Pub1, Pub24 and Pub56* (related again with their ISCED levels).

5.4.2 Summary Statistics

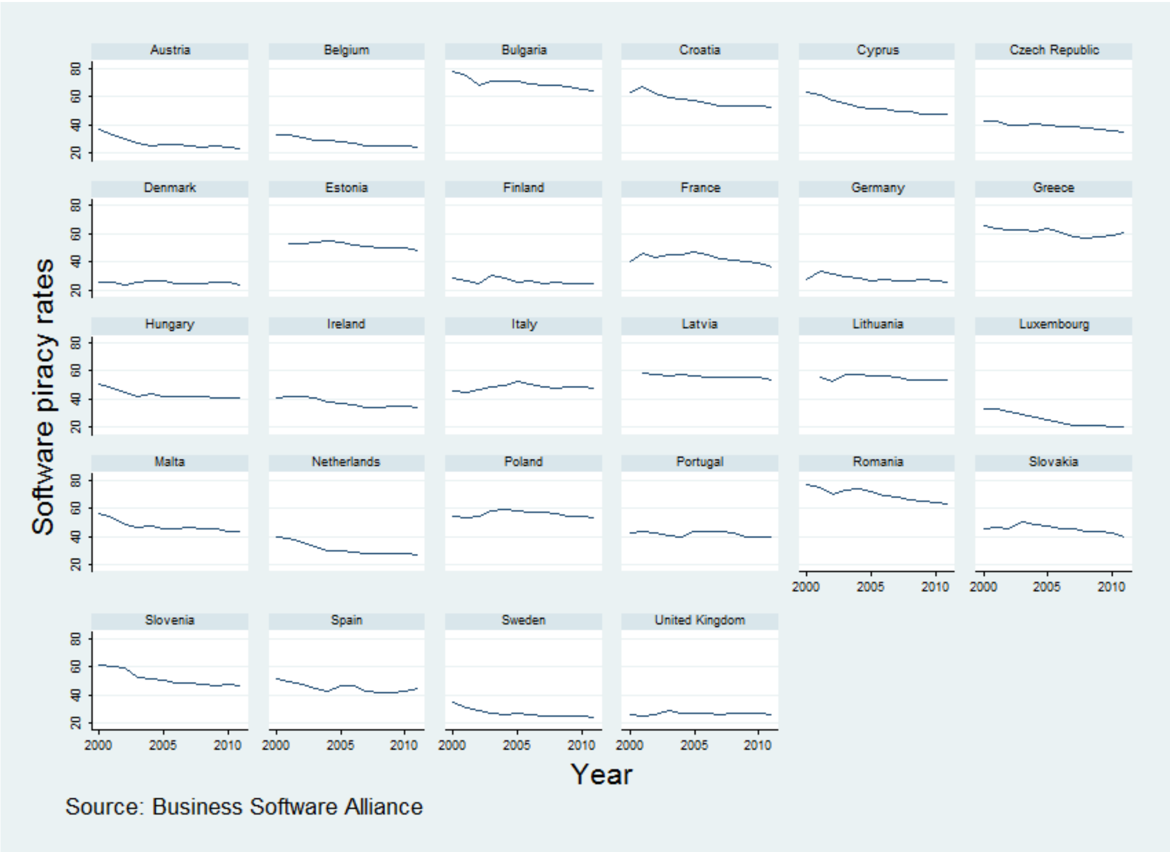
Table 5.3 presents the summary statistics for the entire sample. Luxembourg has the minimum piracy rate, which is 20%. This rate has been constant over the last three years. Bulgaria has the highest rate at 78% in 2000. With respect to financial aid, it can be seen that more resources are allocated into higher levels of education. This also happens in relation to expenditure on education on both public and private educational institutions. Public spending on education on the different ISCED levels show that less spending is devoted to lower educational levels, on ISCED 1 on average 1.34% of GDP is devoted to education while in ISCED 2-4, 2.23%. This increase does not reflect only an increase on the number of pupils in higher levels, but also that expenditure per student, either when we just consider the public or the public and private expenditure, is also higher in higher levels of education, as can be seen when we compare the Pub and *PubPri* variables across education levels. The maximum value of inflation occurred in Romania in 2000. Figure 5.2 also shows the trend in software piracy rates over the last years.

Table 5.3 Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
PR	329	43.60	13.77	20.00	78.00
ln(HFCEpc)	336	9.41	0.74	7.31	10.51
Primary	336	5.32	1.04	4.00	8.00
Secondary	336	6.98	1.08	5.00	9.00
school	336	12.30	0.48	11.00	13.00
TaxConsGDP	334	12.15	1.87	7.3	19.2
TaxCapGDP	334	7.02	2.48	1.7	14
TaxLabGDP	334	17.19	5.1	9.1	30.8
HICPHg	336	3.46	3.88	-1.70	45.70
Change	336	0.75	0.43	0.00	1.00
PubExpall	319	5.28	1.15	2.88	8.81
PubExp0	294	0.56	0.24	0.00	1.61
PubExp1	300	1.34	0.47	0.49	2.69
PubExp24	301	2.23	0.60	0.71	5.31
PubExp56	290	1.23	0.43	0.51	2.71
AIDall	316	6.56	4.29	0.00	23.10
AID14	303	4.25	3.68	0.00	20.90
AID56	306	16.30	11.30	0.10	59.00
Puball	296	25.54	4.90	16.30	48.20
Pub1	301	20.93	5.13	9.80	39.00
Pub24	301	25.48	6.61	13.00	73.10
Pub56	283	40.98	12.26	18.50	95.90
PubPriall	277	25.60	3.91	17.40	43.50
PubPri1	281	21.07	5.00	10.90	37.60
PubPri24	281	25.49	5.76	13.00	63.00
PubPri56	279	38.29	7.13	21.40	56.00

Notes: S.D represents the standard deviation, Min. the minimum and Max. the maximum.

Figure 5.2 Piracy trend



5.5 Effects of public spending on education in software piracy

In this subsection we present the empirical results for public spending on education. We start by introducing an aggregated analysis, and then we examine what happens in the different ISCED levels. In each of the regressions reported we present the Hansen-test statistic that is a robust version of the Hausman test (Schaffer & Stillman, 2010). When performing estimation we must choose the appropriate estimation for the analysis. In our framework we could use the random effect (RE) or the fixed effect model. The Hausman test assumes, under the null hypothesis, that the RE estimator is consistent. The fixed effects estimator uses orthogonality conditions where the regressors are uncorrelated with the idiosyncratic error term. On the other hand, the random effect model assumes on top of this that the regressors are uncorrelated with the group-specific error; Hansen-test treats this assumption as an additional orthogonality condition. In this case, rejecting the null hypothesis favours the fixed effect model. We also report in Annex XII the unit root tests of the variables used, namely the Fisher type unit root test (I. Choi, 2001). In this framework four tests are available: Inverse chi-squared; Inverse normal; Inverse logit and Modified inverse chi-squared. Based on I. Choi (2001) simulations results, the inverse normal Z statistic offers the best trade-off between size and power. All variables are stationary.

5.5.1 Control Variables

Table 5.4 presents the preliminary results. In column 1 to 3 we provide the baseline model in which only the control variables are present; variables have the expected values and are significant with the exception of *tax*.

The first variable introduced that represent an economic dimension, was the household final consumption expenditure (*ln(HFCEpc)*). This variable has a negative value, which indicates that when final consumption of goods increases (also means that households have more money available), this reduces software piracy. Several categories of goods can be considered in this type of consumption: durable goods, semi-durable goods and non-durable goods. We can interpret the magnitude effect of the change in software piracy rate resulting from change in independent variable by one standard deviation. If we consider the

-5.874 coefficient and the standard deviation of 0.74 on the *HFCEpc*, multiplying the two results in a reduction of piracy of -4.3 point.

Durable goods in the framework of the digital economy can be seen as a purchase of a computer or a printer. Semi-durable goods are software products. This purchase can be annual in the case of software such as Antivirus or productivity software in which annual releases are available in a regular basis (e.g. Matlab). Computer and Console games can also be considered a semi-durable good, as the time to amortize them is fairly low, with the exception of certain RPG (Role Play Games) types. Examples of non-durable goods are toners and other consumables (paper, ink). Households also have more money to spend on services; examples of which are the monthly Internet fees, but also annual software subscriptions. One example in the gaming framework is the annual Playstation Plus subscription that allows the user to play many games and purchase others with smaller prices.

Another variable introduced that affects income, namely by changing the price of products, was the inflation rate. While in many cases software products are not affected by inflation, being its prices constant over the years, the effect of inflation have a positive effect on software piracy being significant at 5%. Our initially hypothesis is also supported. This effect indicates that an increase of overall products prices can lead to less disposable income of households to purchase non-essential goods such as movies or music. Households will shift their consumption to illicit software. Increasing this variable by one standard deviation would result in an increase of piracy of 0.44 points (3.88*0.115).

The final control variable introduced measures the relative importance of taxation; significance was not present.

5.5.2 Educational dimension

5.5.2.1 Non-financial educational dimension

Within this dimension, we introduced the total years of schooling offered by a country measured by the *school, primary* and *secondary* variables. This variable has a negative impact on piracy supporting our initial hypothesis. This is not a measure of education attained but a measured of education offered. Results indicate that when a country changes its years of schooling in both primary and secondary education, it can reduce piracy, but the effects may not be verified immediately after the change. These changes must be made with caution has there are countries in which this value is extremely high (13 years in Germany and Ireland are two examples). In this case an increase is not feasible. But there are countries that have only 11 years of schooling (Bulgaria); this value was increase to 12 years in 2003. A change in one standard deviation of this variable results in an improvement of software piracy of (-2.479*1.04) -2.57 in primary and (-2.239*1.07) -2.4 in secondary education. When a detailed analysis is made on the ISCED levels (Table 5.5), both primary and secondary are significant across specifications.

Table 5.4 Public expenditure on Education for all the ISCED levels

VARIABLES	1	2	3	4	5
ln(HFCEpc)	-5.874***	-5.510***	-5.437***	-1.761	-2.333*
	(-4.967)	(-4.708)	(-4.435)	(-1.040)	(-1.867)
HICPHg	0.097	0.095	0.095	0.115**	0.178**
	(1.392)	(1.351)	(1.373)	(2.417)	(2.016)
Primary	-1.651	-1.355		-2.479*	-2.026
	(-1.021)	(-0.906)		(-1.729)	(-1.195)
Secondary	-1.974	-1.689		-2.239	-1.925
	(-1.015)	(-0.921)		(-1.258)	(-0.936)
School			-1.376		
			(-1.029)		
TaxConsGDP	0.003				
	(0.007)				
TaxLabGDP	-0.391				
	(-1.064)				
TaxCapGDP	0.187				
	(0.531)				
Tax		-0.064	-0.068	-0.022	0.119
		(-0.270)	(-0.291)	(-0.118)	(0.767)
AIDall				0.070	
				(0.617)	
AID14					-0.010
					(-0.093)
AID56					0.087**
					(1.976)
PubExpall				-1.164**	-1.168**
				(-2.418)	(-2.398)
Change	-1.947**	-1.993**	-2.009**	-3.722***	-3.252***
	(-2.225)	(-2.250)	(-2.272)	(-2.607)	(-2.733)
Constant	127.991***	117.944***	115.364***	97.331***	90.359***
	(4.941)	(4.894)	(5.498)	(3.912)	(3.685)
Observations	327	327	327	308	285
Countries	28	28	28	28	27
R^2	0.487	0.476	0.476	0.560	0.544
$\bar{R}^2$	0.464	0.456	0.457	0.534	0.515
Hansen test	73.090	72.380	115.641	1008.522	783.704
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *PR* (piracy rates). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. Degrees of freedom of t-distribution for n>120 are: critical values at 10% are 1.645; at 5% are 1.960 and at 1% are 2.576. *, ** and *** represent significance at 10%, 5% and 1% respectively.

5.5.2.2 Financial Educational dimension

In columns 4 and 5 of Table 5.4 we introduce the public spending on education as a share of GDP and financial aid to students. Our initial hypothesis within this dimension is also supported. Results show that public spending on education can reduce software piracy but, at the same time, financial help given to students may have a positive impact on piracy.

When an aggregated analysis is made on financial aid to students, there is a positive impact of 0.070 without significance. In column 5 we present a disaggregated analysis (*AID14*, and *AID56*): *AID14* is negative but not significant; only on higher levels of education, e.g. *AID*56, significance was present with a coefficient of 0.087. This positive impact can be explained by more availability of digital content provided to students but also more knowledge to seek and download illegal software without being caught. As predicted, different impacts on the different levels of education are present. The negative impact on educational expenditure can be explained by more resources available to teachers that will promote educational methods that will be passed to students improving their perception of the new technologies. More resources on education can also be used to control Internet access points using the central server. That policy could limit bandwidth when seeking illicit content. A change in one standard deviation of these variable results in an change of software piracy of 1 point (0.087*12.26) for *AID56* and -1.34 points (-1.168*1.15) for *PubExpall.*

After establishing our baseline model we consider a disaggregated analysis based on the different ISCED levels. Table 5.5 presents the results. In column 6 we include all expenditures on the different educational levels; as expected they have a negative effect on software piracy. Significance was found on *PubExp56* at 1% with a coefficient of -4.031. In the ISCED that ranges from 5 to 6, students are in the University. During this period of their life they begin to learn with the new technologies and preparing to the labour market within its respective fields of study.

Increase awareness through, for example, an improved curriculum, could reduce piracy. But, as results show, financial help to students have a positive effect. The promotion of consumption of legal software is not an easy task; even software with a reduced price is pirated.

Columns 7 to 12 investigate the individual effects on the different ISCED levels; *PubExp56* has the same impact and significance. This result indicates that the first step to reduce piracy is in the university graduates that, by turn, will teach their children and will adopt measures to reduce piracy. Young graduates that will work either at firms or in teaching will increase the awareness of the new generations. An increase by one standard deviation of *PubExp56* would decrease piracy by 1.78 points (-4.162*0.43). Hansen test favours the fixed effect model on all regressions with a significance of 1%.

Table 5.5 Detailed Public expenditure on Education for the different ISCED levels

Variables	6	7	8	9	10	11	12
ln(HFCEpc)	-1.578	-1.467	-1.592	-1.495	-1.164	-1.262	-1.131
	(-1.293)	(-1.077)	(-1.160)	(-1.065)	(-0.991)	(-1.026)	(-1.008)
Primary	-3.328***	-2.762*	-2.857*	-2.719**	-3.254***	-3.104***	-3.316***
	(-2.721)	(-1.958)	(-1.912)	(-2.254)	(-3.269)	(-2.640)	(-3.321)
Secondary	-3.602**	-2.979*	-3.148*	-2.817*	-3.505***	-3.618***	-3.794***
	(-2.492)	(-1.804)	(-1.852)	(-1.922)	(-2.923)	(-2.613)	(-3.193)
TaxConsGDP	0.236	0.090	0.137	0.167	0.198	0.534**	0.534**
	(0.846)	(0.270)	(0.420)	(0.505)	(0.697)	(2.271)	(2.294)
TaxLabGDP	0.002	-0.231	-0.144	-0.163	-0.021	-0.095	0.028
	(0.009)	(-0.986)	(-0.620)	(-0.656)	(-0.105)	(-0.464)	(0.145)
HICPHg	0.162**	0.182***	0.179***	0.164***	0.170***	0.199***	0.187***
	(2.394)	(2.877)	(2.929)	(2.576)	(2.661)	(3.179)	(3.023)
AIDall	0.099	0.028	0.043	0.046	0.088		
	(0.979)	(0.254)	(0.398)	(0.430)	(0.945)		
AID14						-0.001	0.025
						(-0.013)	(0.263)
AID56						0.088**	0.072
						(2.205)	(1.549)
PubExp0	-0.388	-0.258				0.319	
	(-0.193)	(-0.167)				(0.155)	
PubExp1	-0.757		-1.154				
	(-0.593)		(-0.860)				
PubExp24	-0.180			-0.591			
	(-0.410)			(-1.197)			
PubExp56	-4.031***				-4.162***		-2.821**
	(-3.223)				(-3.270)		(-2.094)
Change	-4.817***	-5.463***	-5.663***	-5.547***	-4.883***	-5.851	-4.973***
	(-3.984)	(-4.193)	(-4.269)	(-4.199)	(-4.120)	(-1.233)	(-4.702)
Constant	105.730***	97.346***	99.518***	95.311***	100.337***	92.165***	94.449***
	(5.260)	(4.234)	(4.106)	(4.493)	(5.520)	(4.479)	(5.558)
Observations	284	286	288	289	286	267	268
Countries	27	28	28	28	27	27	27
R^2	0.603	0.569	0.573	0.567	0.594	0.574	0.583
$\bar{R}^2$	0.570	0.538	0.543	0.537	0.565	0.540	0.549
Hansen test	801.993	654.661	1046.784	3514.025	1382.423	1154.172	2068.230
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *PR* (piracy rates). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. *, ** and *** represent significance at 10%, 5% and 1% respectively

5.6 Effects on software piracy of expenditure on education on different types of institutions

Having established that more public spending on education as a share of *GDP* reduces software piracy, this section now investigates in what type of educational institutions more resources must be allocated in order to prevent piracy. Expenditure is measured per student/pupil as a percentage of *GDPpc*. As in with the previous case, we present first an aggregated analysis, which is shown in Table 5.6.

Table 5.6 Expenditure on public and private education and on public education for all the ISCED levels

	Public Institutions		Public and Private institutions	
Variables	13	14	15	16
ln(HFCEpc)	-2.031	-1.994*	-0.921	-0.697
	(-1.159)	(-1.652)	(-0.476)	(-0.567)
School	-0.817	-0.451	-2.694**	-2.504**
	(-0.751)	(-0.358)	(-2.182)	(-2.000)
Tax	-0.053	0.026	-0.182	0.019
	(-0.304)	(0.196)	(-0.927)	(0.115)
HICPHg	0.110***	0.164**	0.214	0.292*
	(3.298)	(2.455)	(1.382)	(1.742)
AIDall	-0.007		0.080	
	(-0.059)		(0.737)	
AID14		-0.121		-0.012
		(-1.520)		(-0.147)
AID56		0.094*		0.108**
		(1.830)		(2.328)
Puball	-0.189**	-0.156*		
	(-2.156)	(-1.733)		
PubPriall			-0.107	-0.091
			(-1.176)	(-1.206)
Change	-3.068**	-2.907***	-3.772***	-3.819***
	(-2.397)	(-2.615)	(-2.846)	(-3.404)
Constant	79.508***	68.825***	93.312***	79.109***
	(3.826)	(3.627)	(4.095)	(4.074)
Observations	287	264	273	259
Countries	28	27	27	27
R^2	0.601	0.621	0.528	0.553
$\bar{R}^2$	0.576	0.593	0.497	0.519
Hansen test	9.3e+04	6615.450	815.291	863.573
p-value	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *PR* (piracy rates). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. *, ** and *** represent significance at 10%, 5% and 1% respectively.

Columns 13 to 16 show the results for expenditure on public and on public and private institutions. A disaggregated analysis on public and private educational institutions is not possible, nevertheless it has a negative effect on piracy. Significance is only present when we only consider expenditure on public educational institutions. More expenditure on education compared to *GDPpc* will lower piracy.

Results for the control variables are maintained but losing some significance. We can also observe that financial aid to students on ISCED 5-6 has a positive effect being significant at least at 10%. Financial aid to students helps to mitigate the problem of software piracy when students are still young, but it has not the desired effect on higher levels. To prevent this it is necessary to implement direct measures that lead students to think that using illicit software is not appropriate, or indirect measures such as a substantial software price reduction of "online software" when compared to the traditional retail versions. This policy is already in practice with respect to Office 365 for students; they can acquire a license for four years for 79 euros. To benefit from this measure it is only necessary a proof such as student number (ISIC) or university email. Results suggest that resources must be focused essentially on public educational institutions, which, in the majority of countries, are also the predominant ones. More formally, a change in one standard deviation of this variable results in an improvement of software piracy of -0.76 (-0.156*4.9) points; in this case it does not reach a 1% improvement.

Years of schooling are only significant when both types of educational institutions are considered, having the expected sign.

Finally, Table 5.7 presents a disaggregated analysis according to the different ISCED levels. When all levels are considered together (column 17 and 18), expenditure on public institutions on ISCED 2-4 and ISCED 5-6 is negative and significant at least at 5%. A disaggregated analysis is made on the remaining columns (19 to 21). All variables that represent public expenditure are negative and significant.

The remaining columns show the expenditure both on public and private educational institutions. Column 22 shows the expenditure on the different ISCED levels considered together. None are significant. A disaggregated (column 23 to 25) analysis show that more expenditure per student on lower levels, e.g, ISCED1 to ISCED 4 will lower piracy. We also confirm that in all regressions the Hansen-test favours the fixed effect model.

Measures to promote ethics can be easily implemented in private institutions as an extra-curricular activity, but this will depend on the willingness of each school. In private schools oriented to business and law this is easily implemented, while in schools more oriented to arts, this may not be so effective. Public institutions have more restrict rules and some face severe financial constraints that can prevent the implementation of additional extra-curricular activities. Considering both public and private educational institutions, if we change by one standard deviation PubPri1 and PubPri24, this will decrease piracy by 1.14 points (-0.228*5) and 0.78 points (-0.135*5.76), respectively. Based on the results, more expenditure per studentis more effective on lower levels of education.

Table 5.7 Expenditure on public and private education and on public education for the different ISCED levels

	Public Institutions					Public and Private Institutions			
Variables	17	18	19	20	21	22	23	24	25
ln(HFCEpc)	-5.861***	-5.987***	-5.426***	-5.968***	-6.650***	-4.445***	-4.390***	-5.316***	-6.045***
	(-4.562)	(-4.925)	(-4.326)	(-5.361)	(-6.013)	(-3.346)	(-3.449)	(-4.374)	(-5.015)
School	-0.131	-0.066	-0.233	0.059	-0.042	-2.008	-2.133	-1.808	-2.058
	(-0.096)	(-0.053)	(-0.151)	(0.048)	(-0.032)	(-1.270)	(-1.293)	(-1.224)	(-1.295)
Tax	-0.048	0.106	0.054	0.085	0.047	0.110	0.083	0.076	-0.010
	(-0.234)	(0.602)	(0.311)	(0.473)	(0.244)	(0.552)	(0.415)	(0.355)	(-0.042)
HICPHg	0.081**	0.115*	0.111	0.124	0.144	0.307**	0.316**	0.299*	0.314**
	(2.508)	(1.737)	(1.146)	(1.506)	(1.639)	(2.023)	(2.045)	(1.945)	(2.022)
AIDall	-0.087								
	(-0.822)								
AID14		-0.097	-0.130	-0.103	-0.154*	-0.010	-0.018	0.000	-0.013
		(-1.092)	(-1.473)	(-1.231)	(-1.686)	(-0.094)	(-0.175)	(0.001)	(-0.117)
AID56		0.016	0.069	0.059	0.046	0.081**	0.085**	0.074*	0.077
		(0.221)	(1.289)	(1.173)	(0.626)	(1.971)	(2.037)	(1.786)	(1.617)
Pub1	-0.072	-0.075	-0.188*						
	(-0.637)	(-0.604)	(-1.792)						
Pub24	-0.102*	-0.111**		-0.148**					
	(-1.915)	(-2.083)		(-2.089)					
Pub56	-0.063**	-0.065**			-0.092***				
	(-2.062)	(-2.063)			(-2.649)				
PubPri1						-0.170	-0.228**		
						(-1.219)	(-2.173)		
PubPri24						-0.079		-0.135***	
						(-1.264)		(-2.577)	
PubPri56						-0.000			-0.024
						(-0.007)			(-0.433)
change	-1.589*	-1.402	-1.242	-1.242	-1.338	-1.404	-1.420	-1.491*	-1.589*
	(-1.863)	(-1.577)	(-1.481)	(-1.498)	(-1.455)	(-1.603)	(-1.616)	(-1.720)	(-1.796)
Constant	110.628***	104.276***	98.555***	98.780***	108.841***	108.949***	110.102***	114.003***	124.654***
	(5.641)	(6.245)	(4.890)	(5.593)	(5.496)	(5.117)	(5.102)	(5.210)	(5.629)
Observations	272	252	265	265	258	259	259	259	261
Countries	26	26	27	27	26	27	27	27	27
R^2	0.553	0.549	0.516	0.528	0.511	0.465	0.461	0.457	0.443
$\bar{R}^2$	0.527	0.518	0.488	0.502	0.483	0.429	0.430	0.425	0.412
Hansen test	1677.655	1160.316	527.681	1151.464	1158.328	391.824	120.626	266.095	297.185
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: Dependent variable is *PR* (piracy rates). All regressions were estimates with time dummies. Robust *t-statistics* are in parentheses. *, ** and *** represent significance at 10%, 5% and 1% respectively.

5.7 Conclusions

This chapter analysed the effects that expenditure on education has in deterring software piracy. We compared the different ISCED levels according to the 1997 classification. This classification will be replaced by a new ISCED 2011 methodology that will begin in 2013 and will take into account a more disaggregated analysis.

Results on the impact of educational expenditure on software piracy were based on the 28 Member States of the European Union from 2000 to 2010. Based on previous literature (Andrés, 2006a; Chen et al., 2010) and also on Chapter 4 we used the fixed effect model that was also the most appropriate according with the Hansen test.

More years of schooling on both primary and secondary education will reduce piracy. In spite of this, this may be difficult to implement in some countries that have already high number of schooling years.

We found that more educational expenditures have a deterrent effect on piracy while financial help to students, favours availability of digital content. This will increase the probability of the search and use of illicit software. When a more detailed analysis is made on the different ISCED 1997 classifications, we found strong evidence that expenditure on ISCED 5-6 as a share of *GDP* can lead to a software piracy decrease. This expenditure can be promoted by national governments, for example with an increase in the quality of school manuals. When the analysis considers the type of institution in which the expenditure is made, more expenditure on ISCED 1 to ISCED 4 per pupil/student as a percentage of *GDPpc* leads to less piracy.

Even if national Governments have financial constraints, namely budgetary deficits that prevent more resources allocated to improve their education, an increase of these expenses could reduce piracy. Within the European Union, structural funds should be better allocated in this area.

Annex XII Unit Root test

Table 5.8 Unit root test

Variable	Inverse Normal Z Statistic
PR	-10.4580***
ln(HFCEpc)	-6.2472***
Primary	-9.3080***
Secondary	-7.1065***
School	-11.2991***
TaxConsGDP	-8.2616***
TaxCapGDP	-9.6379***
TaxLabGDP	-6.3579***
HICPHg	-11.1203***
Pubexpall	-6.6238***
Pubexp0	-7.2837***
Pubexp1	-6.5188***
Pubexp24	-7.8452***
Pubexp56	-8.4047***
AIDall	-8.3605***
AID14	-9.4367***
AID56	-6.6238***
Puball	-5.0545***
Pub1	-5.8668***
Pub24	-4.7734***
Pub56	-7.3692***
PubPriall	-6.2092***
PubPri1	-5.6190***
PubPri24	-6.0002***
PubPri56	-7.7283***

Notes: Unit root Fisher-type test. In all variables it was subtracted cross-sectional means and included a drift term. This test assumes under the null hypothesis that all panels contain unit roots against the alternative hypothesis that at least some panels are stationary. Due to the nature of the panel dataset, being extremely unbalanced this test was the only one available.

Annex XIII Robustness Checks

Table 5.9 robustness using *HFCEpc* from different products/services

VARIABLES	26	27	28	29	30
ln(HFCEpc)	-5.695***				
	(-5.061)				
Ln(HFCEpcdurable)		-1.460**			
		(-2.018)			
Ln(HFCEpcsemidurable)			-1.534		
			(-1.506)		
Ln(HFCEpcnondurable)				-5.285***	
				(-5.459)	
Ln(HFCEpcservices)					-4.641***
					(-4.149)
School	-2.403	-3.394**	-2.900	-2.560	-2.600
	(-1.183)	(-2.307)	(-1.460)	(-1.310)	(-1.302)
tax	0.057	0.065	0.065	0.023	0.009
	(0.274)	(0.306)	(0.299)	(0.108)	(0.038)
HICPHg	0.068	0.104**	0.107**	0.088	0.077
	(1.163)	(2.040)	(1.998)	(1.574)	(1.244)
AIDall	0.059	0.121	0.057	0.095	0.080
	(0.587)	(1.206)	(0.546)	(0.963)	(0.769)
PubexpGDPall	-1.706***	-1.966***	-1.849***	-2.048***	-1.873***
	(-4.190)	(-4.698)	(-4.234)	(-4.472)	(-4.336)
change	-1.285	-1.834**	-1.927***	-1.141	-1.151
	(-1.534)	(-2.429)	(-2.650)	(-1.492)	(-1.358)
Constant	133.649***	103.494***	97.936***	127.533***	123.866***
	(5.030)	(4.880)	(3.733)	(5.082)	(4.703)
Observations	308	285	286	286	286
Countries	28	26	26	26	26
R^2	0.498	0.444	0.442	0.499	0.482
$\bar{R}^2$	0.476	0.417	0.415	0.475	0.457
Hansen test	762.889	540.805	2023.576	1064.785	1390.415
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: *HFCEpc* durable goods (*HFCEpcdurable*), *HFCEpc* semi-durable goods (*HFCEpcsemidurable*), *HFCEpc* non-durable goods (*HFCEpcnondurable*), HFCEpc in services (*HFCEpcservices*). Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5.10 Robustness check using patent applications ICT

VARIABLES	31	32	33	34	35
ln(HFCEpc)	-5.719***	-5.982***	-6.303***	-6.176***	-6.092***
	(-4.706)	(-4.194)	(-5.566)	(-4.818)	(-6.007)
school	-2.470	-2.661*	-2.379	-3.319**	-2.805*
	(-1.209)	(-1.939)	(-1.160)	(-2.527)	(-1.845)
Tax	0.039	0.200	0.240	0.010	0.170
	(0.187)	(1.019)	(1.200)	(0.049)	(0.943)
HICPHg	0.077	0.263***	0.074	0.038	0.068
	(1.228)	(2.601)	(1.110)	(0.458)	(0.762)
aidall	0.069	0.138	0.057	0.125	0.114
	(0.572)	(0.842)	(0.401)	(0.795)	(0.852)
PubexpGDPall	-1.663***	-0.962	-1.042	-1.557***	-1.229**
	(-2.973)	(-1.568)	(-1.594)	(-2.831)	(-2.419)
patICTpc	0.028				
	(1.103)				
patconselectpc		0.171***			
		(6.653)			
Patcomputerpc			0.134***		
			(3.376)		
pattelecomunicationpc				0.013	
				(0.367)	
patotherICTpc					0.092
					(1.058)
change	-1.071	-0.789	-0.741	-1.249	-1.143
	(-1.270)	(-0.872)	(-0.859)	(-1.415)	(-1.289)
Constant	134.046***	125.623***	126.429***	148.940***	133.647***
	(5.013)	(5.877)	(4.581)	(6.962)	(5.824)
Observations	300	231	272	271	283
Countries	28	28	28	28	28
R^2	0.498	0.509	0.530	0.496	0.488
$\bar{R}^2$	0.474	0.477	0.504	0.469	0.461
Hansen test	3865.562	107.160	1727.979	253.904	735.971
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Notes: ICT patent applications to the EPO by priority year at national level. Information and communication technology (ICT) – total (patICTpc), Consumer electronics (patconselectpc), Computers (Patcomputerpc), Telecommunications (pattelecomunicationpc), Other ICT (patotherICTpc). Variables are per per capita. http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database#

Annex XIV The ISCED classification

The International Standard Classification of Education (ISCED) was designed by UNESCO in the early 1970's to serve "as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally". The present classification, now known as ISCED 1997, was approved by the UNESCO General Conference at its 29th session in November 1997. With this method it is possible to compare statistics on education in different countries worldwide.

This classification is divided into six categories:

- ISCED 0- Pre-primary education
- ISCED 1- Primary education or first stage of basic education
- ISCED 2- Lower secondary or second stage of basic education
- ISCED 3- Upper secondary education
- ISCED 4- Post-secondary non-tertiary education
- ISCED 5- First Stage of tertiary education
- ISCED 6- Second Stage of tertiary education.

Each of these categories is characterized by being progressive; each additional level represents more complex subjects taught. When this methodology was implemented, and to facilitate a more detailed analysis within each level of education, some levels were disaggregated. For example the ISCED 3 was divided into 3A, 3B and 3C. Some of these would lead directly to the labor market. Each level has variable proxy's that make possible its calculation; for example, the main criteria for determining the ISCED 6 is the ability to make research-oriented content and submission of thesis or dissertation, the subsidiary criteria is the ability to prepare graduates for faculty and research posts. We now define each level of the ISCED level.

- ISCED 0, (pre-primary) is the initial stage of organized instruction; it is designed primarily to introduce very young children to a school-type environment. One example is the kinder garden.
- ISCED 1 is designed to give students a sound basic education in reading, writing and mathematics along with an elementary understanding of other subjects such as history, geography, natural science, social science, art and music. In some cases religious

instruction is featured. Example of this is the primary education that, in many cases represents 4 years of schooling.

- ISCED 2 is designed to complete the provision of basic education which began at ISCED 1. The educational aim is to lay the foundation for lifelong learning and human development on which countries may expand, systematically, further educational opportunities. The programmes at this level are usually on a more subject-oriented pattern using more specialized teachers and more often several teachers conducting classes in their field of specialization. This level of education sometimes coincides with the compulsory education.
- ISCED 3 begins after the compulsory education. The entrance age to this level is typically 15 or 16 years. The educational programmes included at this level typically require the completion of some 9 years of full-time education (since the beginning of level 1) for admission or a combination of education and vocational or technical experience and with as minimum entrance requirements the completion of level 2.
- ISCED 4 captures programmes that straddle the boundary between upper-secondary and post-secondary education from an international point of view, even though they might clearly be considered as upper-secondary or post-secondary programmes in a national context.
- ISCED 5 level or tertiary programmes are characterized by a theoretical background that will serve for the labor market in future. Depending on the areas, it can range from 4 to 6 years of schooling. Some areas will allow an internship in the final year to apply the theory learned. This level of education will allow the progression to level 6 that is a research program.
- ISCED 6 is reserved for tertiary programmes which lead to the award of an advanced research qualification. The programmes are therefore devoted to advanced study and original research and are not based on course-work only (examples of these are the Master and PhD programs; some have subjects that will help the future research). *Source: Unesco. International Standard Classification of Education I S C E D 1997. Unesco Institute for Statistics. May 2006, Re-edition*

This methodology suffers some deficiencies; the disaggregation is small which can limit international comparisons, for example at a university level. This methodology has 16 years, in 2011 it was published an improvement to this classification with the ISCED 2011. Unfortunately for an econometric analysis we must use the old methodology. International organization such as the EUROSTAT, World Bank and OECD will implement these new measures. It is expected that the first international education data collections using ISCED 2011 will begin in 2013 or 2014.

The new ISCED 2011 levels will be disaggregated into:

- ISCED 0- Less than primary
- ISCED 1- Primary
- ISCED 2- Lower secondary
- ISCED 3- Upper secondary
- ISCED 4- Post-secondary non-tertiary
- ISCED 5- Short-cycle tertiary
- ISCED 6- Bachelor or equivalent
- ISCED 7- Master or equivalent
- ISCED 8- Doctoral or equivalent
- ISCED 9- Not elsewhere classified

This new classification will allow an in deep analysis of the different levels of education, at the university level, allowing international comparisons. Previous ISCED level included many types of education in the same level, unfortunately, even in the ISCED 1997 classification, financial indicators for each dimension is not available (e.g. ISCED 1,2,3 separately).

Chapter 6 Economic growth and software piracy

6.1 Introduction

The literature on software piracy, which can be seen as a subgroup of studies about Intellectual Property Rights (IPR, henceforth), has focused either in studying its determinants or its impact on economic growth.

Examples of the studies that focused on the determinants are: Shadlen et al. (2005) which studied if the level of software protection and also if international mechanisms, such as Copyright laws, can mitigate piracy. They analyze the direct pressures exerted by the US (US Special 301[107]), for the foreign countries to increase or to exert more efficiently IPR protection. Lack of enforcement of Bilateral Political Pressures, TRIPS[108] and Trade dependence on US can explain the levels of piracy in these countries. Others authors, such as (Andrés (2006a); Goel and Nelson (2009)) have done more comprehensive studies (see also Chapter 3 Summing up, these authors found that economic dimensions measured by the introduction of GDP have a negative impact on piracy; higher income leads to less piracy.

In terms of the impact on economic growth, most of the empirical literature has focused not specifically on software piracy but on the impact of IPR protection on Economic growth (Falvey et al., 2006; Gould & Gruben, 1996; Park & Ginarte, 1997). From these studies we can conclude that IPR protection favors economic growth, being this impact slightly higher on more open economies. Also IPR protection appears to favor low and higher income economies while in the middle-income countries this is not necessarily true. Exceptions to this holistic type of analysis are the works of Andrés and Goel (2012) and Rodriguez-Montemayor (2013),which focused specifically on the effects of software piracy. Andrés and Goel (2012) found that software piracy rates affected positively economic growth. Rodriguez-Montemayor (2013) considered the effect of genuine and unlicensed software on income. When both variables were considered separately they had a positive impact, but when both were introduced simultaneously the unlicensed software reduced the

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[107] The Special 301 Report is prepared annually by the Office of the United States Trade Representative (USTR) under Section 301 as amended of the Trade Act of 1974. The reports identify trade barriers to US companies and products due to the intellectual property laws, such as copyright, patents and trademarks, in other countries. Each year the USTR must identify countries which do not provide "adequate and effective" protection of intellectual property rights or "fair and equitable market access to United States persons that rely upon intellectual property rights".

[108] Agreement on Trade-Related Aspects of Intellectual Property Rights

income of the country However, up to our knowledge, these two approaches have not been combined. As is referred in several papers, software piracy has an effect on growth, but growth is one of the determinants of software piracy. This chapter will try to bridge that gap by estimating simultaneous the two effects and measure the effect of piracy on growth and vice-versa.

To answer these questions we used data from the official publications of the *Business Software Alliance* (BSA), *World Development Indicators* (WDI) and Barro and Lee (2013). A simultaneous equation approach (3SLS) for the years 1995, 2000, 2005 and 2010, comprising 75 countries will be used in the analysis.

This chapter is organized as follows: section 6.2 presents the variables and econometric specification; section 6.3 presents the empirical work. Finally, section 6.4 concludes.

6.2 Data and Econometric Specification

Many factors can affect the economic growth of a country, especially innovation in the form of investment (gross capital formation), consumption (GDPpc) and protection of inventions (patents and trademarks). Other variables such as the software piracy in a country can also have negative impact on growth, as potential software sales are lost. On the other hand, the existence of some piracy can have a positive effect on growth as workers productivity may increase, due to access to more software tools. One of the determinants of software piracy is the national income of a country and, in this perspective; economic growth may have a role in this impact. To take into account this simultaneity (e.g. piracy affects economic growth and vice-versa) we will consider a system of equations that can explain this phenomenon.

We will use the 3SLS estimator which is suited when we have a system of structural equations in which one of them include one or more endogenous variables among the explanatory variables (Zellner & Theil, 1962). Another advantage of the 3SLS is that it is more efficient to capture the interrelation between equations and the causal and feedback effects between the variables (AlDakhil, 1998; Wooldridge, 2010).

To construct our model, we retrieved our data from the Word Development Indicators *(WDI)*[109] of the World Bank, the official publications of the *Business Software Alliance*[110] and for the educational dimension we retrieved data on schooling years of the Barro and Lee (2013) dataset[111] for 1995, 2000, 2005 and 2010; for a total of 75 countries. Our model is defined in equation 6.1 and 6.2.

$$\Delta GDPpc_{it} = \alpha_0 + \alpha_1 X + \alpha_{11} PR_{it} + \alpha_{12} PR^2{}_{it} + S_i + DEV_i + \varepsilon_{it} \qquad (6.1)$$

$$PR_{it} = \beta_0 + \beta_1 \Delta GDPpc_{it} + \beta_2 \mathrm{Z} + +S_i + DEV_i + \epsilon_{it} \qquad (6.2)$$

[109] Available at http://data.worldbank.org/data-catalog/world-development-indicators ; these correspond to the control variables
[110] The values of Software Piracy Rates
[111] Data available at http://www.barrolee.com/data/dataexp.htm

The dependent variables are the GDP growth per capita ($\Delta GDPpc_{it}$), and the software piracy rates measured in percentage (PR_{it}). The vector X represents the control variables in the growth equation and the vector Z the control variables in the piracy rate equation; these are explained in the following subsection.

The software piracy rates (BSA, 2003, 2011) measures the percentage of unlicensed software that is used illegally and, as explained before, its effect on growth is dubious.

In economic growth it is common to use five years' intervals to prevent results being affected by business cycles (Barro & Sala-i-Martin, 2003, p. 534). In 2002/2003 occurred a change of the methodology used by the *Business Software Alliance* to compute piracy rates (Png, 2010). As with previous studies, we also consider five period time spans leaving two periods before and after the change in methodology. When implementing the econometric specification, the dataset is reduced to three time periods. In our model we also introduce country dummies represented by S_i and also time dummies. Regarding variable indexes, *i* represents the countries, *t* the time periods and ϵ_{it} represents the error terms. Δ is the first difference operator.

6.2.1 Economic growth equation

Equation 6.3 shows the main determinants of economic growth, extending the neoclassical growth model that is a function of capital and labor (Solow, 1956). In our model the growth equation is a function of several variables.

$$\Delta GDPpc_{it} = \alpha_0 + \alpha_1 L5.GDPpc_{it} + \alpha_2 \Delta GDI_{it} + \alpha_3 \Delta Lab_{it} + \alpha_4 inflation_{it} + \\ + \alpha_5 \Delta Export_{it} + \alpha_6 Net_{it} + \alpha_7 Mobile_{it} + \alpha_8 FBIS_{it} + \alpha_9 Phone \\ + \alpha_{10} school_{it} + \alpha_{11} PR_{it} + \alpha_{12} PR^2{}_{it} + S_i + DEV_i + \varepsilon_{it} \qquad (6.3)$$

i=1,…,75 and t=2000,2005,2010

We introduce the GDP per capita[112] ($GDPpc_{it}$) lagged five periods that is measured at 2005 constant prices. It is expected to have a negative effect based on the results of Romer (1990). In Economic growth we have absolute convergence when poorer economies growth, in per capita terms, faster than richer economies (Barro & Sala-i-Martin, 2003, p. 45). We will test this hypothesis against different groups of countries. To test this absolute convergence, we will also use a dummy variable DEV which takes the value 1 if it is a low or a lower-middle-income country and zero otherwise.

Another variable introduced is the gross capital formation growth (ΔGDI) measured at constant prices. It is expected to promote growth following, between others, Goel and Ram (1994).

We also include the growth rate of labor force (ΔLab). This variable can have mixed results (Aiginger, 2005) and labor policies can also affect economic growth. It can affect positively economic growth because less inactive persons are in the economy. Less social contributions in the form of subsidies to unemployed will be paid. Furthermore, these workers will have more money to spend on the economy. On the other side this variable can affect negatively economic growth because an overwhelming supply of labor force can drive salaries down, following the law of demand and supply. This will lead to less disposable income of workers. Also, more workers can increase pressure on the countries resources and have a detrimental effect on growth.

Inflation rate *(inflation)* may affect economic growth. This variable has been found to negatively affect economic growth (Barro, 2013b). It represents the evolution of prices over the years.

The export growth *(ΔExport)* of goods and services indicates how the national economy is performing. Andraz and Rodrigues (2010) analyzed the impact on exports for the Portuguese economy over the period of 1977 to 2004. Results show that exports increase economic growth in the long run.

A variable that reflects access to digital content is the Internet users (*Net*). This variable indicates the level of access to the World Wide Web (WWW) measured per 100 people. More access to information will increase the consumption of digital goods that will increase national income (C. Choi & Hoon Yi, 2009; Clarke, 2008). Additional to this we

[112] This variable takes into account purchase power parity

will introduce broadband access (*FBIS*), mobile cellular subscriptions (*Mobile*) and telephone users (*Phone*).

Human capital can affect economic growth and, in fact, Barro (2013a) found that it had a positive effect on economic growth. In our model we consider the total effective year of schooling that students have, considering a broad age group of people with age 15 and over (*school*) (Barro & Lee, 2013). More schooling years indicates that employees can be more productive with the same limited resources.

6.2.2 Software piracy equation

The equation (6.4) describes the macroeconomic determinants of software piracy.

$$PR_{it} = \beta_0 + \beta_1 \Delta GDPpc_{it} + \beta_2 \ln(Patpc)_{it} + \beta_3 \ln(Tradpc)_{it} +$$
$$+\beta_4 Net_{it} + \beta_5 Mobile_{it} + \beta_6 FBIS_{it} + \beta_7 Phone + \beta_8 school_{it} + S_i + \epsilon_{it} \quad (6.4)$$

It is a result of the sum of dimensions that represent economic aspects, access to information, educational and variables that describe technological dimensions.

6.2.2.1 Economic dimension

Several measures of income were considered in previous studies. Goel and Nelson (2009) considered the *GDPpc* having a deterrent effect on piracy. Another measured considered using a sample of European Countries (EU 27) in Chapter 4 was the $\Delta GDPpc$. This variable had a positive effect but was not significant. Using a panel of 75 countries for 1995, 2000 and 2002; Bezmen and Depken (2005) also found a positive relationship between $\Delta GDPpc$ and software piracy.

6.2.2.2 Access to information

Access to information measures the availability of digital content and is represented by the variables *Net*, *FBIS, Phone, Mobile* that will affect the availability of software (both legal and illegal). It is expected to affect negatively piracy based on the results of Goel and Nelson (2009), Boyce (2011) and in Chapter 3

6.2.2.3 Educational dimension

The educational dimension is represented by the number of effective schooling years in a country (*school*) (Barro & Lee, 2013) (the same as in the growth equation). More schooling years indicate that students are aware of the consequences of using digital content in an illicit way. Nevertheless, they may seek this content. Previous authors found that this dimension affects negatively piracy in a country using different variables. Years of schooling of population age 25 and over have a negative effect, without significance (Andrés, 2006b). This variable is only available in 5 years' time periods. Extending this result in Chapter 3 we used the years of schooling offered in a country that was also found to have a negative impact on piracy, being significant.

6.2.2.4 Technological dimensions.

The final dimension considered is the technological one; we introduce the patents and trademark applicants done both by residents and non-residents. A trademark is a result of a distinctive sign that identifies a specific product; can represent letters, symbols, drawings, etc. It is sought in order to prevent unfair competition[113] by competitors. A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. In both cases these types of protection can be sought by the residents of a country that offers

[113] Unfair competition in a sense means that the competitors compete on unequal terms, because favorable or disadvantageous conditions are applied to some competitors but not to others; or that the actions of some competitors actively harm the position of others with respect to their ability to compete on equal and fair terms.

protection, but can also be sought by foreigners that want the protection of their products abroad. We use these variables per capita in natural logarithms.

Total patents *ln(Patpc)* is a result of the sum of patents done by residents and by non-residents. In the same way total trademarks *ln(Tradpc)* is the result of the sum of trademark applicants from residents and non-residents. Both variables were retrieved from the *WDI* of the World Bank and are measured in per capita terms. It is expected that these variables can affect software piracy in a country (based on Chapter 3 although the signs can be mixed.

Table 6.1 presents the basic summary statistics of the variables used.

Table 6.1 Summary statistics all sample

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Endogenous variables					
ΔGDPpc	297	0.0341	0.0328	-0.1150	0.1374
PR	273	0.5986	0.2106	0.2	0.99
Exogenous variables					
ΔGDI	295	.0786	0.127	-.424	0.752
GDPpc	298	15451.88	12144.47	813.35	52313.91
ΔLab	300	0.0133	0.0176	-0.0454	0.0611
Inflation	294	0.1037	0.3022	-0.0370	3.7675
ΔExport	295	0.1048	0.0973	-0.518	0.89
Net	293	24.89	27.05	0.0001	95
Phone	299	28.68	20.11	0.24	73.04
FBIS	195	8.60	10.54	0	37.99
Mobile	300	51.43	47.38	0	195.57
School	300	8.81	2.33	1.62	13.1
PR^2	273	0.4026	0.2520	0.04	0.98
ln(Tradpc)	285	-6.99	1.15	-10.32	-3.64
ln(Patpc)	275	-9.11	1.63	-13.32	-5.67
DEV	300	0.24	0.43	0	1

Notes: S.D represents the standard deviation, Min. the minimum and Max. the maximum.

6.3 Empirical Application

6.3.1 Empirical evidence

This section presents the empirical results of the growth equation (see equation 1) and the piracy rate equation (see equation 2) using the 3SLS. In the empirical analysis we introduced country and time dummies to take into account our panel data.

In the growth equation we introduced the initial GDP measured by the *L5.GDPpc,* without significance. In Model 2 and 4 we introduce an alternative measure of income on the growth equation. *DEV* is a dummy variable that represents low income and lower-middle-income countries based on the division of the *WDI*. We found evidence of absolute convergence (due to the significance of *DEV*), which indicates that poor economies growth faster, in per capita terms, than advanced economies. *GDPpcg* represents the economic dimension in the piracy rate equation. Results show that more income growth leads to more piracy because the software market is more mature, e.g., there are more products available to sell in stores and online retailers. This is a robust result, being always significant at 1%.

Regarding gross domestic investment results show that, as expected, it affects positively economic growth, being significant at 1% across specifications.

As Andrés and Goel (2012) some of our results show that the growth of the labor force results in lower economic growth (model 2 and 4). However, not only the result is not robust across equations, but it is never statistically significant.

Another important variable that can affect the growth is the inflation that a country has annually. A high level of inflation, which indicates an overall increase in prices, will have a negative effect on household consumptions, has their disposable income is reduced by this phenomenon, decreasing their standard of living (Barro, 2013b). It was expected that this variable had a negative effect on growth and a positive effect on software piracy. However, although the point estimations were positive in both models, they were never statistically significant.

We also considered the effect of exports of goods and services *(ΔExport).* Exports represent the importance of goods and services that are produced nationally, and sold to the rest of the world. As expected it has a positive effect (Andraz & Rodrigues, 2010) being significant. More production of goods such as merchandize or services will increase profits of firms, which will offer more work to the nationals that, in turn, will increase national income.

Four measures that represent access to digital content were introduced in the growth equation (*Net, Mobile, Phone* and *FBIS*). All these variables measure the usage per 100 inhabitants.

We can observe that these variables can affect economic growth in two ways. The first way represents a positive impact: more access to information leads to increase productivity as people will seek better ways to do their jobs, and more consumption of digital goods (C. Choi & Hoon Yi, 2009; Clarke, 2008) which is represented by the access to broadband (*FBIS*) variable. The other effect that Internet users have is a negative one: as more users access at the same time the network, they will decrease the overall Internet traffic speeds which will potentially lower productivity. This negative effect can be seen especially on firms that need the Internet to work on a daily basis such as online retail stores, consulting and distribution of digital content such as games, movies or music. This negative effect is represented by the access to the Internet (*Net*) variable. Results are surprising and suggest that, for attaining a sustainable growth, it is necessary good infrastructures, but these must represent quality. In our case the simple access to the Internet is not sufficient to attain growth; it is necessary broadband access. Both variables are robust.

These variables also affect the piracy rate equation. They represent access to information dimension. Results shows that having the ability to search digital content don't necessarily mean that people will seek illegal software. Although even people that always sought legal software can seek illegal content at some point in their life. This result indicates that infrastructures that can seek potential pirates are well developed and that they are used efficiently by national Governments.

Results show that the education offered by a country has a positive effect on economic growth, results also obtained by Barro (2013a). This indicates that more years of schooling will lead to higher productivity. To assess the impact of education on the piracy rate equation, we also introduced total years of schooling (*school*). This variable has a negative impact on piracy (reduces piracy). However in both cases the estimator was not significant. A negative impact was found by Andrés (2006b) using a cross-sectional data analysis. Other measures exist such as literacy rate (see Goel and Nelson (2009)), and education expenditure (see Chapter 5

To see the impact of piracy on economic growth we introduced the piracy rate (*PR*) and squared *PR*. We found a negative coefficient on the quadratic term of the piracy rate, thus indicating a concave relation between PR and growth. As can be seen in Annex XV, until a certain level of piracy it will promote economic growth but at a diminishing rate, achieving a maximum around 80%. From this level onwards, increases in PR will lead to smaller levels of economic growth. This indicates that the potential benefits of using illegal software to the economy due to a marginal increase in PR will be smaller as PR increases and eventually they will be overtaken by losses. Our results are opposed to the ones found by Andrés and Goel (2012), who found a convex relationship. However we should note that these authors used a cross sectional approach, which does not consider the time dimension, which is captured in our approach.

Finally we also introduced in the piracy rate equation a dimension that measures technological development in a country. The benefits of a higher level of protection can be seen in the negative effect of trademarks, being significant at 1%. Firms may seek on national and international Intellectual Property Office protection for their products (brands, logos, drawings) and due to the high value added that they bring to the economy they are protected. Another variable in this dimension that was introduced was the patent applicants. A patent occurs when an innovation is present on a product that can differentiate it against other products. One example of an innovation is a new process that can be implemented that will increase units produced with the same amount of resources. We also have a negative impact on this variable, although statistically insignificant. These results indicate that national and international Intellectual Property Rights Offices appear to protect well both trademarks and patents, although only the first is significant.

Table 6.2 3SLS regressions

	Model 1		Model 2		Model 3		Model 4	
VARIABLES	1	2	3	4	5	6	7	8
	ΔGDPpc	PR	*ΔGDPpc*	PR	*ΔGDPpc*	PR	*ΔGDPpc*	PR
ΔGDPpc		0.9813***		1.0473***		0.9737***		1.0184***
		(0.2048)		(0.2061)		(0.2006)		(0.1971)
L5.GDPpc	-0.000001		-0.0000001					
	(0.0000)		(0.0000)					
DEV					-0.4160***		-0.3798***	
					(0.1109)		(0.0887)	
ΔGDI	0.0779***		0.0824***		0.0779***		0.0829***	
	(0.0168)		(0.0165)		(0.0176)		(0.0172)	
ΔLab	0.0339		-0.0361		0.0463		-0.0286	
	(0.1554)		(0.1468)		(0.1622)		(0.1542)	
Inflation	0.0398		0.0378		0.0432		0.0408	
	(0.0394)		(0.0377)		(0.0409)		(0.0392)	
ΔExport	0.1119***		0.1084***		0.1148***		0.1121***	
	(0.0319)		(0.0301)		(0.0325)		(0.0303)	
Net	-0.0006*	0.0003			-0.0006*	0.0003		
	(0.0003)	(0.0005)			(0.0003)	(0.0005)		
Phone	-0.0003	-0.0008			-0.0002	-0.0008		
	(0.0005)	(0.0007)			(0.0005)	(0.0007)		
FBIS	0.0012**	-0.0025***	0.0008	-0.0019***	0.0013**	-0.0026***	0.0009*	-0.0020***
	(0.0006)	(0.0008)	(0.0005)	(0.0007)	(0.0006)	(0.0008)	(0.0005)	(0.0007)
Mobile	-0.0001	-0.0005**	-0.0002	-0.0004**	-0.0001	-0.0005***	-0.0002	-0.0005**
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
School	0.0051	-0.0033	0.0037	-0.0055	0.0045	-0.0038	0.0035	-0.0055
	(0.0075)	(0.0117)	(0.0074)	(0.0118)	(0.0079)	(0.0117)	(0.0078)	(0.0117)
PR	1.9232***		1.9846***		2.0492***		2.0805***	
	(0.4706)		(0.4555)		(0.4733)		(0.4426)	
PR^2	-1.1991***		-1.2273***		-1.2744***		-1.2862***	
	(0.3744)		(0.3570)		(0.3802)		(0.3506)	
ln(Tradpc)		-0.0382***		-0.0413***		-0.0383***		-0.0416***
		(0.0129)		(0.0124)		(0.0129)		(0.0123)
ln(Patpc)		-0.0066		-0.0081		-0.0069		-0.0081
		(0.0053)		(0.0053)		(0.0052)		(0.0052)
correlation	-0.64761		-0.66758		-0.64759		-0.6622	
Observations	172	172	173	173	173	173	174	174
R-squared	0.234	0.981	0.196	0.981	0.179	0.981	0.153	0.981

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Correlation is the correlation errors of equation 1 and 2.

6.4 Conclusion

This chapter analyzed the effect of software piracy on economic growth. To implement this analysis it was introduced a system of equation using the 3SLS for a large panel of countries for which information on software piracy was available (1995, 2000, 2005 and 2010 spanning 75 countries). This allowed us to control simultaneously the two reciprocal problems, e.g., software piracy affect economic growth combined with the effect of economic growth on piracy.

We found that access to the digital economy through Internet access is not sufficient to promote growth; broadband access must be made available to the population in order to foster growth. Variables regarding access to information negatively affected software piracy rates.

We analyzed the nonlinear relationship of piracy on economic growth with the introduction of the square of this variable. Results showed that there is evidence of a concave relationship between piracy rates and economic growth. For lower levels of piracy rate, a marginal increase on it will increase the growth rate, however this increase will be smaller the bigger is the level piracy rate, and from around 80% marginal increases in PR will lead to smaller levels of economic growth. This indicates that the potential benefits of using illegal software to the economy due to a marginal increase in PR will be smaller as PR increases and eventually they will be overtaken by losses.

Annex XV Relationship between piracy and growth

Figure 6.1 Concave relationship in model 1

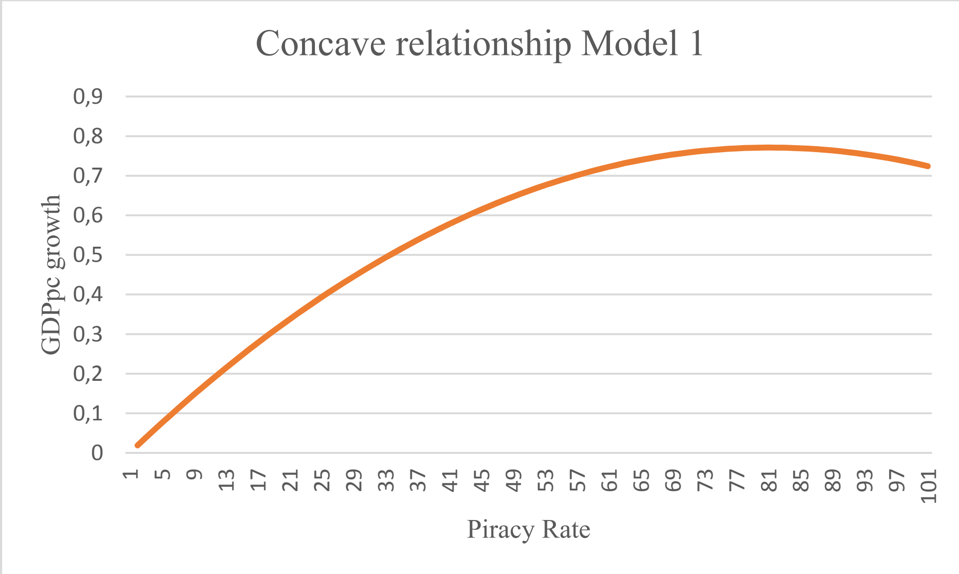


Figure 6.2 Concave relationship in model 2

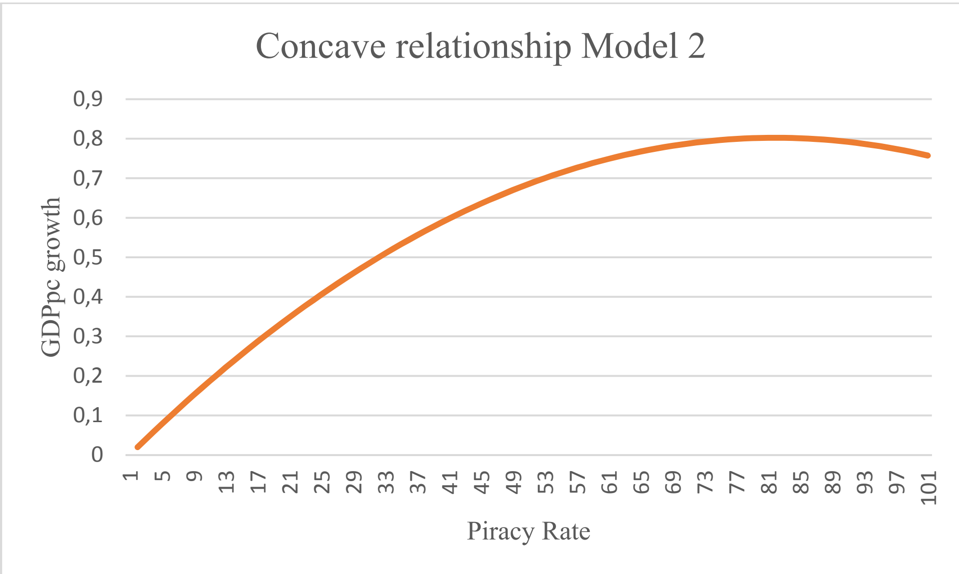


Figure 6.3 Concave relationship in model 3

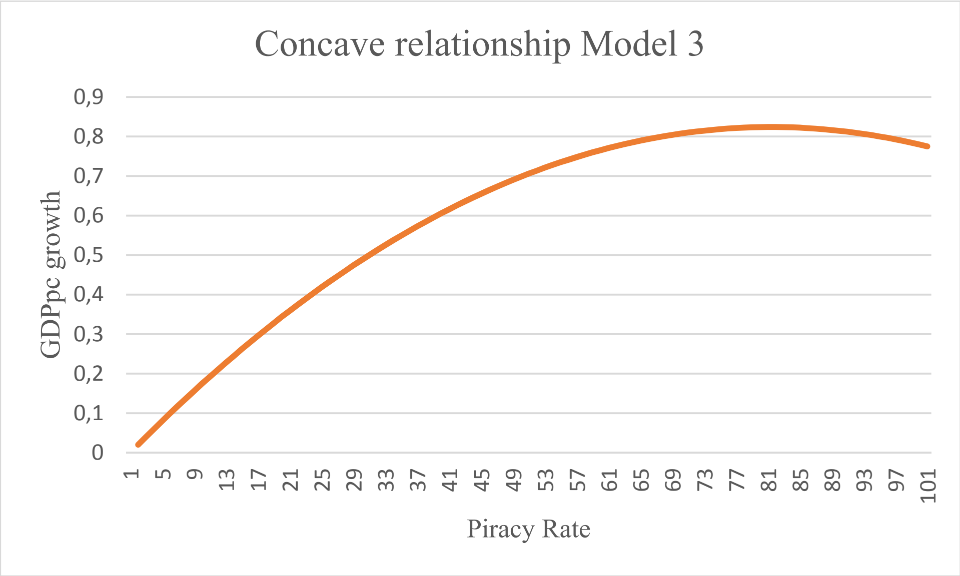
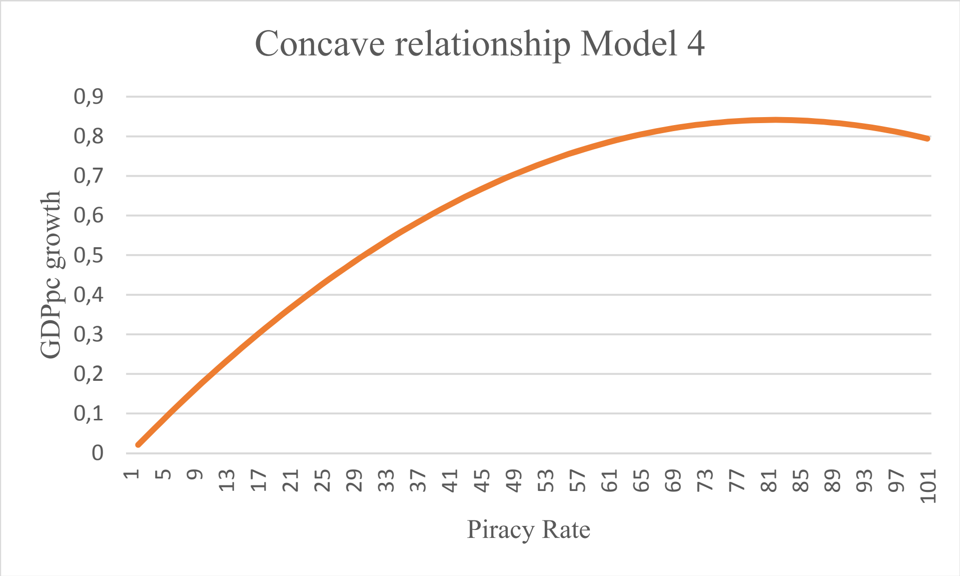


Figure 6.4 Concave relationship in model 4



Chapter 7 Final Conclusions

This work tried to study the main macroeconomic determinants of software piracy. The main objective was to provide a comprehensive understanding of the software piracy phenomenon, first with a global approach using all countries for which information on software piracy data is available, then analyzing a specific region, the European Union. Our work departs from previous empirical literature in the sense that we provide a cross country time series approach to the problem from a large time span as opposed to simple cross sectional data.

Empirical literature on this specific topic is still relatively new, and due to data restrictions on certain dimensions, the majority of studies opted for a cross country analysis.

The objective of Chapter 1 was to provide an introduction to the problem of software piracy and its relevance for the economy and the benefits in its reduction.

The main objective of Chapter 2 was to provide a detailed summary of previous empirical findings, systematizing them on stylized facts that were used in subsequent chapters. Literature only focused on systematizing theoretical works; our major contribution was in systematizing empirical ones. The major difficulty faced here was on the proliferation of methodologies and results found by different areas of studies that made difficult a systematization of results in the field of economics.

Chapter 3 used results from some stylized facts encountered in Chapter 2 expanding it to new variables. The main focused was on the determinants of software piracy losses, the methodology used was the System GMM because the dataset was persistent over the years. When determining the causes of software piracy it was taken into account the break in the series occurred in 2002/2003 that was a result of the change in methodology to compute software piracy. The major macroeconomic dimensions that represented labor force, technological, educational and access to information and institutional dimensions were significant, and could explain this phenomenon. Although the methodology was appropriate for this analysis, a detailed comparison of continents and levels of developments were not possible. Future empirical work must take into account whenever possible the different realities of countries and the division of continents present in the official publications.

After establishing that these macroeconomic determinants were significant we proceeded our analysis for the European Union. A more detailed analysis on variables was available on the Eurostat website which were used in the subsequent chapters.

Chapter 4 described the effects that taxation can have on several typical households of the European Union. We also used the Software piracy losses as a dependent variable, but in this case, due to small number of observations, we used the fixed effect model that was also found to be appropriate when analyzing this phenomenon of Europe (Andrés, 2006a). Results showed that taxation had a positive effect on software piracy but affecting differently the households. To further assess our results we split our sample into Old Countries (15 European Countries) and the Euro Zone (17 European Countries). Results were only significant on the New countries (12 European Countries) and outside the Euro Zone (10 European Countries). These results can be used by the European Commission and the European Patent Office when assessing and promoting policies to reduce piracy and the use of other illicit content, even one based on hardware.

We also choose to analyze the determinants of software piracy in the European Union, focusing on the effects that education expenditure has on piracy in a county in Chapter 5 We introduced software piracy rates as a dependent variable. Several estimations were possible but we choose the fixed effects as with the previous chapter. Two measures of expenditure were introduced, public expenditure on education, measured as a share of GDP, that comes from national Governments budgets and also the expenditure that is made on private and public educational institutions measured as a percentage of *GDPpc*. Another measure was introduced that reflected the financial aid to students as a share of *GDP*. Results showed that more expenditure on education considering all ISCED levels will reduce software piracy. A detailed analysis was made considering a detailed disaggregation based on the different ISCED levels; results showed that more expenditure on ISCED 5-6, will reduce piracy. The other dimension introduced that measured the financial aid to students had a positive impact on piracy. These results indicate that for reducing piracy, resources must be better allocated, for example trough funds that come from the European Union.

Both Chapter 4 and Chapter 5 presented a detailed analysis with a detailed disaggregation of variables measuring household taxation and educational expenditure.

Having established the major macroeconomic dimensions in the previous chapters we provided a detailed analysis of the effects of piracy on economic growth in Chapter 6 We implemented a panel data analysis using 3SLS (3 Stage Least Squares). New technologies can improve productivity but lack of protection can result in less investment because software companies have less incentive to invest because returns of their investment on R&D will be smaller. Results show that software piracy will reduce economic growth. One possible limitation was that with this methodology it was not possible to divide the sample into the different continents. Future empirical works studying the effects of this illicit behavior on economic growth must take into account this disaggregation.

Overall, this thesis makes a substantial contribution to the empirical literature in the sense that it provides the major determinants of software piracy considering a large time span and large country sample. This work can also be used as the foundation of future theoretical works focusing on policy implications of several actions that policymakers can choose. It also provides the baseline requirements to construct an index that can be used to measure the illicit behavior in the subject of the digital economy, namely software piracy.

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