Why do Software Manufacturers Tolerate Piracy in Transition and Less Developed Countries? A theoretical model

Michael Kunin

CERGE-EI

Charles University
Center for Economic Research and Graduate Education
Academy of Sciences of the Czech Republic
Economics Institute

WORKING PAPER SERIES (ISSN 1211-3298)
Electronic Version

231

Why do Software Manufacturers Tolerate Piracy in Transition and Less Developed Countries? A theoretical model*

Michael Kúnin†

Abstract

This paper provides an explanation as to why software manufacturers from developed countries tolerate widespread copyright infringement in less developed countries and often even offer local versions of their products. In a simple two-period framework, I show that if network externalities are present and an improvement in copyright enforcement is expected, then it is profitable for the software manufacturer to enter the market even if it incurs losses in the beginning when copyright enforcement is weak.

Abstrakt

Článek dává vysvětlení, proč výrobci softwaru z rozvinutých zemí tolerují rozšířené porušování autorských práv v rozvojových zemích a často dokonce nabízejí lokalizované verze svých produktů. V jednoduchém dvouperiodovém modelu ukazuji, že pokud jsou přítomny síťové externality a očekává se zlepšení vymahatelnosti autorských práv, je pro výrobce softwaru výhodné vstoupit na trh i v případě, že by tímto na začátku, kdy je vymahatelnost autorských práv nízká, utrpěl ztráty.

JEL classification: O34; L20

Keywords: Intellectual property rights; Software; Piracy; Transition; Network externalities.

---

* I wish to thank Milan Horniaček and Guido Friebel for helpful comments..

† Charles University and the Academy of Sciences of the Czech Republic, CERGE-EI, Politických vězňů 7, 111 21 Prague 1, Czech Republic; michael.kunin@cerge-ei.cz.

1 Introduction

Illegal reproduction of microcomputer software, known as copyright infringement or software piracy, has been claimed a major problem for the software industry since no later than the 1980s. The share of pirated software in, for example, the United States has been estimated to be higher than 25% during the whole 1990s (Conner and Rumelt, 1991; Slive and Bernhardt, 1998; Marron and Steel, 2000), and this figure is even higher in other countries. This should mean that the software developers lose such substantial parts of their profits to piracy that one could expect the firms to spend much on anti-piracy measures. Indeed, the firms often announce their new copyright protection technologies in newspapers and on the Internet, and they also declare their intention to use all legal ways to fight software piracy. However, Slive and Bernhardt (1998) state that in practice software manufacturers continue to spend little on copyright protection. Conversely, some of them offer fully functional "evaluation" versions for free download from the World Wide Web. Thus, in many cases the rhetoric is not supported by real action.

This phenomenon is even more pronounced in transition and less developed countries. For example, Marron and Steel (2000) provide data showing that the average piracy rates in Central Europe in 1994-97 were around 65%, whereas these rates in the neighbouring countries of Western Europe (Germany, Austria) did not exceed 50%. In general, top-level firms in the software industry seem to tolerate copyright infringement in less developed countries. Moreover, these firms undertake country-specific investments (e.g., they translate their software into local languages), which at the first sight results in direct losses since most of the copies are acquired illegally. In addition, the firms seem to be quite unwilling to resist software piracy by influencing the national governments.

The issue of copyright protection is a particular case of the general problem of intellectual property rights (IPR) protection, which is an important issue both for developed countries, where most of the world's R&D work is conducted, and for transition and less developed countries. The developed countries, often referred to as the North, which believed that lax IPR protection and IPR infringement by the less developed countries (the South) resulted in large losses for northern firms, raised the IPR problem at the Uruguay Round of General Agreement on Tariffs and Trade. In response, the South claimed that IPR protection is just a device for transferring monopoly rents to rich Northern countries.

The North-South trade framework is one of the most common for analysing the effects of IPR protection and infringement. In a path-breaking theoretical paper on these issues, Chin and Grossman (1990) find that the South benefits from no IPR protection whereas the North is worse off. Deardorff (1992) confirms this result in stating that the North always benefits from IPR enforcement. Taylor (1993) finds that Northern innovative firms can overcome the IPR infringement problem by means of "masquing" activities. In the case of software, such activities can include programming traps, partial code encryption, and several other methods, though "masquing" in the software industry is not especially efficient thanks to hackers' activity. Žigić (2000) shows that IPR violations in the South lead to higher tariffs on Southern products in the North. All these papers, in various ways, support the view that the lack of IPR protection always harms the Northern country. However, this conclusion is not uncontested. For instance, Jarolím and Yeung (1998) find that in a simple two-period framework wherein present IPR setting affects future market size, the North may benefit from no IPR protection. According to Žigić (1998), relaxing IPR protection in the North, if such protection results in Northern firms having too much monopoly power, may improve the North's welfare.

Intellectual property issues play an extremely important role in the software industry and the Internet, and there is the following analogy with the North-South framework. Software manufacturers, who invest in software design, (claim to) suffer substantial losses due to illegal copying. Thus the software manufacturers, like the North in the North-South framework, seem to benefit from copyright enforcement whereas the users, like the South, seem to gain from a lack of copyright protection. It is interesting to note that the viewpoint according to which effort exerted by software firms to tighten copyright protection would result in higher monopoly profits rather than in "fair" compensation for costs prevails in less developed countries and is often encountered even in developed countries (e.g., Microsoft antitrust case).

However, there exist several substantial differences between conventional industries and the software industry. The principal distinction is that the software industry exhibits very low marginal costs, and, in fact, it costs zero for a firm to have any number of copies of its software downloaded from the Internet. In addition, any copies (and copies of copies, and so on) of software are identical to the original unless the original is copy protected, which distinguishes illegal copying of software from that of books, journals or even audio- and video-cassettes (Shy and Thisse, 1999).

Another major distinctive feature of the software industry is its network nature. Hence, one can expect that network externalities may render it profitable for the software producers to tolerate piracy to a certain extent. Slive and Bernhardt (1998) even call this phenomenon "tacit approval to piracy." This is confirmed in an empirical paper by Stolpe (2000), who finds that 40% of German software developers whose products are industry-specific and therefore not liable to network effects use hardware keys, an advanced technique virtually excluding illegal copying, whereas the corresponding figure for standard applications is just 23%.

In this paper, I model the conditions under which software manufacturers from the developed countries can tolerate extremely high piracy rates in less developed countries and even develop local versions of their products. I claim that if the firms expect future improvements in intellectual property rights (IPR) protection along with growing market size, then it can be optimal to allow some (and even much) copyright infringement "today" due to higher profits and market shares "tomorrow."

The policy of top software producers such as Microsoft in Central and Eastern Europe can serve as an example. The current copyright protection status in those countries is not extremely satisfactory, and sometimes they are characterised by the self-explanatory expression "one-CD countries." Their accession to the EU, however, can serve as an "outside anchor" for copyright protection; this argument is similar that of Berglöf and Roland (1998), where EU accession may serve as an "outside anchor" that relieves political constraints on reforms. The market for software is rapidly growing as computers and the Internet become more and more widespread. In other words, the software market exhibits inherent growth that does not depend on the activity of software firms.

Another issue of interest is the copyright protection setting under which social welfare is maximised. Different opinions exist about how copying, which is the immanent form of IPR violation in software markets, affects welfare. Johnson (1985) claims that the society benefits in the short run from legal restriction of copying whereas in the long run the effect is uncertain. Takeyama (1997) compares the static and the intertemporal consequences of copying and obtains the following results. First, the harm to firms (and to welfare) can be substantially higher in an intertemporal framework than in a static one. Second, under certain conditions firms receive higher profits with copying than without it, which happens due to intertemporal price substitution.

The paper proceeds as follows. Section 2 contains the description of the model framework. In Section 3 I analyse the behaviour of the monopolist when it takes the levels of copyright protection as given, and in Section 4 I describe how and why welfare maximisation results in copyright protection improvement when network externalities and "outside anchors" are present. Section 5 concludes. All mathematical proofs and figures are in the appendices.

2 The model

2.1 The firm

The industry has a single monopolist firm (as in Slive and Bernhardt, 1998) that operates in two periods. I assume that marginal production costs equal zero as in the software industry, where programmes can be purchased and installed via the Internet (McKnight and Bailey, 1998). The firm is assumed to be foreign, and its sales in the local market constitute only a small fraction of its total sales. Thus, the firm's fixed costs essentially equal *localisation* costs, e.g., translation of the product interface into the local language, adapting the product to different measurement and monetary systems, and the like.

In the beginning, the firm decides whether to enter the market or to stay out in each period, and then decides on the price in all periods in which it decides to operate. Thus, the firm's strategy can be formalised as $(\alpha_1, \alpha_2, p_1, p_2)$, where $\alpha_i = 1$ if the firm decides to operate in period i and $\alpha_i = 0$ otherwise, and p_i is the price charged in period i if $\alpha_i = 1$ and is arbitrary, e.g., $p_i = 0$, if $\alpha_i = 0$. The commodity produced by the firm is like software upgraded over time, which implies that the firm should incur localisation costs in any period in which it decides to operate. For simplicity I assume that the localisation costs amount to F per period. Then the profit of the firm in period i if it decides to enter the market in this period ($\alpha_i = 1$) equals $\Pi_i = p_i q_i - F$, where q_i is the number of *legally* purchased copies. Thus, the firm's objective function, which is the joint profit in both periods, is

$$\Pi = \alpha_1 \Pi_1 + \alpha_2 \Pi_2 = \alpha_1(p_1 q_1 - F) + \alpha_2(p_2 q_2 - F) \tag{1}$$

(I assume no discounting.)

2.2 The consumers

The market size (number of consumers) in period i is M_i, each consumer has a valuation of the firm's product, and the valuations are uniformly distributed on $[0, A]$. In each period every consumer has three options: to purchase the product legally, to make an illegal copy (to engage in piracy), or to do without the product. In addition, I assume that the "period 1" version has no value to consumers in period 2.

In each period, the consumers are divided into two types, independently of their valuations of the product. They are "controlled" consumers who cannot engage in piracy, and "uncontrolled" consumers, who can pirate.[1] Copyright protection in period i is measured by $\beta_i \in (0, 1)$, which can be interpreted as the share of "controlled" consumers in the total or as the probability that a particular consumer is "controlled." The values β_i are exogenous for the firm, i.e., the firm has no power to influence the level of copyright protection and cannot penalise pirating consumers, nor can it undertake "masquing" activities to resist piracy. At this point, the level of copyright protection is assumed low in the first period and high in the second one, i.e., $\beta_1 < \beta_2$. A justification for this assumption is provided in Section 4.

The objective function of a consumer with valuation v when the product of the firm is sold at price p is the surplus which equals $v - p$ if the consumer purchases a legal copy, v

[1] In many theoretical models of firm behaviour in the software and similar industries the consumers are divided into two groups, one of which is less inclined to make illegal copies (in this paper the "controlled" consumers constitute such a group.) Specifically, Takeyama (1997) simply divides the consumers into "low-valuation" and "high-valuation". Slive and Bernhardt (1998) assume that there are "business consumers" and "private consumers", with only the former gaining from network externalities and paying higher piracy penalties than the latter. Shy and Thisse (1999) develop a static duopoly location model where there are again two types of consumers: those who demand software support and thus are willing to purchase the product and those who do not benefit from support and, therefore, prefer to copy the product illegally.

if the consumer makes a pirated copy and zero if the consumer does without the product. Taking into account that $p \geq 0$ and $v \geq 0$, the valuation maximisation implies that a "controlled" consumer will buy if $v \geq p$ and do without if $v < p$, and an "uncontrolled" consumer will always pirate since there is no punishment for piracy.

If there are M_i consumers in period i and a share of β_i of them is controlled, then the *legal* demand for the product is

$$q_i = q_i(p_i) = \beta_i M_i Prob\{v \geq p_i\} = \beta_i M_i(1 - p_i/A) = \beta_i M_i(A - p_i)/A \tag{2}$$

for $p_i \in [0, A]$ and $q_i = 0$ for $p_i > A$. Since all uncontrolled consumers engage in piracy, the total number of product users in period i equals

$$n_i = q_i + (1 - \beta_i)M_i = M_i(A - \beta_i p_i)/A. \tag{3}$$

2.3 Network effects and demand

The industry in question is a network industry (Economides, 1995), and the market size is not constant over time. In this model the network nature of the industry means that the present action of the firm can influence its future market size. Namely, the more consumers use the firm's product in period 1 (both legally and illegally), the more consumers will use its upgrade in period 2, which is a special case of a positive network externality (Katz and Shapiro, 1985). The trade-off faced by the firm is whether it should tolerate present piracy in order to obtain higher future profits or restrict its present activity in order to prevent piracy, which will lead to lower future profits.

In this model, the network effects are formalised in the following way. I denote the market size in period 1 $M_1 = M$ and assume that in period 2 the market increases by μ per each user of the product in period 1, i.e., $M_2 = M + \mu n_1$. The parameter $\mu > 0$ measures the strength of the network externality. Thus, according to (2) and (3) the legal and total demands in period 1 equal

$$q_1 = \beta_1 M(A - p_1)/A \text{ and } n_1 = M(A - \beta_1 p_1)/A \tag{4}$$

respectively and the legal demand in period 2 amounts to

$$q_2 = \beta_2(M + \mu n_1)(A - p_2)/A = \beta_2 M(A - p_2)(1 + \mu - \mu\beta_1 p_1/A)/A. \tag{5}$$

3 Profit maximisation

This section deals with the case when the monopolist firm, which always in this model takes the copyright protection rates β_1 and β_2 as given, is the only player in the game. Denote $f = AF/M$, $C = 4f/A^2 = 4F/(AM)$ and assume that $\mu < 1$ and $C < 1$ (i.e, that the network externality is not too strong and the market is not too small and/or the costs are not too high.)

As was stated in Section 2, the firm first chooses $\{\alpha_1, \alpha_2\}$, i.e., it chooses whether to enter and in which periods. Since both α_1 and α_2 can take only two values, there are four possible cases, which I denote as None (superscript N, $\alpha_1 = \alpha_2 = 0$), First (F, $\alpha_1 = 1$, $\alpha_2 = 0$), Second (S, $\alpha_1 = 0$, $\alpha_2 = 1$) and Both (B, $\alpha_1 = \alpha_2 = 1$). Having chosen $\{\alpha_1, \alpha_2\}$, the firm decides on prices $p_1, p_2 \in [0, A]$ in order to maximise its profit.

From (1), (4) and (5) it follows that

$$\Pi^N \equiv 0, \quad \Pi^F = \beta_1 M p_1 (A - p_1)/A - F, \quad \Pi^S = \beta_2 M p_2 (A - p_2)/A - F,$$

$$\Pi^B = \beta_1 M p_1 (A - p_1)/A + \beta_2 M p_2 (A - p_2)(1 + \mu - \mu\beta_1 p_1/A)/A - 2F$$

($n_1 = 0$ for the case S.) In the rest of this Section, all profits are multiplied by A/M for the sake of convenience so that the values used are

$$\Pi_N \equiv 0, \quad \Pi_F = \beta_1 p_1 (A - p_1) - f, \quad \Pi_S = \beta_2 p_2 (A - p_2) - f,$$

$$\Pi_B = \beta_1 p_1 (A - p_1) + \beta_2 p_2 (A - p_2)(1 + \mu - \mu\beta_1 p_1/A) - 2f.$$

The results of profit maximisation are summarised in the following lemma.

Lemma 1 *Let $\beta_2\mu < 4$. Then the prices maximising the profit of the firm are*

$$p_1^F = p_2^S = p_2^B = \frac{A}{2}, \quad p_1^B = \frac{A}{2}\left(1 - \frac{\mu\beta_2}{4}\right), \tag{6}$$

and the corresponding maximal profits equal

$$\Pi_N^0 \equiv 0, \quad \Pi_F^0 = \frac{A^2}{4}\beta_1 - f, \quad \Pi_S^0 = \frac{A^2}{4}\beta_2 - f, \tag{7}$$

$$\Pi_B^0 = \frac{A^2}{4}\left(\beta_1\left(1 - \frac{\mu\beta_2}{4}\right)^2 + (1+\mu)\beta_2\right) - 2f. \tag{8}$$

The proof of this lemma can be found in Appendix A. The assumption that $\beta_2\mu < 4$ is necessary to ensure that the price p_1^B is positive; this assumption holds if $\mu < 1$ since $\beta_2 \in (0, 1)$.

The most important outcome of Lemma 1 is that if the firm operates in both periods and there is a network externality ($\mu > 0$), then the price charged in period 1 is below the monopoly price $p^m = A/2$. This conforms with the general result of intertemporal pricing that if the products sold in different periods are complements (i.e., when a decrease in price in one period entails an increase in demand in another one, as is here $\partial q_2/\partial p_1 < 0$), then the monopoly power (measured by the difference between the price and the marginal cost) is not higher than in the case of independent demands (Tirole, 1988).

Now the firm chooses the strategy which yields the maximal profit among the four possible options N, F, S and B. However, from (7) it follows that if $\beta_1 < \beta_2$ then $\Pi_F^0 < \Pi_S^0$, i.e. option F is strictly dominated by option S.

Corollary 1 *If the copyright protection level in period 2 is higher than in period 1, then the firm never decides to enter the market in period 1 and to stay out of the market in period 2.*

The key result of this section is the following proposition.

Proposition 1 *Let $\mu < 1$, $C < 1$ and $\beta_1 < \beta_2$. Then*

(i) There exists a continuous function $G(\beta_2)$ defined for $\beta_2 \in [0, C/\mu]$ and decreasing in β_2 such that the firm operates in both periods if $\beta_1 > G(\beta_2)$;

(ii) If $\beta_1 < G(\beta_2)$ then the firm stays out of the market in both periods if $\beta_2 < C$ and enters only in period 2 if $C < \beta_2 < \min\{1, C/\mu\}$;

(iii) If $\mu > C$ and $\beta_2 > C/\mu$ then the firm operates in both periods regardless of the value of β_1.

The proof of this proposition can be found in Appendix B. The proposition is illustrated in Figures 1 and 2, where β_1 is plotted against the vertical axis and β_2 is plotted against the horizontal axis. Regions in the (β_1, β_2) plane wherein the firm does not enter at all, enters in period 2 and operates in both periods are marked N, S and B, respectively. Figure 1 corresponds to the case $\mu < C$ when the firm never operates in period 1 under zero copyright protection, and Figure 2 illustrates the case $\mu > C$ in which such a situation can occur.

Thus, the higher the level of copyright protection in the future, the higher the firm's tolerance of piracy at present. It is even possible that the firm's optimal strategy implies suffering a loss in period 1 and being compensated for it in period 2. For example, this can happen if part *(iii)* of Proposition 1 applies because if $\mu > C$ and $\beta_2 > C/\mu$ then the firm always operates in both periods, and if $\beta_1 = 0$ then the profit of the firm in period 1 equals $\Pi_1 = -f < 0$. In general, the following corollary provides a sufficient condition for such a situation to occur.

Corollary 2 *Let the assumptions of Proposition 1 hold. If β_2 is such that either $G(\beta_2) < \beta_2$ or $\beta_2 > C/\mu$ then there exists at least one value of β_1 such that $\beta_1 < \beta_2$ and it is strictly optimal for the firm to operate in both periods although the firm makes a loss in period 1.*

The proof of this corollary can be found in Appendix C. In other words, if the assumptions of Proposition 1 hold and the level of copyright protection in period 2 is sufficiently high so that the firm strictly prefers to operate in both periods for some β_1, then for some (possibly different) β_1 the firm still operates in both periods while making a loss in period 1.

The most important comparative statics result of this model is that if C decreases then the set of values (β_1, β_2), such that the firm operates in both periods, enlarges, and the set of values (β_1, β_2), such that the firm completely stays out of the market, shrinks. Since $C = 4F/(AM)$ this means that the firm becomes more tolerant of piracy if the localisation costs fall and/or if the market size rises. A similar shift towards the firm operating in both periods takes place when the network externality μ increases. These results could explain why software developers operate (and offer localised versions) in certain countries where piracy rates exceed 90% according to Marron and Steel (2000).

Though the *present* copyright protection level β_1 can be observed, the *future* copyright protection level β_2 is, in fact, the firm's expectation. The question appears whether an expectation that copyright protection will improve is rational. This is discussed in the next section.

4 Endogenous copyright protection

In this section, I introduce another player called *the government* into the game. This player controls the copyright protection rates β_1, β_2 and its objective function is net welfare, which consists of the following two components. First, it is the consumer surplus from *legal* sales (I assume that surplus from piracy does not enter welfare). If a consumer with valuation v buys a legal copy at price p, the welfare generated is $v - p$. Second, in order to enforce copyright protection at rate β_i in period i, the government should spend $E_i(\beta_i)$, where $E_i(\cdot)$ is a convex differentiable function defined on $[0, 1]$ with the following properties.

$$E_i(0) = 0, E_i' \geq 0, E_i'' > 0, E_i'(0) = 0, E_i'(1) = +\infty.$$

This reflects the fact that it is cheap to control small fractions of consumers but it is virtually impossible to control all of them (the condition $E_i'(1) = +\infty$ means that the cost of total copyright enforcement should exceed the welfare attained under it). Note that the profit of the firm does not enter welfare because the firm is foreign.

In this paper, I assume that in period 1 $E_1(\beta_1) = AME(\beta_1)/8$ and in period 2 $E_2(\beta_2) = \alpha AME(\beta_2)/8$, where $E(\cdot)$ is the same in both periods and $\alpha \in (0, 1)$, which means that it is cheaper to enforce copyright protection in period 2 than in period 1. For instance, if the market in question is situated in an EU accession country then the assumption $\alpha < 1$ can be attributed to the "outside anchor" effect (e.g., the EU may partially compensate for the expenditures on copyright protection). Developments in copyright protection technology may also lead to copyright enforcement becoming cheaper. The parameter α may also reflect the political will to enforce copyright protection, where lower α corresponds to higher political will. For example, the government may wish to increase IPR protection in order to improve its reputation in this area, or under pressure exerted by developed countries and international organisations (the other side of the "outside anchor" is that the country might be punished for lax treatment of intellectual property rights violations).

In the interaction between the government and the firm, the former takes the leader's role. In other words, the government chooses the copyright protection rates taking into account the firm's reaction, which consists of the prices (6) and the firm's entry decision according to Proposition 1. On the contrary, the firm takes β_1 and β_2 as given. However, I assume that the government makes its decision on both rates simultaneously when period 1 begins, and it cannot modify its choice of β_2 afterwards, e.g., in the beginning of period 2. That is, the government *commits* to a certain level of β_2. This commitment assumption can be justified similarly to the assumption that $\alpha < 1$ by an argument of "outside anchor" or reputation.

If the price charged by the firm in period i is p_i and the quantity sold legally is $q_i = q_i(p_i)$ determined by (2), then the consumer surplus from legal purchases in period i equals

$$W_i = \int_{p_i}^{A} q_i(v)dv = (A - p_i)q_i/2 \tag{9}$$

(the demand is linear). If the firm decides to operate in both periods then from (4), (5), (6) and (9) it follows that

$$W_1 = \frac{AM}{8}\beta_1\left(1 + \frac{\mu\beta_2}{4}\right)^2, \quad W_2 = \frac{AM}{8}\beta_2\left(1 + \mu\left(1 - \frac{\beta_1}{2}\right) + \frac{\mu^2\beta_1\beta_2}{8}\right).$$

The objective function of the government is

$$W_T = W_1 + W_2 - E_1(\beta_1) - E_2(\beta_2) =$$

$$\frac{AM}{8}\left(\beta_1 + \beta_2 + \mu\beta_2\left(1 + \frac{3}{16}\mu\beta_1\beta_2\right)\right) - \frac{AM}{8}(E(\beta_1) + \alpha E(\beta_2)).$$

For the sake of convenience, I divide this function by $(AM/8)$ so that the function used is

$$W = \beta_1 + \beta_2 + \mu\beta_2\left(1 + \frac{3}{16}\mu\beta_1\beta_2\right) - (E(\beta_1) + \alpha E(\beta_2)). \tag{10}$$

The principal result of this section is the following proposition.

Proposition 2 *Let $\mu, \alpha \in (0,1)$ and $\alpha E''(\beta) > 3\mu^2\left(1 + \sqrt{1+4\alpha}\right)/16$ for all β. Then the values of copyright protection rates β_1, β_2 maximising (10) are interior ($\beta_1, \beta_2 \in (0,1)$) and copyright protection is stronger in period 2, i.e., $\beta_1 < \beta_2$.*

The proof of this proposition can be found in Appendix D. The condition on $\alpha E''(\beta)$ is needed to ensure that the function (10) has an interior maximum. Thus, the assumption that copyright protection improves over time is justified.

In this section, it is assumed that the firm operates in both periods. However, in Proposition 2 it is not guaranteed that the government will actually choose β_1 and β_2 such that $\beta_1 > G(\beta_2)$, where $G(\beta_2)$ is introduced in Proposition 1. Nevertheless, if $C = 4F/(AM)$ is sufficiently low (i.e., if the localisation costs are not too high and/or the market is not too small), then $\beta_1 > G(\beta_2)$ and the firm will operate in both periods.

5 Conclusion

In many theoretical papers about IPR issues in the software industry, the authors consider the case when a firm or firms produce(s) for the domestic market. The contribution of this paper is that it provides an explanation for the fact that software manufacturers from developed countries may tolerate illegal copying in transition and less developed countries when an improvement in intellectual property rights protection is expected. Like Slive and Bernhardt (1998) I assume that there is only one firm but the framework is dynamic (two-period) as in Takeyama (1997), and that there are intertemporal network externalities similar to those discussed by Jarolím and Yeung (2000). I find that under very general conditions it is optimal for the monopolist to tolerate piracy in period 1 if copyright protection is stronger in period 2 and that this enforcement of copyright protection is socially optimal if network externalities and "outside anchor" effects are present.

For the sake of simplicity I abstract from some issues which can be relevant. First, the firm may be capable of protecting its software against piracy (Conner and Rumelt, 1991; Takeyama, 1997). If such protection is not costly then the firm would be more likely to enter the market at the very beginning. Second, after-market services such as documentation and maintenance can be available for legal users. With these after-market services the consumers with the highest valuations can buy the product even if they can engage in piracy (Shy and Thisse, 1999). Third, consumers in period 2 may use software purchased or pirated in period 1, which would erode the firm's profit and make the firm less willing to enter in the beginning.

However, the most important simplification is that there is a monopoly. If there are many firms then, on the one hand, competition would lead to lower profits and therefore to lower willingness to enter if copyright protection is weak (thus, the firms would avoid illegal copying of their products by not entering the local markets). On the other hand, the firms may want to enter in the beginning in order for the local consumers to get acquainted with their products. Such firms may expect higher market shares and profits in the future (when copyright protection is enforced) even if their products are dominated in quality by other software because the consumers are unwilling to switch between products[2]. The case of more than one firm is a possible extension of the paper and a topic for further research.

References

Berglöf, E. and G. Roland (1998), "The EU as an 'outside anchor' for transition reforms," *SITE Working Papers* 132.

[2]Slive and Bernhardt (1998) mention that this phenomenon had been noted prior to 1991.

Chin, J. C. and G. M. Grossman (1990), "Intellectual property rights and North-South trade," in Jones, R.W., and A. O. Krueger, eds., *The political economy of international trade: essays in honour of Robert E. Baldwin*, Basil Blackwell.

Conner, K. R. and R. P. Rumelt (1991), "Software piracy: an analysis of protection strategies," *Management Science* 37, 125-139.

Deardorff, A. V. (1992), "Welfare effects of global patent protection," *Economica* 59, 35-59.

Economides, N. (1996), "The economics of networks," *International Journal of Industrial Organization* 14, 673-699.

Jarolím, M. and B. Yeung (1999), " FDI spillovers and property rights protection: a policy dilemma," *CERGE-EI Discussion Paper Series* 1999-30.

Johnson, W. R. (1985), "The economics of copying," *Journal of Political Economy* 93, 158-174.

Katz, M. and C. Shapiro (1985), "Network externalities, competition and compatibility," *American Economic Review* 75, 424-440.

Marron, D. B. and D. G. Steel (2000), "Which countries protect intellectual property? The case of software piracy," *Economic Inquiry* 38, 159-174.

McKnight, L. W. and J. P. Bailey, eds. (1998), *Internet Economics*, MIT Press.

Shy, O., and J. F. Thisse (1999), "A strategic approach to software protection," *Journal of Economics & Management Strategy* 8, 163-190.

Slive, J., and D. Bernhardt (1998), "Pirated for profit," *Canadian Journal of Economics* 31, 886-899.

Stolpe, M. (2000), "Protection against software piracy: a study of technology adoption for the enforcement of intellectual property rights," *Economics of Innovation and New Technology* 9, 25-52.

Takeyama, L. N. (1997), "The intertemporal consequences of unauthorised reproduction of intellectual property," *Journal of Law & Economics* 40, 511-522.

Taylor, M. S. (1993), "TRIPS, trade, and technology transfer," *Canadian Journal of Economics* 26, 625-637.

Tirole, J. (1988), *The theory of industrial organization*, MIT Press.

Žigić, K. (1998), "Intellectual property rights violation and spillovers in North-South trade," *European Economic Review* 42, 1779-1799.

Žigić, K. (2000), "Strategic trade policy, intellectual property rights protection, and North-South trade," *Journal of Development Economics* 61, 27-60.

APPENDIX

A Proof of Lemma 1

Cases F and S are trivial. As regards case B, the first-order conditions are

$$\begin{array}{rclcl} \partial\Pi_B/\partial p_1 & = & \beta_1(A-2p_1-\mu\beta_2 p_2(A-p_2)/A) & = & 0, \\ \partial\Pi_B/\partial p_2 & = & \beta_2(A-2p_2)(1+\mu-\mu\beta_1 p_1/A) & = & 0. \end{array} \tag{11}$$

From the second equation in (11) it follows that either $p_2 = A/2$ or $1+\mu-\mu\beta_1 p_1/A = 0$, but in the latter case $p_1 = A(1+\mu)/(\mu\beta_1) = (A/\beta_1)(1+1/\mu) > A$ since $\beta_1 < 1$ and $\mu \geq 0$. Thus, the only feasible stationary point has $p_2 = A/2$ and from the first equation in (11) $p_1 = (A/2)(1-\mu\beta_2/4)$. Substitution of these prices into the profit function Π_B leads to the profit value in (8).

Since the Jacobian matrix of Π_B is not guaranteed to be negative definite for all values $p_1, p_2 \in [0, A]$, the borders of this square should be checked. If $p_1 = 0$, then $\Pi_B = \beta_2 p_2(A-p_2)(1+\mu)-2f$, which is maximised at $p_2 = A/2$ and results in $\Pi_{B0} = (A^2/4)\beta_2(1+\mu)-2f$. If $p_1 = A$, then $\Pi_B = \beta_2 p_2(A-p_2)(1+\mu-\mu\beta_1)-2f$, which is also maximised at $p_2 = A/2$ and results in $\Pi_B = (A^2/4)\beta_2(1+\mu-\mu\beta_1)-2f < \Pi_{B0}$ since $\beta_1 > 0$. If either $p_2 = 0$ or $p_2 = A$, then $\Pi_B = \beta_1 p_1(A-p_1)-2f$, which is maximised at $p_1 = A/2$ and results in $\Pi_B = (A^2/4)\beta_1 - 2f < \Pi_{B0}$ since $\beta_1 < \beta_2$ and $\mu \geq 0$. Thus, the maximal profit over the boundary of the square $0 \leq p_1, p_2 \leq A$ is reached at $p_1 = 0$ and $p_2 = A/2$. Finally, $\Pi_B^0 - \Pi_{B0} = (A^2/4)\beta_1(1-\mu\beta_2/4)^2 > 0$ so that (p_1^B, p_2^B) actually delivers the global maximum in case B.

B Proof of Proposition 1

The firm (strictly) prefers operation only in period 2 to staying out of the market if $\Pi_S^0 - \Pi_N^0 = \Pi_S^0 > 0$, operation in both periods to staying out of the market if $\Pi_B^0 - \Pi_N^0 = \Pi_B^0 > 0$, and operation in both periods to entering only in period 2 if

$$\Pi_B^0 - \Pi_S^0 = \frac{A^2}{4}\left(\mu\beta_2 + \beta_1\left(1-\frac{\mu\beta_2}{4}\right)^2\right) - f \tag{12}$$

exceeds zero. Thus, the firm (strictly) prefers

$$\begin{array}{l} S \text{ to } N \text{ iff } \beta_2 > C, \\ B \text{ to } N \text{ iff } \beta_1 > \dfrac{2C-(1+\mu)\beta_2}{(1-\mu\beta_2/4)^2}, \\ B \text{ to } S \text{ iff } \beta_1 > \dfrac{C-\mu\beta_2}{(1-\mu\beta_2/4)^2}. \end{array} \tag{13}$$

Note that the denominator in the last two conditions in (13) is positive because $\mu < 1$ by assumption and $\beta_2 \in [0, 1]$, and that from (8) and (12) it follows that

$$\frac{\partial\Pi_B^0}{\partial\beta_1} = \frac{\partial(\Pi_B^0 - \Pi_S^0)}{\partial\beta_1} = \frac{A^2}{4}\left(1-\frac{\mu\beta_2}{4}\right)^2 > 0, \tag{14}$$

$$\frac{\partial \Pi_B^0}{\partial \beta_2} = \frac{A^2}{4}\left(1 + \mu\left(1 - \frac{\beta_1}{2}\right) + \frac{\mu^2 \beta_1 \beta_2}{8}\right) > 0, \tag{15}$$

$$\frac{\partial (\Pi_B^0 - \Pi_S^0)}{\partial \beta_2} = \frac{A^2}{4}\left(\mu\left(1 - \frac{\beta_1}{2}\right) + \frac{\mu^2 \beta_1 \beta_2}{8}\right) > 0. \tag{16}$$

The function $G(\cdot)$ is defined in the following way.

$$G(\beta_2) = \begin{cases} \dfrac{2C - (1+\mu)\beta_2}{(1 - \mu\beta_2/4)^2}, & \beta_2 \leq C, \\ \dfrac{C - \mu\beta_2}{(1 - \mu\beta_2/4)^2}, & \beta_2 > C. \end{cases} \tag{17}$$

The function $G(\cdot)$, as follows from (13), determines the set of copyright protection levels (β_1, β_2), where $\beta_1 = G(\beta_2)$, such that $\Pi_B^0 = \Pi_N^0 = 0$ if $\beta_2 \leq C$ and $\Pi_B^0 = \Pi_S^0$ if $\beta_2 > C$. This function is continuous because $\beta_2 = C \Rightarrow 2C - \beta_2(1+\mu) = C - \mu\beta_2 = C(1-\mu)$. It also takes non-negative values for $\beta_2 \in [0, C/\mu]$ because $C - \mu\beta_2 > 0$ for $\beta_2 < C/\mu$ and for $\beta_2 < C$ $2C - \beta_2(1+\mu) > 2C - C(1+\mu) = C(1-\mu) > 0$.

If $\beta_2 < C$, then by (14) and (15) $G'(\beta_2) < 0$. If $C < \beta_2 < C/\mu$, then by (14) and (16) $G'(\beta_2) < 0$. Thus, $G(\beta_2)$ decreases in β_2 for $0 < \beta_2 < C/\mu$.

If $\beta_1 = G(\beta_2)$, then the firm is indifferent between options B and N if $\beta_2 \leq C$ and between B and S if $\beta_2 > C$. By (14) the firm will prefer B (operation in both periods) if $\beta_1 > G(\beta_2)$. The proof of part *(i)* is complete.

From (14) it also follows that B is dominated if $\beta_1 < G(\beta_2)$. This dominating strategy is N if $\beta_2 \leq C$ and S if $\beta_2 > C$. If $C < \mu$ and $\beta_2 > C/\mu$, then $G(\beta_2) < 0$, which implies that B is optimal for all values of β_1. The proof is complete.

C Proof of Corollary 2

If $\beta_2 > C/\mu$ (which is possible only if $C < \mu$), then $G(\beta_2)$ is not defined, the firm operates in both periods regardless of β_1, and the value which satisfies the claim of the Corollary is, for instance, $\beta_1 = 0$, as was noted in Section 3.

Let $\beta_2 \leq \min\{C/\mu, 1\}$ and $G(\beta_2) < \beta_2$. Then by Proposition 1 the firm operates in both periods when $G(\beta_2) < \beta_1 < \beta_2$. Then the firm's profit in period 1 (multiplied by A/M) equals $\Pi_1 = \beta_1 p_1(A - p_1) - f$, and in period 2 $\Pi_2 = \beta_2 p_2(A - p_2)(1 + \mu - \mu\beta_1 p_1/A) - f$. Substituting the optimal prices $p_1 = p_1^B$, $p_2 = p_2^B$ from (6) yields

$$\Pi_1 = \frac{A^2}{4}\beta_1\left(1 - \frac{\mu^2\beta_2^2}{16}\right) - f \text{ and}$$

$$\Pi_2 = \frac{A^2}{4}\beta_2\left(1 + \mu - \mu\frac{\beta_1}{2}\left(1 - \frac{\mu\beta_2}{4}\right)\right) - f.$$

Note that

$$\Pi_2 - \Pi_1 = \frac{A^2}{4}\left(\beta_2(1+\mu) - \beta_1\left(1 - \frac{\mu\beta_2}{4}\right)\left(1 + \frac{3\mu\beta_2}{4}\right)\right) > 0$$

since $\beta_2 > \beta_1$, $\mu < 1$, and $\beta_2 < 1$. The last inequality is strict even if $\beta_1 = \beta_2$.

Let $\bar{\Pi}_i$ be the limiting value of Π_i as $\beta_1 \to G(\beta_2)$. If $\beta_2 \leq C$, then $\beta_1 = G(\beta_2)$ is the border between the firm operating in both periods and staying completely out of the market, and $\bar{\Pi}_1 + \bar{\Pi}_2 = 0$. Since $\bar{\Pi}_2 - \bar{\Pi}_1 > 0$ as well, $\bar{\Pi}_1 < 0$. If $\beta_2 > C$, then

$$\bar{\Pi}_1 = \frac{A^2}{4}\mu\beta_2\frac{C/2 - 1 - \mu\beta_2/4}{1 - \mu\beta_2/4}.$$

Since $\mu < 1$ and $\beta_2 \in (0,1)$, $1 - \mu\beta_2/4 > 0$. Since $C < 1$, $C/2 - 1 - \mu\beta_2/4 < 0$. Hence, if $\beta_1 = G(\beta_2)$ then $\bar{\Pi}_1 < 0$.

Thus, $\bar{\Pi}_1 < 0$ when β_2 is such that $\beta_2 \leq \min\{C/\mu, 1\}$ and $G(\beta_2) < \beta_2$. Since Π_1 is continuous in β_1, there exists β_1 such that $G(\beta_2) < \beta_1 < \beta_2$ (i.e., the firm operates in both periods) and $\Pi_1 < 0$. The proof is complete.

D Proof of Proposition 2

The government maximises (10) with respect to β_1 and β_2 (I abstract from the conditions $\beta_1, \beta_2 \in (0,1)$ for the time being) so that the first-order conditions are

$$\begin{array}{rclcl} \partial W/\partial\beta_1 & = & 1 + 3\mu^2\beta_2^2/16 - E'(\beta_1) & = & 0, \\ \partial W/\partial\beta_2 & = & 1 + \mu + 3\mu^2\beta_1\beta_2/8 - \alpha E'(\beta_2) & = & 0. \end{array} \tag{18}$$

The condition $\alpha E''(\beta) > 3\mu^2(1+\sqrt{1+4\alpha})/16$ ensures that the Jacobian matrix is negative definite so that the solution to (18), if interior, is a local maximum.

Since $E'(0) = 0$, $E'' > 0$, $E'(1) = +\infty$, and according to (18) $E'(\beta_i) \geq 1$ and $E'(\beta_i)$ is finite, both β_1 and β_2 are interior, $\beta_i \in (0,1)$.

From (18) it follows that

$$E'(\beta_2) - E'(\beta_1) = (1-\alpha)/\alpha + \mu/\alpha + 3\mu^2\beta_2(\beta_1/\alpha - \beta_2/2)/8,$$

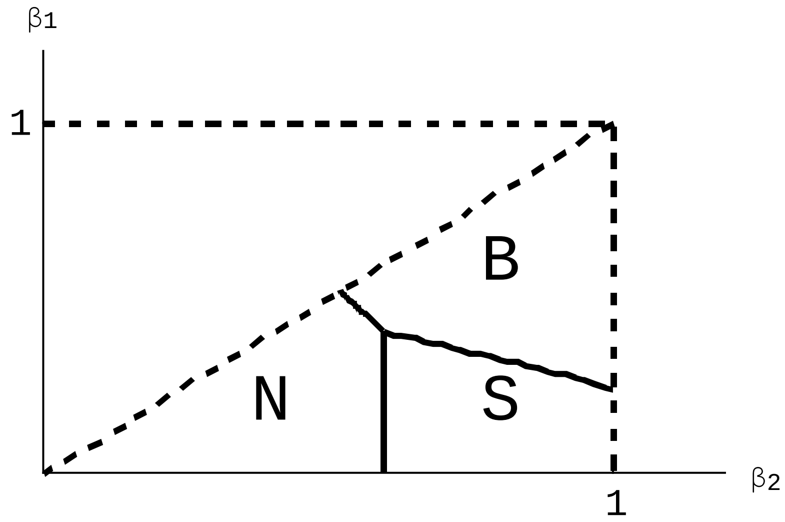
which is strictly greater than (since $\alpha < 1$, $\mu > 0$, $\beta_i \geq 0$)

$$\mu\Big(1/\alpha - 3\mu\beta_2^2/16\Big),$$

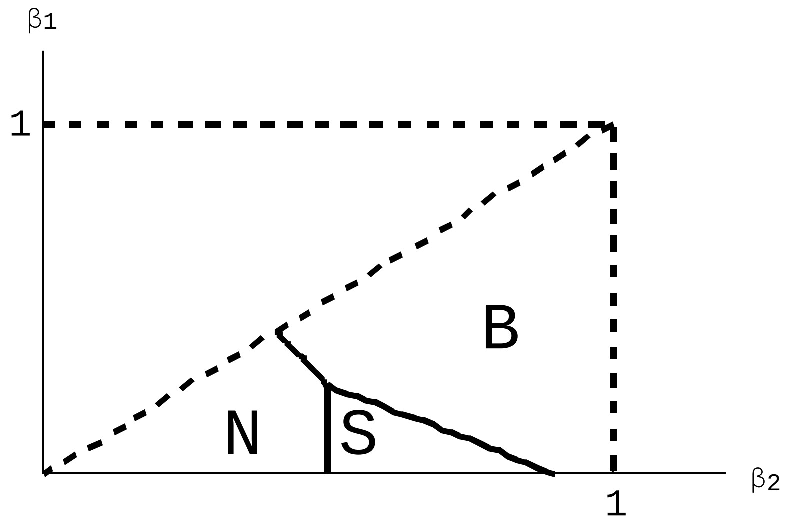
which is positive since $\mu > 0$, $1/\alpha > 1$ and $3\mu\beta_2^2/16 < 3/16 < 1$. Thus, $E'(\beta_2) - E'(\beta_1) > 0$, which implies $\beta_2 > \beta_1$. The proof is complete.

FIGURES

1



2



CERGE-EI
P.O.BOX 882
Politických vezòù 7
111 21 Prague 1
Czech Republic
http://www.cerge-ei.cz