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INTELLECTUAL PROPERTY REGULATION AND SOFTWARE PIRACY: A DYNAMIC APPROACH

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Abstract. Promoting Intellectual Property Rights (IPRs) is of particular importance to nations engaging in significant innovation. The existing literature relating to software piracy research is typified by the use qualitative methods to analyse the impact of IPRs on software piracy. Most concern themselves with a handful of important macroeconomic factors in an effort to identify whether they possess any explanatory power, employing qualitative frameworks for analysis. More contemporary research has given greater attention to the role of key regulatory variables on software piracy using econometric methods. In this paper, the relationship between foreign political pressure, IPR regulatory reforms and software piracy is considered. We estimate a model of software piracy as a function of bi-lateral pressure and investment (where US 301 reporting is the proxy for bilateral pressure, and capital investment the proxy for bi-lateral investment), Scientific investment, trade dependence and government effectiveness. The models are estimated using data from 80 countries over nine years. The study responds to the dearth of research employing dynamic panel estimations in estimating the impact of IPR reforms on software piracy. The findings suggest out of cycle review and US 301 reporting are pertinent factors potentially moderating software piracy.

1. Introduction

The accelerated adoption of intellectual property agreements around the world has been the source of much discussion.[1] Yet, there is little known about the impact of intellectual property rights related regulatory reforms on the infringement of intellectual property rights. Foreign political pressures and the impact of IP reforms on infringing activity serve as the motivation for this paper. The present study considers the potential impact of WTO cases, Bilateral trade, U.S. 301 reporting (herewith US301),[2] Out of Cycle Review (herewith OoCR)[3] and government effectiveness[4] on changes in the rate of software piracy. The study considers the impact of IPRs on the rates of software piracy across 80 countries,

The author would like to thank the editor and the anonymous reviewers for their helpful and insightful comments.
[1]The literature is replete with examples. Consider the comprehensive analysis of Wilson (1997) and Antons (2006).
[2]U.S.301 reporting, relates to the inclusion of a particular country or group of countries featuring in the special 301 reporting provided by the U.S.T.R.
[3]Out of cycle review relates to a country level review conducted by the U.S.T.R.
[4]Government effectiveness is an index measure of effectiveness constructed by Shadlen et al. (2005).

contrasting the impacts across differing income panels. The present study addresses the shortage of research that considers the impact of IPR agreements on software piracy, specifically where intellectual property protections and enforcement practices are not fully developed or only recently enacted. The study focuses specifically on Low and High GDP countries to consider the impact of reforms and enforcement activities. There is a genuine shortage of research considering these matters and the present study appears to be the first employing dynamic estimation methods to discern the relative impacts.

Consider the general definition of software piracy, for the sake of clarity. Higgins and Makin (2004) define software piracy as an act in which an individual illegally copies commercially available software in order to avoid fees, or when an individual makes unauthorized copies of an organization's internally developed software for personal use or distribution (Straub and Collins, 1990; Britz, 2004). While piracy behaviours may be viewed as a breach of both copyright and patent provisions depending upon the jurisdiction of focus, the common act of utilising software secured through illegitimate means is simply a copyright breach. The patent is not exploited through the direct application of the software and is not employed in a manner that gives rise to a breach of the patent generally. It is estimated that the losses due to software piracy exceeded 11 billion in 1997 (Software Piracy Report 1997), as has now risen to 51 billion in 2015 (Global software survey, 2015).[5]

Stanford and Symantec offer a useful taxonomy of piracy:

> Counterfeiting is the illegal duplication, distribution and/or sale of copyrighted material with the intent of imitating the copyrighted product.[6]

[5]The quoted statistics are based on the data provided by the Business Software Alliance. The estimates are based on the difference between supply side purchases and actual installation counts, while this is an imperfect approach it is considered widely to be the best estimate of piracy (Png, 2010). For complete analysis of the methodological approach see Png (2010).

[6]In the case of packaged software, it is common to find counterfeit copies of the compact discs incorporating the software programs, as well as related packaging, manuals, license agreements, labels, registration cards and security features.

> Internet piracy occurs when software is downloaded from the Internet. The same purchasing rules apply to online software purchases as for those bought in compact disc format.[7]
>
> End user piracy occurs when an individual reproduces copies of software without authorization.[8]
>
> Client-server overuse occurs when too many users on a network are using a central copy of a program at the same time. If you have a local-area network and install programs on the server for several people to use, you have to be sure your license entitles you to do so. If you have more users than allowed by the license, that's "overuse."
>
> Hard-disk loading occurs when a business sells new computers with illegal copies of software loaded onto the hard disks to make the purchase of the machines more attractive.[9]

The economic impacts of piracy behaviours are significant and warrant research focus. Yet much of the extant research fails to consider the role of bilateral pressure and domestic regulatory reform in moderating piracy. Pertinently, much of the extant empirical work on software piracy and copyright has not afforded focused attention to policies aimed at promoting economic development while accounting for specific development level characteristics. There is, however, an extensive literature on patents and rational country level policy. This literature and the more directly relevant proximate copyright literature shall be reviewed more fully in the subsequent section. The article is organised in the following manner; notable proximate research is detailed in the first part of the article. This is

[7]Common Internet piracy techniques are, websites that make software available for free download or in exchange for others, internet auction sites that offer counterfeit or out-of-channel software and peer-to-peer networks that enable unauthorized transfer of copyrighted programs (see n.9).
[8]These include, using one licensed copy to install a program on multiple computers, copying discs for installation or distribution, taking advantage of upgrade offers without having a legal copy of the version to be upgraded, acquiring academic or other restricted or non-retail software without a proper license, swapping discs in or outside the workplace (see n.9).
[9]Types of Piracy | Symantec. (2017.). Retrieved from https://www.symantec.com/about/legal/anti-piracy/types-piracy.

followed by a discussion of the data and model parameters, followed by a through discussion of estimation methods and issues pertinent to the research design. The final sections outline the study findings and pertinent conclusions.

2. Software piracy research; a precis

2.1. **The costs and benefits of piracy behaviours, and a commentary on proximate intellectual property research.** It is important to consider why an analysis of piracy behaviour and piracy rates is an important focus for scientific enquiry and social science research. The former, while not being a focus herein, provides valuable insight into human behaviour and motivation. The latter serves as the central focus of this study and is a valuable focus for research for a number of reasons. Firstly, perhaps most notably, analysis of piracy rates affords a fuller understanding of the economic impact of copyright contravening actions on firms and nations more broadly. Secondly, the analyses of software piracy provide a worthwhile starting point in understanding the impact of contravening behaviour on firm level and national level productivity. The focus of the present study remains solely on understanding the factors that impact upon national piracy rates. This is not to suggest that a discussion of the economic benefit or potentially deleterious impact of piracy behaviours on firm level and national level innovation is not worthwhile. Within the present section, relevant proximate research relating to the innovation and productivity impacts of piracy shall be outlined. This discussion shall be followed by a precis of all relevant research pertaining to modelling piracy rates.

As noted, much of the existing empirical work relating to software piracy and copyright has not afforded focused attention to policies aimed at promoting economic development while accounting for specific development level characteristics. There is, however, an extensive literature on patents, innovation and other incorporeal works and rational country level policy. The unique qualities of innovation and incorporeal properties more generally, in particular, basic research and its set of relations with economic growth are well espoused by Romer (1986). Romer (1986) framed the parameters, by which incorporeal properties

lead to growth. Romer asserts that the essence of incorporeal works is that they are non-rivalrous in nature and offer increasing returns to scale. Grossman and Helpman (1990) assert aptly that knowledge is a public good in so far as muliple parties may benefit from it concurrently at no additional costs. The work of Romer (1986) is pertinent, Romer has asserted that so called 'knowledge spillovers' may cause investment in knowledge sectors to exhibit non-decreasing returns to scale. This enables the innovation process to be sustainable in the long run (Grossman and Helpman, 1990).[10] Software is an intellectual property that is made excludable through the application of DRM technologies, notwithstanding its inherant non-rival and non-excludable nature.[11]

If we conclude that business software is complementary to innovation, has innovation augmenting qualities, or is a necessary prerequisite to R&D, patent generation, and the creation of intellectual properties then; it may be asserted a priori that software piracy may be a productivity and innovation driver. The previous studies evidence the impact of university R&D spillovers to economic patenting.[12] IT infrastructure is shown to be innovation enabling, and a further a priori claim could be asserted that IT infrastructure and broadband and of little use without business software to enable their use.

Santillanes and Felder (2015) proffer a stronger claim, "As the ... the world becomes increasingly dependent on computerized research methods, the ethical questions surrounding the use of that technology crystallize. Scientists and researchers in virtually every

[10]Grossman and Helpman (1990) assert that when investment takes place in an economic environment that evidence increasing returns to scale the marginal product of capital need not decline over time to the level of the discount rate. Grossman and Helpman (1990) consider the role of Research and development asserting that it is a process essential to the knowledge generation process and consistent with Romer (1986).

[11]The extant literature evidences a recent trend whereby theoretical studies have sought to better enumerate the growth innovation relationship by attempting to fully endogenise innovation in the growth function. Broadly speaking the studies have considered four types of innovation process; Learning (Romer,1986), Human Capital (Lusas 1988), R&D (Romer 1990, Aghion et al. 2001) and Public Infrastructure (Waverman 2001).
Empirical studies conducted in response to the theoretical work supports the posited relationship (see Coe and Helpman, 1995). There is, however, little national level research conducted into these matters (see inter alia, Geroski 1989, Bernstien & Mohnen 1994). Geroski (1989) considering firm level data between 1976 and 1979 argued that innovations (employing the SPRU innovations database as a proxy) accounted for approximately 50% of growth for 30% of the entities considered. Bernstien and Mohnen (1994) investigate the impact of R&D in the US and Japanese polities on TFP in the corresponding nation, the study finding that US R&D accounted for 60% of Japanese TFP while 20% of US TFP could be attributed to Japan.

[12]Academic science based research is shown to be a major contributor to productivity growth in Adams (1990) the author evidences a lag period of approximately 20 years. The work of Jaffe (1989) and Rosenberg (1994) is somewhat consistent with Adams (1990). Acs, Audretsch and Feldman (1992) observe that spill overs from university R&D can be quite significant with patent elasticities of approximately 10% for the corporate sector in respect of university based R&D.

discipline rely on sophisticated hardware and software in order to push the boundaries of human knowledge.[13] Much of this software is privately owned and sold by for-profit companies. However, researchers not affiliated with large universities are often unable to afford to purchase the licenses necessary to use this software legally, leading to attempts to procure the software by illegal means."[14] There is an obvious tension that exists between the intentions of copyright law and its implications under certain circumstances.

Asongu (2015) presents the current discussion aptly; "the debate has centred around IPRs protection, with some scholars postulating that increased protection of IPRs stimulates economic growth and development through the appealing impact on factor productivity (Gould and Gruben, 1996; Falvey et al., 2006). On the other hand, sceptics are of the stance that, IPRs protection and adherence to international treaties (laws) may seriously infringe the growth prospects of developing countries (Yang and Maskus, 2001). This strand supports its thesis by purporting that, less tight IPRs regimes are necessary (at least in the short-term) for developing countries, to enable knowledge spillovers, imperative for growth and development."

Herein the study does not offer a position on whether piracy should be encouraged tolerated, or admonished, this is a discussion for a further discrete study. Rather, the present study acknowledges that the true impacts of software piracy are likely to be nuanced. Piracy may be beneficial to innovation and economic productivity under some circumstances and potentially deleterious under other conditions. The motivation of the present study is to further the understanding of the role played by international monitoring (U.S.301 reporting, and out of cycle review), sanctioning and disputes (WTO cases) relating to copyright infringement on software piracy rates.

[13]Griliches and Lichtenberg (1984) shows evidence of spillovers between academic research and government research and development and the private sector. Pavitt et al. (1987) assert that the relationship between firm size and innovation is non-linear, evidencing strong associations between small and large firms and innovation and a weaker association between mid-sized firms and innovation.

[14]Wickman et al. (1992), identifies that 38% of academic staff working in universities in the United States, admit to illegally downloading software. Equally pertinent, Wickman ad el. (1992), identify that 24.2% of academics claim that they believed software could be downloaded if used for academic research purposes. A comparable study by Rahim et al. (2000), claim that 69% of the academics surveyed engaged in software piracy behaviours.

2.2. **Modelling software piracy, individual, firm level, and national level studies.** Software piracy studies can be broadly categorised into three groups, individual, firm level, and national level studies. In recent years, there has been a proliferation of research in these categories. Higgins and Makin (2004), offer a simple premise for much of the recent research, as does Britz (2004); Higgins and Makin (2004) assert that the ease with which software can be pirated makes such behavior difficult to detect. Britz (2004) commented that software piracy is all but impossible to stop. Given the challenges and complexity of piracy behaviour, a number of researchers have explored these matters at an individual, firm level or at a national level. Herewith, a number of relevant studies are outlined with a particular focus on national level studies. It should be noted that there is a relative dearth of national level research in comparison with the other noted categories.

Holsapple et al. (2008), conducted an important systematic review of the extant software piracy research identifying key omissions within the literature. The authors identify a number of parameters not considered extensively within the existing body of research. The authors provide a useful taxonomy of the research methods, practices, and parameters within the extant research. Notably, the literature survey focuses predominately on individual level studies and parameters with limited regard for national level studies and parameters.

An earlier all-encompassing study is that of Glass and Wood (1996), that considers the scope of the piracy problem. Glass and Wood (1996) assert that growth in the use of computers has made life much easier for many people in the world, but this growth in computer usage parallels the growth in software piracy. Software piracy is asserted to be a problem of significance and is said to occur frequently within companies, academic institutions, and amongst individuals (n.b. inter alia, Glass and Wood, 1996, and Cheng, Sims and Teegen 1997).

A number of individual level studies consider collegiate student behaviour (n.b. Solomon and O'Brien, 1990; Sims, Cheng and Teegan, 1996, and Hinduja, 2001). Piracy behaviours are said to be very common amongst collegiate students (Solomon and O'Brien, 1990; Sims, Cheng and Teegan, 1996). Students who have previous software piracy or computer

experience are more likely to engage in further piracy activities (Hinduja, 2001). The extant literature pertaining to piracy behaviours and impacts suggests that the activity is widespread and that software developers are losing billions of dollars on an annual basis (Peace, Galletta and Thong, 2003; Seale, Polakowski and Schneider, 1998).

Hinduja (2003) employs univariate and bivariate findings from a quantitative study on students to demonstrate the incidence, scope, and associated correlates of Internet piracy within a university environment. The author engages in a discussion of technological and ethical factors that a tertiary institution might consider and seek to frame policy around. The study ranks amongst the handful that employs empirical methods in analysing the problem. The study does not, however, consider the problem from a macroeconomic perspective. The study is a worthwhile empirical contribution to the literature but does not offer any insight into the national-level challenges.

Further individual level studies consider the behaviour of professionals. Peace and Galetta (1996) claim that there is, perhaps, no more visible financial dilemma and significant challenge in the software industry today than that of software piracy. In their paper, the authors provide an account of the development and formal validation of a predictive model of software piracy. The study focused on computer using professionals, with the empirical model employed deriving from prior research expected utility theory and deterrence theory. A total of 201 individuals participated in the study with the results indicating that "individual attitudes, subjective norms, and perceived behavioural control are significant precursors to the intention to illegally copy software. In addition, punishment severity, punishment certainty, and software cost have direct effects on the individual's attitude toward software piracy, whereas punishment certainty has a significant effect on perceived behavioural control" (Peace and Galetta 1996). Pertinently, 52% of respondents claim to have engaged in piracy behaviour.

Sun et al. (2013) assert that the existing literature still does not shed enough light on the factors motivating individuals to pirate software, nor what the key issues are moderating piracy are at a higher (national) level. Sun et al. (2013) also assert that research investigating these issues problem has been rather qualitative in scope and approach, and

empirical research within the extant literature is scarce (Gopal and Sanders 1997; Thong and Yap 1998). Many of the extant empirical studies have focused largely on firm-level issues, and survey-based data (Wang and Zhu, 2003, Hinduja, 2003). While the noted studies are of immense value, there is a dearth of macro level research, and inter country comparison.

The study utilised two methods to analyse the piracy decision. A survey was used to test the entire model, and a quasi experiment was undertaken to quantify several relationships between the variables under consideration. The results indicate that the identified factors have a significant impact on the decision to engage in piracy. The presented model is a useful tool in further understanding this behaviour, albeit at a consumer level rather than at a firm or national level. The study findings address the relative dearth of research into piracy behaviour within a professional environment.

A number of works in the software piracy literature consider national level piracy rates (Ang et al. 2001, Wang and Zhu, 2003, Yoo et al. 2014). Wang and Zhu 2003 engaged in an analysis of Chinese consumer behaviours as they relate to the purchase of software. The authors sought to establish and empirically validate a formal model of behaviour, rather than qualitatively analyse the issue, a unique contribution to the literature. The authors employ a research model that is based on the work of Ang et al. (2001) in studying Singaporeans' purchase of pirated CDs. The authors employ a stepwise regression, and an exploratory factor analysis, identifying four personal and social factors that are important in influencing Chinese consumers' attitude towards software piracy. These included value consciousness, normality susceptibility, novelty seeking, and collectivism. Five further attitude measures were identified, which were asserted as important in influencing consumer purchase intention. Reliability of pirated software recognized social benefits of piracy, the functionality of pirated software, risks of purchasing, and perceived legality of purchasing were deemed to be critical attitudinal factors.

Yoo et al. (2014), sought to determine the effect of deterrence policy in software piracy. The cross-country study focused on comparing piracy rates within South Korea and Vietnam. The authors surveyed 277 respondents in 2008. The results indicate that the relationships between punishment certainty and attitude, and mimetic pressure and intention, are significantly different between Korea and Vietnam. Several implications are considered from the political and cultural aspects (Yoo et al. 2014).

At a national level, several notable studies sought to account for the impact of macro-economic factors on software piracy. Andres and Asongu (2016) examine the dynamics and trends of software piracy to ease the benchmarking of current efforts towards harmonising the standards pertaining to intellectual property rights. The authors estimate dynamic panel data models for 99 countries over the period 1994-2010. The authors identify he absence of convergence in the world level panel. The absence of convergence (in absolute and conditional terms) for the World panel indicates that blanket policies may not be effective unless they are contingent on the prevailing trajectories, dynamics, and tendencies of software piracy. Policy implications and caveats are also discussed (Andres and Asongu 2016).

Andres (2006) investigated the extent to which income inequality influences national piracy rates across a sample of 34 countries. The study asserted that economic inequality seems to have a significant negative effect on national piracy rates. Furthermore, the research findings show that income and education are not important determinants of piracy rates (Andres, 2006). Other notable country level studies include, inter alia, Granstad (2012), and Kyper et al. (2004).[15] Similarly, Shadlen et al. (2005) sought to identify the impact of macro-economic conditions and monitoring (as measured by WTO cases and U.S. 301 reporting and out of cycle review) on software piracy rates. The authors do not

[15]Gramstad (2012) considers the association between domestic software piracy rates and the use of Linux as a desktop operating system while controlling for factors such as the gross domestic product per capita and local anti-piracy efforts. Gramstad asserts that the presented model predicts that more people would use Linux if software piracy, in general, was less pronounced at a national level. Though it is important to note that given the nominal level of initial Linux usage the aggregate utilisation of Linux would not exceed 1.5%. Kyper et al. (2004), investigate the importance of income level in determining software piracy rates at a national level. The authors control for various measures of income to predict piracy rates on a national level. The author's results indicate that median household income is the best measure of income in determining piracy rates.

identify any statistically significant impact associated with monitoring activities. Though notably, the authors assert that such an effect is highly plausible and was anticipated in their estimation.

Of the noted studies employing empirical methods, only Shadlen et al. (2005), Andres (2006), and Andres and Asongu (2016), employ macroeconomic data to consider the issue from a national and regional perspective. Considering specifically the Shadlen et al. (2005) study, the authors examine the pressures that are brought to bear through bilateral investment treaties and the U.S.T.R. specifically through U.S.T.R. out of cycle reviews and the Special 301 processes. The author's control for scientific investment, GDP per capita and a number of other macro-economic variables. Pertinently the authors claim that neither a country's classification under Special 301 nor being subject to an out-of-cycle review has an impact on the level of protection that is actually delivered. The authors further assert that such pressures may well affect the structure and content of local legal norms governing IPRs, but as Sell (1995) has suggested, this is no guarantee of the enforcement of such rights.[16] It is worthwhile to acknowledge the potential endogeneity problem that may afflict Shadlen et al. (2005) and other macro-economic studies. It is logical to assert that a priori that bilateral pressures may be directed towards countries evidencing high rates of piracy and also those countries most likely to respond to pressures. Shadlen et al. (2005) does not appear to be afflicted by severe endogeneity problems, though endogeneity tests conducted within the present study suggest that endogeneity may be present within the Shadlen et al. (2005) specifications.[17] Additionally, the specifications may be

[16]Shadlen et al. (2005) test for interaction effects noting specifically "To ensure against wrongly denying the efficacy of either Special 301 or out-of cycle reviews, we considered an array of alternative specifications of the variables. For example, in place of the 0–3 scale we used two different dichotomous codings. In a more inclusive formulation, following Drahos (2001), we scored countries as subject to U.S. pressure if they were included in the Special 301 report, without distinguishing between countries on the WL, those on the PWL, and those named as PFC. In a more exclusive formulation, hypothesizing that lower-level pressures from the USTR may simply be ignored, we scored as subject to U.S. pressure only those countries that were on the PWL or labelled as a PFC. But the use of these dichotomous classifications had no meaningful effect on our results. We also examined whether the effects of bilateral pressure might be conditional upon the structure of trade relations with the United States (Zeng, 2002), interacting Special 301 and out-of-cycle reviews with trade dependence. But, here again, neither of these measures predicted the level of IPP that was delivered, either directly or in interaction with trade dependence. At least in the case of software, this kind of bilateral pressure does not necessarily produce on-the-ground results."

[17]Endogeneity tests conducted on three variants of the five factor models, models incorporating five factors from the available variables, indicates that endogeneity may be present within the specifications. The prob value of the chi statistic is p = 0.0935. Given the moderate evidence of endogeneity, the GMM system estimation technique is

affected by dynamic panel bias (See Nickell, 1981).[18] The system GMM method adopted does address endogeneity better than the popular pooled panel OLS method (or LSDV method) through the use of additional instruments (differenced independent estimator) and by controlling for panel level effects. Shadlen et al. (2005), assert their surprise at this set of findings, having anticipated a USTR bilateral pressure effect. This finding serves as the impetus for the present study. Herein, we seek to account for the impact of special 301 processes and out of cycle review actions on piracy rates. We test for the bilateral pressure effect employing the GMM system estimation approach.

The present study extends upon Shadlen et al. (2005), employing model correction techniques and income level panels, to offer more robust findings, and pertinently to consider the impact of development status on piracy levels. The current accommodated difficulties associated with unit roots within the datasets and correlation between unobserved panel level effects and lagged dependent variables. Standard estimators may be inconsistent with specification given that the unobserved panel-level effects are correlated with the lagged dependent variables. Additionally, differenced independent variables are used as instruments within the level equation consistent with the system estimation approach developed by Blundell & Bond (1998).

3. Research Objectives

The primary objective of this paper is to consider the impact of key IPR factors (U.S. 301 reporting and current WTO case proceedings before international courts) on software piracy rates, and given the dearth of the extant literature, better enumerate these relationships. This objective is motivated by a desire to develop a basic understanding of the association between IPR diffusion measures and software piracy. The initial specifications focus primarily on Trade Dependence and government effectiveness and as such excludes other critical IPR variables such as WTO sanctions and proceedings. The initial specifications these and a number of other IPR variables to enable government effectiveness and

employed. The benefits of this approach are discussed extensively within the broader econometric literature (n.b. Roodman 2012, Nickell 1981).

[18]Shadlen et al. (2005), employ a pooled panel LSDV approach.

trade measures to be considered first isolation, and in the context of broader regulatory reform programs enacted at national levels. The ancillary objective of this study is to consider the relationship between a number of key non IPR macroeconomic variables, most notably Government Effectiveness, and Bilateral trade, and the rate of software piracy. The study shall consider the association between the noted variables and software piracy with a particular focus on Low GDP countries.

4. Data and Summary statistics

The study utilises concatenated country data across 80 developed and developing countries for the period between 1993 and 2002. The panel constructed is strongly balanced.[19] Summary statistics for the (non-binary/non-dummy) variables are noted in Table 1. The countries are listed in Appendix 1. The data gathered was procured from a number of different sources, primarily World Bank WDI Database and from Shadlen et al.'s (2005)[20] seminal study.

Table 1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
PiracyY	699	65.2289	19.08597	24	100
HumanCap	789	74.34981	13.39925	43	100
GDPCap	695	9959.822	11341.78	247	47064
ScientificInv	600	1.865	1.800281	0.1	7.1
Gov	800	0.388013	0.841795	-1.321	2.082
US301	723	0.633472	0.775195	0	3
TradeDep	720	17.39722	18.52725	0.2	90.739
BilatInv	800	825.255	2602.2	0	23080

The dataset is a strongly balanced panel, constituted by 800 observations across 80 countries. It represents one of the first studies to use such a significant number of cross sections in a DPD (dynamic panel data) model of software piracy. Additional dummy

[19] Strongly balanced refers to the panel structure being consistent across each cross section.
[20] All data excluding the regional panel data and the instrument data created within the models derives from the seminal study of Shadlen et al. (2005).

variables are included for WTO case status, pertaining to the existence of a WTO case that is active in the international court. A further dummy variable is framed to represent the Out of Cycle review effect, caused by USTR (US trade representative) review of countries IPR policies out of the cycle.

Table 2: Study Variables and Descriptions[21]

Variable	**Description**
PiracyY	A measure of Software piracy per year (%) as measured by the Business Software Alliance
GDPCap	Gross Domestic Product (GDP) per capita (1997 dollars)
HumanCap	Combined primary, second and tertiary enrolment ratio, total primary secondary and tertiary enrolment as a ratio of total potential enrolees
ScientificInv	The number of active scientists and engineers per 1000 members of population
Gov	Government effectiveness index as measured by Kaufmann et al. (2002)
US301	USTR 301 Report inclusion, denoting inclusion within 301 reporting, serving as a proxy for bilateral pressure
TradeDep	The degree of U.S. & Canada trade dependence as measured in trade dollar terms. The quantum of North American related trade
BilatInv	The level of bilateral investment, USD terms, between the country and North America
OutofCycle (OoCR)	Out of Cycle review, country level, conducted by the U.S.T.R.

The frequency distribution dependent variable software piracy, PiracyY, across all years and cross sections is depicted in Figure 1. Each cross section is heterogeneous exhibiting significant variability noting that significant variation that exists within each country cross section and that significant differences are evident between high GDP and low GDP countries in terms of piracy rates. As anticipated the distribution is non-normal evidencing left skewness. Software piracy varies markedly between countries with a number of low and low-middle income countries evidencing substantially higher rates of software piracy during the study interval.

[21]All monetary values are in 1997 US constant dollars.

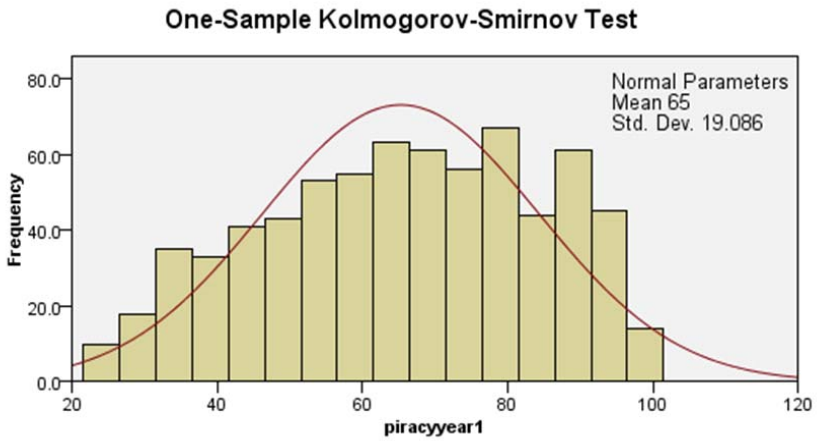

Figure 1: Frequency distribution of software piracy

The variation in piracy rates between low income and high income countries is notable and warrants further inquiry. The present study explores the impact of income status on piracy rates through a series of model specifications that accounts specifically for income level.

Table 3: Bi-variate correlations

	PiracyY	GDPcap	HumanCap	ScientificInv	Gov	US301	TradeDep	BilatInv
PiracyY	1							
GDPcap	-0.7391	1						
HumanCap	-0.705	0.6846	1					
ScientificInv	-0.5921	0.7874	0.6853	1				
Gov	-0.6986	0.8101	0.7499	0.586	1			
US301	0.2449	-0.243	-0.2175	-0.2095	-0.2794	1		
TradeDep	0.0592	-0.1271	-0.1874	-0.2209	-0.2	0.0986	1	
BilatInv	-0.1064	-0.0393	0.1218	0.0733	0.0515	0.0803	0.402	1

The correlation coefficient of -0.74 between software piracy and GDP per capita supports the assertion that the two variables are strongly related. A correlation coefficient of -0.71

indicates a comparable and albeit less strong relationship between software piracy and Scientific investment. The evidenced correlation between GDP and software piracy adds further credence to the assertion that income level is pertinent to piracy rates. This relationship is depicted within Figure 2 below, which depicts the relationship between Piracy rate and GDP per capita. The observations are pooled from all cross sections across all years.

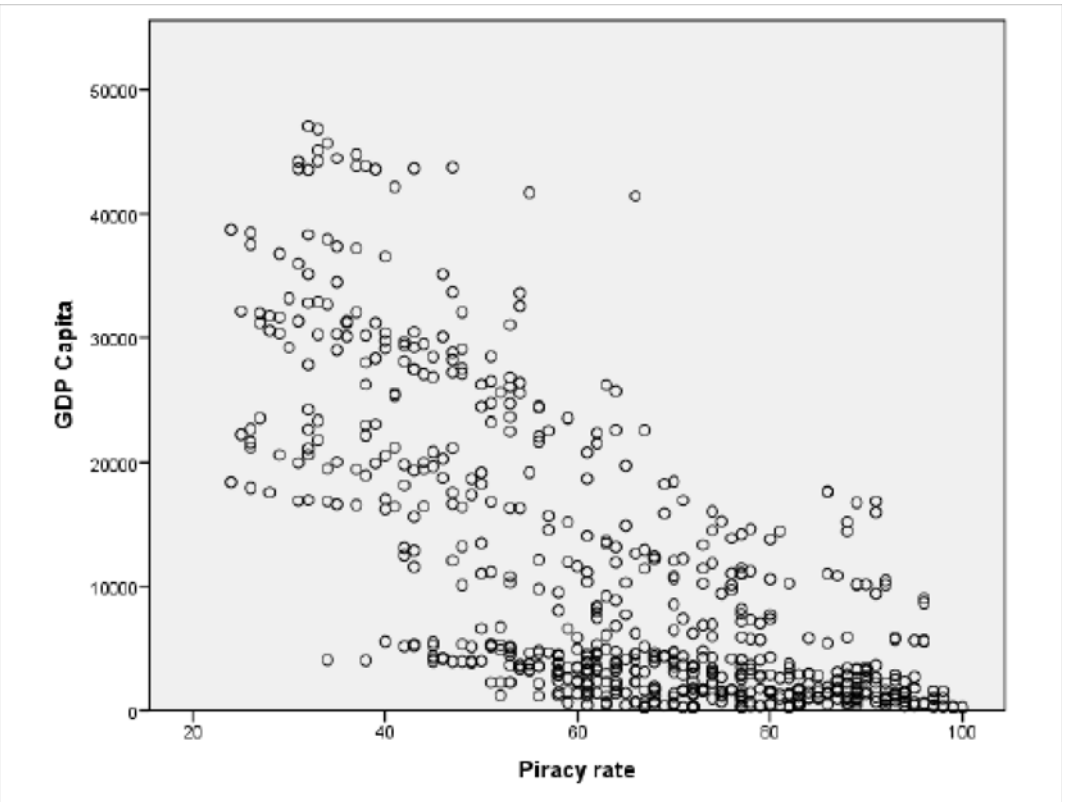

Figure 2: GDP per capita and software piracy

The graphical depiction of the relationship between piracy rates and GDP further supports the claim that development status and income level are likely to be highly important to piracy behaviours. These observations are consistent with our a priori assumptions in relation to software piracy behaviours and a number of country specific studies (see Yoo et al 2014).

As with the GDP parameter, government effectiveness also appears to evidence a strong association with piracy rates with countries that evidence low levels of government effectiveness consistently observing higher rates of software piracy. This may be in part due to the government effectiveness measure capturing economic performance and income level effects. Due to the potential for collinearity and the efficacy of the GDP parameter, the government effectiveness estimates were not retained within the final specifications. The specifications and estimation strategy, are detailed below.

5. Overview of the Dynamic Linear Model

Linear dynamic panel-data models differ from Linear pooled panel models through the inclusion of p-lags of the dependent variable as covariates and contain fixed or random unobserved panel-level effects. Standard estimators may be inconsistent with the specification, given that the unobserved panel-level effects are correlated with the lagged dependent variables. Given the existence of unit roots, and the noted challenges of pooled panel models where there are a significant number of cross sections and relatively few time periods, we adopt the methods proposed by Arellano and Bover (1995).

The key innovation of these model variants relates to the structure of the regressors and the dearth of research dealing with software piracy in economics and econometrics. The models correct for endogeneity and dynamic panel bias more broadly, the methods of error correction are noted below. The Arellano and Bover (1995) and Blundell and Bond (1998) technique as first proposed by Holtz-Eakin, Newey and Rosen (1998) is employed. Given the potential complications (dynamic panel bias, see Nickel, 1981) associated with the static panel specifications using OLS, herein dynamic estimations are presented as only the estimators within the dynamic specifications are claimed to be robust. To correct for both endogeneity and other aspects of dynamic panel bias (Nickel, 1992) lagged and differenced predictive estimators are employed as instruments and incorporated into the specification, consistent with the system GMM estimation approach. As this approach incorporates orthogonal deviations in panels, it maximises sample size.

This estimator is designed for datasets with many panels and few periods. This method assumes that there is no autocorrelation in the idiosyncratic errors and requires the initial condition that the panel-level effects be uncorrelated with the first difference of the first observation of the dependent variable.[22]

The methodology adopted is consistent with the recent literature, notwithstanding the adjustments necessary to accommodate the dynamic estimation methods. Moreover, the goal of the present study is not to specify the perfect exogenous growth model, but rather to understand the relative impacts of WTO cases, Government Effectiveness and pertinently out of cycle reviews and U.S. 301 reporting, while controlling for GDP level (high versus low) on software piracy. Models are estimated for high GDP and low GDP countries where the World Bank Atlas method[23] is employed. This distinction, while seemingly arbitrary, affords greater insight into the moderating impact of development status on regulatory reform and foreign pressure as they relate to piracy rates. The dynamic specification employed in this study utilises the General Method of Moments system estimator developed by Arellano and Bover (1995).

$$\begin{aligned} P_{it} &= \beta_1 L_1 \Delta P_{it} + \beta_2 GDPcap_{it} + \beta_3 HumanCap_{it} + \beta_4 ScientificI_{it} + \beta_5 TRIPS_{it} + \\ &\quad \beta_6 WTO_{it} + \beta_7 BilatInv_{it} + \beta_8 Gov_{it} + \beta_9 TradeDep_{it} + \varepsilon_{it} \end{aligned}$$

Where P_{it} is the variable of interest, namely the rate of software piracy, and where $L_1 \Delta P_{it}$ is the lagged first differenced dependent variable. The remaining variables are the intellectual property legislative proxy variables ($TRIPS$, WTO) and bilateral pressure variables (US301, out of cycle review) as well as the listed macro-economic control variables (refer Table 1). First differenced control variables, bilateral pressure and intellectual property legislative proxy variables are used as instruments within the difference level equation (refer Table 1). In this specification, levels of the dependent variable lagged one period and first differenced exogenous covariates are employed to estimate software

[22]The dynamic specification is not limited by the complications of the static form, and as such, enables a fuller understanding of the underlying relationship. It is believed that this is amongst the first studies to adopt the dynamic specification in this area of research. While the author is of the view that software piracy may result from factors beyond those included in the initial specification, the specifications are robustly defensible.

[23]GDP ranking under the Atlas method involves the use of the World Bank gross national income ranking table.

piracy. The application of this method provides a more conservative set of estimations, and addresses any issues associated with the inclusion of a lagged first differenced dependent variable in a simple OLS (fixed effects) specification. Through these model specifications, a number of the key concerns mounted by Aschauer (1989), and Roodman (2012), are accommodated.[24] As such, the model specifications below all employ System GMM (generalised method of moments) estimation method.[25] To account for development status effects, the models are estimated based on income status employing the World Bank income classification method. This approach enables a more nuanced analysis and more complete understanding of the role of development status on piracy behaviour.[26]

6. Empirical Findings

The initial specifications consider the impact of scientific investment on Software Piracy, as well as GDP and Human Capital. The specification suggests that the existing rate of change in software piracy, as well as scientific investment, are significantly and negatively associated with software piracy. This finding is consistent and robust across both the high income and low income panels. The finding is also consistent with the conclusion that investment in scientific research and the lagged first derivative of software piracy are strongly associated with the rate of change in software piracy.[27] Interestingly, government effectiveness appears to have a positive impact on software piracy within High GDP countries but appears to have an opposing effect on lower GDP countries. A pertinent

[24]Aschauer (1989) contends that many significant results are consequential to country level effects and aggregation biases.

[25]The results of the Sargan test on the Arellano/Bond specifications suggested potential over-restriction. The adoption of the System approach (Arellano and Bover, 1995; Blundell and Bond, 1998) are supported by favourable Sargan test results. Consider the initial specifications, Arellano/Bond specification Prob > chi2 = 0.0000; Arellano/Bover Prob > chi2 = 0.1285.

[26]Herein, the World Bank definition of income classification is employed. Low income countries (LIC) are defined as those generating GDP of equal to or less than 1,025 dollars per capita, per year. High income countries (HIC) are those countries generating GDP of equal to or greater than 12,037 dollars per year. Categorisations based on U.S. dollar classifications.

[27]The lagged rate of change in software piracy ($L_1\Delta P_{it}$) appears to be more strongly related to piracy than GDP. Consider that existing piracy rate change as calculated by $L_1\Delta P_{it}$ within the specification; is a measure of the current level of software piracy change. By virtue of its construction this value could be considered the first derivative of the stock of pirated material, if the absolute rate of software piracy is taken to be a measure of the level of piracy. This was not considered within Shadlen et al (2005) and may give rise to inconsistencies. Absent of the inclusion of this pertinent variable, other specifications may be inaptly framed.

finding is an association between WTO case activity and software piracy within low GDP countries, noting however that the result was not significant at the 10% level.

Table 4: Scientific investment, Government effectiveness, and Bilateral Trade

Variables	(1) High GDP GMM	(2) Low GDP GMM	(3) High GDP Government/Bilateral	(4) Low GDP Government/Bilateral
$L_1\Delta P$	0.909464***	0.987***	0.9477924***	0.8880348***
$GDPcap$	0.000204**	0.0060139	0.0002282**	-0.0094544***
$HumanCap$	-0.34339***	-0.0238615	-0.23147	0.0025016
$ScientificInv$	-0.85447*	-9.549974***		
Gov			-1.188213	7.578199
$BilatInv$			0.0002018	-0.000973
Constant	29.58851***		16.2288	18.06556
WTO			0.6637727	-2.274854
Obs.	346	85	346	85

Table 4 includes models that consider the relationship between Government effectiveness, Bilateral investment (as measured by Kaufmann (1991) and the dollar value of bilateral investment) and Piracy rates. The dependent variable is the rate of piracy at a national level. Models are estimated with robust standard errors. The model is a GMM System model based on Arellano and Bover (1995) and Blundell and Bond (1998). The absolute t-statistics are in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.[28]

Out of cycle reviews appear to have a negative impact on piracy, with large coefficients. The effect is only significant, however, for high GDP countries. The Special 301 Report is an annual document framed by the USTR that offers a review of the global state of intellectual property rights (IPR) protection and enforcement. The USTR conducts the review under Section 182 of the Trade Act of 1974, as subsequently amended by the Omnibus Trade and Competitiveness Act of 1988 and the Uruguay Round Agreements

[28]Recall again that Pooled panel models are estimated utilising the Generalised Method of Moments approach rather than the OLS approach, based on the method developed by Arellano and Bover (1995).

Act. The effect of the US 301 report appears to be highly significant. The study identifies that U.S. 301 inclusion is highly significant to software piracy. Inclusion within the 301 report has a negative impact on software piracy. This is arguably the most significant contribution of the study.

Herein, we offer the "Political signalling hypothesis" that the inclusion of a nation in the 301 Report, results in increased U.S. and foreign nation scrutiny which is likely to cause software companies to be more aware and alert about their selling and distribution practices within the country. Moreover, and more pertinently, it results in greater USTR scrutiny of the practices adopted by the country and creates the perception of or potential of sanction, or political pressure.

The findings indicate that reductions in piracy rates within high income countries are associated with Out of cycle review while Low GDP countries appear to be more significantly associated with ongoing reporting mechanisms as evidenced by the association evident between U.S. 301 Reporting and Piracy. It is plausible that developing countries that generally evidence higher rates of software piracy are less likely to be subjected to out of cycle reviews as they are frequently subject to U.S.301 reporting. High GDP countries generally evidence lower software piracy rates and consequently may respond more significantly to what they perceive to be the credible threat associated with out of cycle review.

The study findings in relation to U.S. 301 reporting and out of cycle review are in contrast with those within Shadlen et al. (2005). These divergent findings are plausibly due to the dynamic panel bias corrections and endogeneity controls within the present study. Notably, the effect size estimates within the present study are substantially different to those within Shadlen et al. (2005). This finding is consistent with earlier studies were dynamic panel bias corrections are employed (n.b. Roodman 2012, Nickell 1981). This matter is discussed extensively in Roodman, (2012). It is notable however, that the findings are consistent with the expectations outlined within the original Shadlen et al. (2005) study. While these findings are consistent with the anticipated effects of bilateral pressure, they nonetheless, warrant further research.

Table 5: Out of Cycle Review, Trade and U.S. 301

Variables	(1) High GDP GMM (OoCR & Trade)	(2) Low GDP GMM (OoCR & Trade)	(3) High GDP US301	(4) Low GDP US301
$L_1\Delta P$	0.9763932***	0.9497462***	0.945164	0.907771***
$GDPcap$	-0.0077992***	0.0002729**	0.0002753	-0.00643***
$HumanCap$	0.2688571*	-0.371046***	-0.3756982	0.168807
$OutofCyc$	-7.478845**	-0.3886549		
$TradeDep$	0.0221603	0.0440319**		
$US301$			0.160787	-1.1265*
Constant	-9.402642	25.15029***	1.144559	26.32945***
Obs.	346	85	346	85

Table 5 includes models that consider the relationship between Out of Cycle Review, Trade and U.S. 301 reporting and Piracy rates. The dependent variable is the rate of piracy at a national level. Models are estimated with robust standard errors. Model is a GMM System model based on Arellano & Blover/Blundell & Bond. The absolute t-statistics are in parentheses. Significance levels; *p $<$ 0.10, **p $<$ 0.05, ***p $<$ 0.01.[29]

7. Conclusions

This study has sought to address the dearth of research utilising country and income panel data to identify empirical linkages between IPRs, Region, WTO membership, and pertinantly measures of bi-lateral pressure including U.S. 301 reporting and out of cycle reviews and the observed rates of software piracy. The extant literature is of qualitative nature, or survey based. Such research seeks to theorise rather than analyse piracy behaviours. Shadlen et al. (2005) rank amongst the few contemporary studies employing quantitative methods to analyse the relationship. The seminal study considered a number of pertinent macroeconomic variables in an effort to surmise whether any possess any explanatory power. In particular, in Shadlen et al. (2005), the authors have afforded greater

[29]Ibid.

attention to the role of WTO membership and multilateral agreements in moderating software piracy.

This study extends significantly upon Shadlen et al. (2005), addressing specification issues, and incorporating income grouping based panel analysis to offer robust findings. In this study, the relationship between IPRs, enforcement activities and software piracy is considered. It is a response to the dearth of research incorporating both dynamic methods of estimation, and consideration of TRIPSs affords into a single set of specifications. Uniquely, the study also considered the role of GDP level, though High and Low GDP groupings, on piracy levels.

The study sought to consider the role that U.S. 301 reporting and Out of Cycle review activity play in developed and developing economies. The findings (and pertinently the more robust Arellano and Bond dynamic estimations) suggest that U.S. 301 reporting has played a significant role in reducing software piracy in contrast with Shadlen et al. (2005). This is a significant finding and indicates that further research into economies in transition would be particularly apt. The study has offered more robust coefficient estimates and pertinently more robust estimates of the significance for Out of Cycle review and U.S. 301 reporting, with the evidenced effect sizes smaller than those presented in Shadlen et al. (2005). It is evident that further empirical research into multilateral agreements and regulatory reform would be highly beneficial to the intellectual property and software piracy literature.

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Appendix 1 – **List of countries included in the study**

Argentina, Australia, Austria, Bahrain, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Finland, France, Germany. Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan,

Kenya, Korea, Kuwait, Latvia, Lebanon, Lithuania, Malaysia, Malta, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, UAE, UK, Uruguay, Venezuela, Vietnam, Zimbabwe.

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