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Increasing Intellectual Property Rights Protection: which countries do better?

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Abstract

Developing countries are under increasing pressure to increase their levels of intellectual property rights (IPR) protection. This paper examines how the welfare effects of increasing IPR protection vary with country characteristics. A theoretical model that takes into account the fact that consumers are differentiated by income levels is calibrated with data on income distribution and piracy rates for a sample of 48 countries in two industries characterized by high piracy levels: music (CDs) and software. An index is constructed which allows us to rank countries based on their initial conditions with respect to income distribution and IPR protection. Results indicate that the effects of increasing IPR protection are nonlinear: in the short run, greatest losses are borne by countries with the best or worst initial conditions, while “average” countries fare best. In the long run however, the greatest losses are borne by below average countries, suggesting that in the long run the countries with greatest income inequality, lowest average income and lowest levels of initial IPR protection have the most to lose from the movement towards higher levels of IPR protection.

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Introduction

The protection of intellectual property rights (IPRs) has become an increasingly debated issue both domestically and in international arenas. Legislation on IPR protection seeks to achieve an equilibrium between the need to reward innovators for their efforts and the social benefits arising from dissemination of knowledge and information.

Developing countries are under increasing pressure to improve their levels of IPR protection, while international organizations such as the World Trade Organization (WTO) and the World Intellectual Property Organization (WIPO) push to achieve harmonization of IPR protection. Intellectual property rights protection is considered a critical precondition for private investment and the transmission of new technology.

The issue has become particularly pressing to many developing countries, as the United States negotiates bilateral free trade agreements that include commitments on intellectual property rights protection that are more stringent than those contemplated by the World Trade Organization (WTO) through its Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). It is important that countries entering such agreements be aware of the implications of these commitments.

Much theoretical work has been done on the implications of IPR protection and the optimal level of such protection, that seeks an equilibrium between the need to reward innovators for their efforts and the desire to allow the dissemination of knowledge. An influential literature (see Aghion and Howitt [1992], Grossman and Helpman [1991], Romer [1990a]) endorses the close connection between innovative activity and the establishment of monopoly rights and therefore has been used as a basis for the argument in favor of strong IPR protection. More recently Boldrin and Levine (2002, 2004) have argued that IPR protection is in fact too high in general and has the result of stifling, not fostering, innovation. Bessen and Maskin (2000) specify that when innovation is sequential and complementary, as in the case of software, semiconductors and computers, IPR protection can interfere with competition and innovation, and provide supporting empirical evidence for the software industry. On the empirical side, most research has been limited to country specific studies, such as those on the pharmaceutical industry in India.¹

¹ For in depth studies on the effects of increasing IPR protection on pharmaceuticals in India, see Chaudhuri, Goldberg and Jia (2003) and Fink (2000).

The method of analysis is the calibration of the theoretical model developed in Scandizzo (2001) to actual country data with respect to income distributions, intellectual property rights protection and piracy rates. A simulation exercise is then performed to answer the question of what would be the effects in terms of price and welfare of an increase in the protection of intellectual property rights, and compare these results across countries and industries.

The model is calibrated for two product markets, music CDs and software, for the availability of data on piracy rates across countries. These are in fact two industries where piracy is most rampant, due in part to ease of counterfeiting from a technological standpoint, sheer size of demand, and difficulty in enforcing protection. Furthermore, data on piracy levels in these two industries are available across a wide selection of countries, and products tend to not differ much across different markets.

An important omission from this study is the case of pharmaceuticals, where the debate over intellectual property rights protection has been particularly heated. The market for pharmaceuticals is much more complex, with countries differing not only with respect to penetration of generics or outright intellectual property rights violations, but also with respect to basic market structure, for example the relative weight of health costs born by insurance companies, the private and the public sector. Furthermore, the demand for pharmaceuticals is quite complex, in fact even within narrowly specified therapeutic segments, consumers must choose between drugs with different pharmaceutical ingredients, and within these must choose between different brands and generics. Lastly, cross country data is more difficult to obtain.

The simulations reveal to what extent price increases and static consumer welfare losses depend on the values of the model's parameters and provide valuable insights with regard to how industry characteristics interact with income levels and inequality in determining the effects of IPR protection. An index is constructed with principal components analysis to include "initial conditions", based on average income, income inequality and initial levels of IPR protection. Regression analysis reveals that the relationship between a country's initial conditions and the welfare effect of increasing IPR protection is nonlinear: countries that fare worst are those with the worst or the best initial

conditions. In the long run however it is the countries with the lowest initial conditions that bear the greatest costs.

The model²

Technological development takes place by fixed steps along quality ladders, i.e. by quality increments, as in Grossman and Helpman (1991). When a new generation good is introduced, it provides λ times as many services as the previous state of the art good:

$$q_k = \lambda q_{k-1} \quad (1)$$

where q_k is the quality of variety k of the good.³ Assume λ to be exogenous, constant and greater than 1. Technological development is uncertain, and entails a fixed cost investment in research and development.

Consumers either buy a single unit of one of the qualities on offer or else buy nothing at all. Consumers are not identical but instead differ in their level of income y , which translates into a difference in their willingness to pay for quality improvements. Consumers' incomes are described by a generic density function $f(y)$ and its cumulative $F(y)$. Consumers' preferences are identical and are given by the utility function

$$U(y, k) = q_k (y - p_k), \quad k = 1, 2, \dots, n \quad (2)$$

where p_k is the price of generation k and $q_1 < q_2 < \dots < q_k$. Once a consumer decides which quality of the good to buy, $(y - p_k)$ is the amount of income left over to buy other goods.⁴

² The model is described in detail in Scandizzo (2001)

³ The terms "generation" and "variety" are interchangeable in this model given that goods are vertically differentiated and innovation is quality enhancing.

⁴ One also needs to allow for the possibility that a consumer decides to not buy the good at all: in this case all her income is available for spending on other goods

$$U(y, 0) = q_0 y$$

and we assume $q_0 = 1$. Furthermore, the utility derived from having no income is equal to zero:

$$U(0, k) = 0$$

For any two products k and $k-1$, of corresponding quality q_k and q_{k-1} , that sell at prices p_k and p_{k-1} , we can define the indifference income y_k as the income of the consumer who is indifferent between consuming the two goods. This entails:

$$U(y_k, k) = U(y_k, k-1) \quad (3)$$

which is equivalent to:

$$q_k(y_k - p_k) = q_{k-1}(y_k - p_{k-1}) \quad (4)$$

This tells us that y_k defines the lower limit of the market share of the firm's selling variety k . Another interpretation is that given p_{k-1} , p_k is the maximum price that firm can charge and just attract the consumer with income y_k .

Define r_k :

$$r_k = \frac{q_k}{q_k - q_{k-1}} \quad (5)$$

Solving for y_k :

$$y_k = r_k p_k - (r_k - 1)p_{k-1}, \quad k = 1, 2, \dots, n \quad (6)$$

For simplicity, assume the unit cost of production of all varieties of the good is the same (as long as the variety in question has been discovered). If we assume that the patent on the last generation good has expired, then Bertrand competition will drive the price of such good down to cost and profits will be zero. The discoverer of the state of the art good holds a patent and therefore is a monopolist. There will be no other qualities offered: qualities higher than the state of the art have not yet been discovered, and qualities less than the last generation will charge the same price but are of lower quality, and therefore will have zero demand. This is a strong case of the so called *finiteness property*.⁵

⁵ In general, the number of qualities consumed will depend on the distribution of income of consumers: in particular, if income doesn't vary much between consumers, only one quality (the highest) will be consumed. With a greater distribution of income, more qualities will be consumed, but always a finite number. This *finiteness property*, labeled such by Shaked and Sutton (1987), is a particular characteristic of vertically differentiated markets. (In fact it does not apply to horizontally differentiated products.) The necessary

The state of the art firm will set price to maximize profits:⁶

$$\max_{p_s} S(p_s - p_c)(F(b) - F(y_s)) \quad (7)$$

$$\text{s.t. } y_s = r_s p_s - (r_s - 1)p_c$$

where S is the measure of the size of the economy, p_c is marginal cost, b is maximum income and $F(b) = 1$. The F.O.C. yields a solution for the state of the art firm's pricing strategy:

$$\frac{d\Pi_s}{dp_s} = S(1 - F(y_s)) - S r_s f(y_s)(p_s - p_c) = 0 \quad (8)$$

$$p_s = \frac{(1 - F(y_s))}{r_s f(y_s)} + p_c \quad (9)$$

Consider now the effect of the introduction of a counterfeit good. By definition, the quality of a counterfeit good is higher than that of the old generation, and lower than that of the state of the art. Assuming there is more than one counterfeiter, which is reasonable, Bertrand competition will push price down to cost, i.e. p_c . This will immediately push the old generation good out of the market, in as it offers an inferior product at the same price. The market will now be divided between the state of the art good and the counterfeit.

Given our assumptions on the technology of innovation and assuming $q_0 = 1$, the quality levels of the last generation good, of the state of the art and of the counterfeit good are respectively:

condition for this property to hold is that unit variable costs of production increase “not too steeply” with the level of quality, in particular, more slowly than consumers' willingness to pay for increased quality. This type of relationship between technology and tastes reflects the fact that the main burden of quality improvement falls on fixed rather than variable costs (as is the case in patent races).

Here we consider an extreme case in which the necessary condition holds: that in which the unit variable cost is the same for all qualities. In this case, if consumer preferences were homogeneous, all consumers would prefer to consume the high quality good. Since we have instead differing taste for quality, a finite number of qualities will be consumed, with poorer individuals choosing the lower quality varieties.

⁶ From hereon, the subscript s will be used to refer to state of the art variables, the subscript l to refer to last generation variables, and the subscript c to refer to counterfeit variables.

$$\begin{aligned}
q_l &= \lambda^{k-1} \\
q_c &= \lambda^{k-\delta} \\
q_s &= \lambda^k
\end{aligned}$$

where k is the generation of the good and $\delta \in (0,1)$ is the (exogenously determined) qualitative distance between the state of the art good and the counterfeit good. Notice that for $\delta = 1$ there is absence of imitation, while for $\delta \rightarrow 0$ the quality of the counterfeiting tends to that of state of the art good.

In this case, r_s can be written as:

$$r_s = \frac{q_s}{q_s - q_c} = \frac{\lambda^k}{\lambda^k - \lambda^{k-\delta}} = \frac{\lambda^\delta}{\lambda^\delta - 1} \quad (10)$$

We can define r_s as an measure of the relative quality of the counterfeit with respect to the state of the art, and it satisfies the following properties: 1) The introduction of a counterfeit good increases r_s ; 2) The higher the quality of the counterfeit good, i.e. the closer to the quality of the state of the art, the greater r_s . 3) r_s is decreasing in δ . If we consider δ as positively related with the degree of IPR protection, this can be interpreted as the relative quality of the counterfeit good *falling* with an increase in IPR protection.⁷

It can also be shown, that given these properties of r_s , the following proposition holds: the introduction of a counterfeit good will always decrease the price of the state of the art good, while market share remains constant.⁸ Furthermore, increasing IPR protection will always increase the price of the state of the art good.

Consumer welfare in the economy, W_C , is given by the sum of the utility of consumers that choose the lower quality good and of the utility of consumers who choose

⁷ The fact that the quality of the counterfeit good unambiguously falls with an increase in IPR protection is due to our assumption that production costs are the same for all producers.

⁸ Constant market share is a common result for the case of a monopolist facing a downwards sloping demand curve, and is a direct result of the linear relationship between quality and utility implied by equation (2). In our case, substituting equation (9) into equation (6) yields $y_s = \frac{1-F(y_s)}{f(y_s)} - p_c$, which is a standard assumption in the literature of vertical product differentiation. Assuming instead, for example, that quality sensitive consumers place increasing value on higher quality products, this result would no longer hold. We assume the linear quality-value assumption made in this paper to be an acceptable simplification for the type of goods considered.

the high quality good. In appendix 1, we show that aggregate utility from consumption is proportional to the maximum amount of units of good that each type of individual could buy with a certain level of income, and can be approximated in the following way.⁹

$$W_c = \int_a^{y_s} \Phi(\lambda, \delta) \frac{y}{p_c} dF(y) + \int_{y_s}^b \frac{y}{p_s} dF(y) \quad (11)$$

where a is minimum income, b is maximum income, and $\Phi(\lambda, \delta) \in (0,1)$ is a function that adjusts utility from consuming the counterfeit good and makes it comparable to the utility from consuming a superior quality good, i.e. the state of art good. The aggregation process reveals that $\frac{\partial \Phi(\cdot)}{\partial \lambda} < 0$, $\frac{\partial \Phi(\cdot)}{\partial \delta} < 0$. The first captures the idea that in industries where the innovative step is greater, not only is counterfeiting more difficult (and therefore the relative quality r_s is smaller), but consumers of the counterfeit lose relatively more from not consuming the state of the art good. The derivative $\frac{\partial \Phi(\cdot)}{\partial \delta} < 0$ shows that the smaller the quality gap between the counterfeit good and the state of the art good, the closer the utility derived from the counterfeit good to that derived from the state of the art good.

In general, the introduction of a counterfeit good always increases consumer welfare, and the greater the quality of the counterfeit good the greater the welfare increase. This is because both types of consumers in the economy benefit from a better imitation: the ones consuming the counterfeit good will get a higher quality good, and the ones consuming the state of the art good will be charged a lower price.

Furthermore, since $\frac{\partial \Phi(\cdot)}{\partial \delta} < 0$ and $\frac{\partial p_s}{\partial \delta} > 0$, it can be shown that an increase in δ (for example due to an increase in IPR protection) will always cause a fall in consumer welfare.

$$\frac{dW_c}{d\delta} = \int_a^{y_s} \frac{\partial \Phi}{\partial \delta} \frac{y}{p_c} dF(y) + \int_{y_s}^b \frac{y}{p_s} \left[-\frac{\partial p_s / \partial \delta}{p_s} \right] dF(y_s) < 0 \quad (12)$$

⁹ It is important to note that this function is an approximation. Alternatively, one could consider a welfare function that takes into account a multi stage utility maximization, where consumers initially decide how much music or software to consume, and then whether to consume the state of the art or the counterfeit. Unfortunately, it would be prohibitive to estimate this type of function over a large sample of different countries.

The first element on the right hand side can be considered a quality effect, due to the fact that an increase in protection decreases the quality of the counterfeit good consumed by lower income consumers, lowering their welfare. The second element is a price effect, due to the fact that in the face of reduced competition the state of the art firm is free to charge a higher price. What we are interested in examining in this paper is the magnitude of this effect, and how the latter varies depending on country characteristics.

Data

To calibrate the theoretical model, we need information on countries' income distributions, prices of the state of the art good, information on the market share of the state of the art good, and a measure of IPR protection.

Considering this set of information, the most difficult task is to find a good estimation of δ . As argued above, δ directly depends on the level of IPR protection exhibited by a country, since strong IPR enforcement tends to render imitation difficult, lowering the quality of the counterfeit good. Park and Guinarte (1997) construct an index of IPR protection based on the strength of patent laws of a country. The index takes on values between zero and five, with higher number reflecting stronger levels of protection¹⁰. We standardize this index between zero and one and directly interpret it as δ , with $\delta = 1$ being the case of perfect protection (no imitation occurs) and zero perfect counterfeiting (the state of the art and the counterfeit good become perfect substitutes). In this way, δ is as a country specific but industry homogenous variable. This assumes that countries' patent laws are equally enforced in all industries, which is debatable but a necessary simplifying assumption.

In a market with only two goods, a state of the art and a counterfeit, the market share of the state of the art good is by definition the complement of the market share of the counterfeit. In general, this last concept is methodologically close to measures on piracy rates, which estimate what portions of the goods consumed in the industry are not legally

¹⁰ The index considers five aspects of patents laws: coverage, membership in international patents agreements, provisions for loss of protection, enforcement mechanisms, and duration. Therefore, the index only includes actual legislation, but not enforcement, which can also vary across countries.

produced. Therefore, we will use data on piracy rates as representative of the counterfeit good's market share, and "1 – piracy rate" as the market share of the state of the art.

Piracy rates for the software industry were taken from the 2004 Business Software Alliance Piracy Study. Piracy rates in this report are determined as the differences between software put into use and software paid in year 2003. Piracy rates for the music industry are from the United States International Intellectual Property Alliance 2003 Special 301 recommendations to the United States Trade Representative.

Prices for the music industry are estimated using information from the "Record Industry Interim Sales" report, produced by the International Federation of the Phonographic Industry. Prices for software are derived from the model (more on this below), although prior information on the "one price policy" of Microsoft is considered.

Finally, to estimate country income distributions, we use data on income per capita from the Penn World Tables.¹¹ Gini coefficients, Lorenz curves are from the World Bank.

Table 1. Data for the music industry

	IPR Index	Piracy rate	Income p/capita	Gini's coef.
Argentina	2,06	60%	11.124	0,52
Bolivia	1,48	85%	2.684	0,45
Brazil	1,52	53%	6.979	0,59
Chile	1,96	35%	9.459	0,57
Colombia	1,13	65%	5.467	0,58
Costa Rica	1,84	50%	5.417	0,47
Ecuador	1,60	90%	3.559	0,44
Guatemala	1,15	60%	3.953	0,48
Indonesia	0,33	89%	3.831	0,34
Pakistan	1,70	83%	1.973	0,33
Paraguay	1,29	99%	4.762	0,57
Peru	0,65	98%	4.505	0,50
Philippines	2,52	40%	3.416	0,46
South Africa	3,45	25%	7.422	0,59
Thailand	1,44	42%	6.554	0,43
Turkey	1,29	75%	6.792	0,40
Uruguay	1,63	60%	9.757	0,45
Venezuela	0,75	75%	6.486	0,49

Income p/capita is expressed in constant \$, and refers to annual figures.

¹¹ Income per capita are averages for 1995-2000. We use the measure of real gross domestic income, adjusted for terms of trade changes.

Table 2. Data for the software industry

	IPR Index	Piracy rate	Income p/capita	Gini's coef.
Argentina	2,06	71%	11.124	0,52
Australia	2,84	31%	24.353	0,35
Austria	3,53	27%	22.362	0,30
Belgium	3,48	29%	22.298	0,25
Bolivia	1,48	78%	2.684	0,45
Brazil	1,52	61%	6.979	0,59
Canada	2,67	35%	24.777	0,33
Chile	1,96	63%	9.459	0,57
Colombia	1,13	53%	5.467	0,58
Costa Rica	1,84	88%	5.417	0,47
Denmark	3,11	26%	25.458	0,25
Ecuador	1,60	68%	3.559	0,44
El Salvador	1,97	79%	4.316	0,53
Finland	2,39	31%	21.324	0,27
France	3,48	45%	21.231	0,33
Germany	3,29	30%	21.805	0,28
Greece	2,01	63%	13.702	0,35
Guatemala	1,15	77%	3.953	0,48
India	1,39	73%	2.293	0,33
Indonesia	0,33	88%	3.831	0,34
Ireland	2,46	41%	22.005	0,36
Israel	3,53	35%	17.146	0,36
Italy	3,50	49%	21.134	0,36
Japan	3,48	29%	24.207	0,25
Jordan	1,52	65%	3.933	0,36
Kenya	2,49	80%	1.265	0,45
Korea	3,00	48%	14.048	0,32
Mexico	1,30	63%	8.049	0,55
Netherlands	3,70	33%	22.888	0,33
New Zealand	2,98	23%	18.010	0,36
Nicaragua	0,94	79%	1.660	0,55
Norway	2,92	32%	26.738	0,26
Pakistan	1,70	83%	1.973	0,33
Panama	2,15	69%	5.995	0,56
Paraguay	1,29	83%	4.762	0,57
Peru	0,65	68%	4.505	0,50
Philippines	2,52	72%	3.416	0,46
Portugal	1,82	41%	14.512	0,39
Singapore	2,16	43%	26.038	0,43
South Africa	3,45	36%	7.422	0,59
Spain	3,53	44%	16.802	0,33
Sweden	2,99	27%	21.871	0,25
Switzerland	3,23	31%	25.511	0,33
Thailand	1,44	80%	6.554	0,43
United Kingdom	3,26	29%	21.540	0,36
Uruguay	1,63	22%	9.757	0,45
USA	3,52	67%	31.357	0,41
Venezuela	0,75	72%	6.486	0,49

For the music industry, a complete data set was available for only 18 countries, which are all developing countries. This introduces a possible bias of results that will be taken into account in the analysis. Data for the music industry is presented in Table 1. The sample for the software industry is much larger, consisting of 48 countries, including both developing and developed countries, as shown in Table 2.

Estimation of country income distribution

The predictions of the theoretical model depends heavily on the shape of the individual income distribution (i.e. its probability density function – p.d.f.) of each country. In this section, we show how such distributions were constructed for each country based on information provided by the Gini coefficient, the Lorenz curve, total income and population.

Typically, income distributions, in particular the right tail, are well represented by the Pareto density function, which allows for the fact that a small part of the population can earn a large portion of the economy's total income. Pareto distributions are characterized by a parameter α , which takes higher values for distributions with longer right tails, i.e. in the case of higher income inequality. Chaves (1996) derives a mathematical relationship between the Gini coefficient and the value of α , the derivation of which is sketched in appendix 2.

With countries' Gini coefficients, we can retrieve the parameter α that characterizes the Pareto distribution of income for each country. Lorenz curves provide additional information on how income is allocated within each country. To incorporate this additional information in estimating each country's p.d.f., we first derive *income classes* for each decile of the population. Each class is characterized by two values: the minimum and maximum income earned by a person belonging to the class. Income classes are derived using expression (A1) and applying values for total income and population size¹². We then impose that income be distributed uniformly within each class, except for the last class, which is represented by a Beta Pert distribution¹³. Stochastic simulations generate a final

¹² As mentioned in the text, data on population and income is taken from the World Bank. The values used are the average per capita real income and average population for the last five years (2000-2004).

¹³ The Beta Pert distribution is calibrated assuming that the mode of the distribution is equal to the minimum income of the class, to create a downward slope consistent with the distribution of income of the richest

estimated income distribution for each country taking into account the density of each class, and the probability of falling into each class of income implicit in the Lorenz curve.

Empirical model

In this section we explain how the data and the theoretical model are combined to obtain predictions on welfare changes across a set of countries, when IPR protection is increased. Methodological differences between the music and software industries are also described and justified.

Music industry

In the case of the music industries, we consider specifically the market for CDs. We make a simplifying assumption and consider that differences in quality of CDs across countries are negligible, so that for practical purposes, the good is homogeneous. CDs in fact are currently the most common way of acquiring music in most countries (with few exceptions), and are the easiest medium to counterfeit.¹⁴

Although CD quality is similar across countries, prices do vary due to differences in demand factors such as size of market, preferences, income structure, etc. These are estimated from IFPI's "Record Industry Interim Sales Report". Although this report does not directly specify prices across countries, it contains values for total revenue and for quantities of CDs and cassettes sold for forty five countries which allows us to recover estimated average prices for CDs.¹⁵ The prices estimated range between \$5 and \$19 with average of \$12, and tended to be higher for industrialized countries.

Given the estimated income distribution, the estimated price of CDs, the value of δ (i.e. the level of IPR protection), the industry piracy rate¹⁶, and an assumption regarding the marginal cost of CDs¹⁷, we can retrieve an estimated value of r_s (the index of qualitative

members of the population. The Beta Pert distribution was chosen for this class of income for its versatility and for its characteristic of having finite support.

¹⁴ In this paper we are considering music counterfeiting exclusively as the production of pirated CDs through pressed discs from illegal CD plant operations and CD-R, and *not* through illegal downloads of music from the internet.

¹⁵ Prices of CDs were assumed to be twice the price of cassettes. This assumption is based on average internet prices of CDs for Tower Records in the U.S. market. Samples prices were taken from four categories of music: blues, rock and pop, hip hop and Latin.

¹⁶ Recall that the piracy rate is interpreted as $F(y_s)$, i.e. the market share of the counterfeit good.

¹⁷ Marginal cost of production of CDs is equal to \$1.

superiority), which allows us to compute an implicit λ (the measure of the quality step of innovation). The value of r_s is obtained from equation (9) and the value of λ from equation (10).

For the set of countries considered the average estimation of λ is 1.012. This low value can be interpreted as representing the fact that innovation in the music industry is basically horizontal, with new generations of CDs qualitatively very close to old ones. It is also interesting to point out that the variance coefficient in the sample is smaller than 1%, indicating that differences in quality innovation across countries are not very significant. This is to be expected, as λ is basically an technological parameter, and therefore should be industry, but not country, specific.

Software industry

When analyzing this industry, we took Microsoft Office as our reference product. According to the “formal pricing policy” of Microsoft, the price of Office is the same in all countries where distributed, around \$200 per unit. But imposing this assumption in the model produced estimated values of λ with large differences across countries. This initial finding is troubling considering the fact that the product in question is indeed homogeneous. However, the value of λ in the industrialized countries of the sample (sixteen out of forty eight) are very similar, with a variance coefficient of only 1%. This similarity of results may be explained by the fact that the “actual” pricing policy does in fact discriminate across countries of different levels of income and market characteristics. Furthermore, since software is often sold in a package with hardware, or as part of large licensing agreements, implied prices can in fact vary. Furthermore, Microsoft has recently begun a trend of charging lower prices in select developing countries, whereas in industrialized countries the price is closer to its formal value.

The average value of λ for industrialized countries is 1.046, which is higher than that of the music industry. This might reflect the fact that innovation in the software industry is more vertical, since a new version of the software incorporates a greater quality improvement. To incorporate the fact that λ is a purely technological parameter, and therefore constant across countries, we carry out estimations as follows: given the estimated income distribution, the value of δ (level of IPR protection), the piracy rate in the industry,

the marginal cost of software¹⁸ and a value of $\lambda=1.046$, we can retrieve an estimated value of r_s (the index of qualitative superiority), which allows us to compute p_s , the implicit average price at which software is sold in each market. The value of r_s is obtained from equation (10), and the value of p_s comes from equation (9).

The estimated prices for the software in 50% of the sample range between \$40 and \$188, being lower in developing countries than in industrialized countries. Also, the average price of the complete sample is \$123 and the standard deviation is \$99.

Welfare measure

To obtain an empirical measure of consumption welfare, we need to estimate expression (11). We impose $\Phi(\lambda, \delta) = (1 - \delta)^\lambda$, which satisfies the requirements that $\Phi(\lambda, \delta) \in (0, 1)$ and $\frac{\partial \Phi(\cdot)}{\partial \lambda} < 0$, $\frac{\partial \Phi(\cdot)}{\partial \delta} < 0$. This expression for Φ , although arbitrary, allows us to magnify the quality effects from changes in IPR protection while preserving the basic properties of the utility measurement, highlighting welfare variations. We can therefore rewrite the welfare function as

$$W_C = (1 - \delta)^\lambda \frac{E(y \leq y_s)}{pc} + \frac{E(y \geq y_s)}{ps} \quad (13)$$

Since E is the expectation operator, i.e. the first term refers to the average units of the counterfeit good that consumers of income below y_s can buy, and the second to the average units of the state of the art good that consumers of income above y_s can buy.

Increasing IPR protection

To examine the effect on welfare of increasing IPR protection in the two industries under consideration, we conduct three distinct experiments:

- 1) An absolute increase in IPR protection, equivalent to an increment of 0.04 units in δ , with market share held constant and prices changing to achieve equilibrium;
- 2) A relative increase in IPR protection, or 20% increment of δ , with market share held constant and prices changing to achieve equilibrium;

¹⁸ Marginal cost of production of software is assumed to be higher than CDs', i.e. equal to \$5.

3) An increase in IPR protection (of 0.04 units in δ), with market share varying but holding constant the price of the state of the art good.

In general, an increase in δ will cause a reduction in the index r_s that will drive either a reduction in the state of the art price (p_s) or in the market share of the counterfeit good (piracy rate). We believe adjustments in prices are more likely to occur in the short run, whereas adjustments in the market share will tend to occur in the long run. All these experiments cause a reduction in consumer welfare and the objective is to compare them across industries and countries.

Results are summarized in the following tables (3 and 4) for each industry, showing relative variations in welfare (Wc), prices (p_s) and market share (piracy rate). The statistics presented are the mean and standard deviation of the sample (s.d.), and for a selection of percentiles.

Table 3. Results for the music industry

	Case 1: absolute Δ IPR		Case 2: relative Δ IPR		Case 3: absolute Δ IPR	
	ΔWc	Δp_s	ΔWc	Δp_s	ΔWc	Δ market share
Mean	-10%	14%	-15%	18%	-31%	-20%
s.d.	5%	9%	6%	1%	16%	11%
p. 0.05	-17%	5%	-30%	16%	-63%	-34%
p. 0.25	-10%	10%	-15%	18%	-40%	-29%
p. 0.5	-9%	11%	-13%	18%	-27%	-20%
p. 0.75	-8%	15%	-12%	18%	-17%	-12%
p. 0.95	-6%	29%	-11%	19%	-9%	-4%

Table 4. Results for the software industry

	Case 1: absolute Δ IPR		Case 2: relative Δ IPR		Case 3: absolute Δ IPR	
	ΔWc	Δp_s	ΔWc	Δp_s	ΔWc	Δ market share
Mean	-10%	10%	-22%	18%	-24%	-18%
s.d.	3%	6%	11%	2%	15%	9%
p. 0.05	-15%	5%	-42%	14%	-49%	-35%
p. 0.25	-11%	6%	-32%	17%	-37%	-23%
p. 0.5	-10%	8%	-16%	19%	-17%	-19%
p. 0.75	-8%	11%	-13%	19%	-14%	-13%
p. 0.95	-6%	20%	-10%	19%	-7%	-3%

When comparing cases 1 and 3, results show that for both industries, welfare losses are greater when reductions in the market share of the counterfeit good, are allowed. This is

explained by the fact that the loss of purchasing power associated with giving up consumption of the counterfeit good is more significant than that experienced by people acquiring a more expensive state of the art good. These results also suggest that consumer losses are smaller in the short run than in the long run, indicating that when IPR protection is increased, consumption effects may not be immediately acknowledged.

For case 2, where IPR protection increases in relative terms, welfare losses are also significant, and greater than for case 1 (specially in the software industry). This probably happens because for countries already exhibiting a high level of protection, a 20% increase of the IPR index entails huge rises in prices of the state of the art good and reductions in quality of the counterfeit good. This particular experiment, although feasible, is in reality of not much interest if considered that most of IPR agreements tend to put more pressure on countries with weak levels of protection.

Comparison across industries show that for software, greater losses are registered for case 2 and case 3. On the contrary, in the music industry losses are by far greater when market shares vary, i.e. when reductions in the piracy rate occur (case 3). Since these differences might be explained by the fact that sample of countries for each industry are also different (i.e. the sample for the music industry contains no industrialized countries), no conclusions regarding this matter are drawn at this point.

Construction of the Initial Conditions Index

To better understand which countries win or lose the most when IPR protection increases, we relate welfare losses to specific individual country conditions: level of per capita income, Gini coefficient and initial level of IPR protection. However these country specific variables are highly correlated, which prevents us from doing direct regression analysis. The simple correlation of countries’ conditions is shown in table 5:

Table 5. Matrix of simple correlations

	Income p/capita	Gini	IPR index
Income p/capita	1	-0,66	0,77
Gini		1	-0,56
IPR index			1

As expected, countries with a high per capita income tend to exhibit high levels of IPR protection and a better income distribution (i.e. low Gini coefficients).

To condense this country specific information into one variable, and at the same time resolve multicollinearity problems, we construct an index of initial conditions using principal component analysis (PCA). The methodology consists in finding a convex linear combination of the variables that maximizes their simultaneous covariance.

Table 6. Principal component analysis

	Income p/capita	Gini's coef.	IPR index	Variance explained	Eigenvalue
Comp 1	0,61	-0,55	0,58	0,77	2,32
Comp 2	0,20	0,81	0,55	0,15	0,46
Comp 3	0,77	0,22	-0,60	0,07	0,22

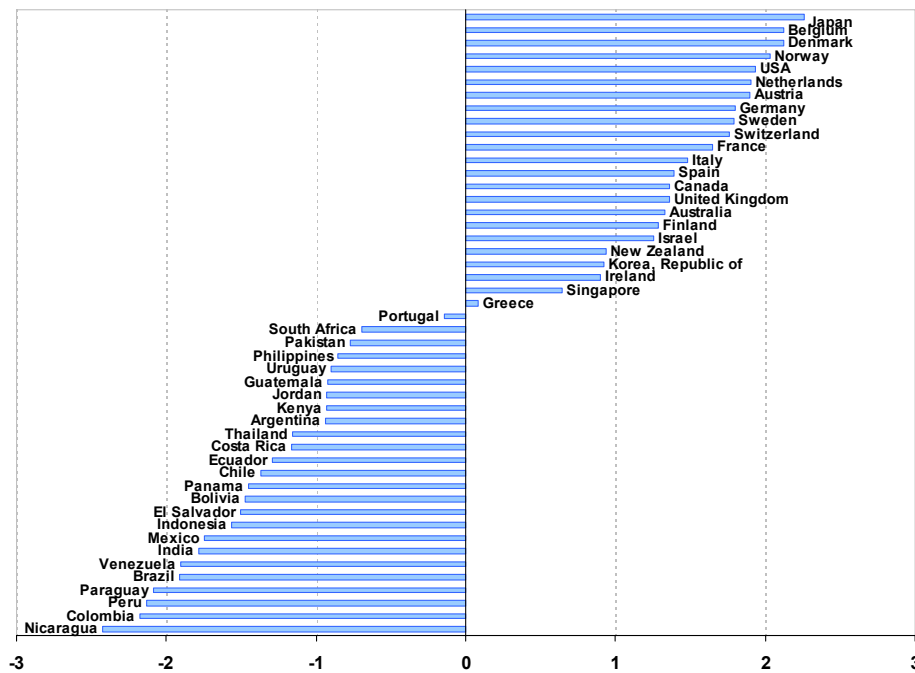
Of the three components obtained, we choose the first to construct the index. In fact not only does it explain a higher proportion of the covariance between the variables, but its elements also have the expected sign according to the underlying theory. The value of the index (*ICI*) for country *j* is calculated as:

$$ICI_j = 0.61 \frac{(I_j - \bar{I})}{\sigma_I} - 0.55 \frac{(G_j - \bar{G})}{\sigma_G} + 0.58 \frac{(IPR_j - \bar{P})}{\sigma_P} \quad (14)$$

where I_j , G_j , IPR_j are the per capita income, the Gini coefficient, and the intellectual property right index for country *j*, respectively. Variables \bar{I} , \bar{G} , \bar{P} represent the sample mean, and σ_I , σ_G , σ_P the sample variance.

According to the way this index is constructed, countries with a relatively high per capita income, more equal income distribution and strong IPR protection will tend to show large positive values, while countries with relatively low per capita income, more unequal income distribution and weaker IPR protection will exhibit large negative values. Moreover, given the values of the index, we can order countries decreasingly so that we can rate top countries as the ones with best initial conditions and bottom countries as the ones with worse initial conditions. Countries with values of the index close to zero are labeled *average conditions countries*.

Graph 1. Initial Conditions Index (ICI)



The ordering of the index is very intuitive, with more industrialized countries ranking higher and less developed countries rating lower.

Which countries do in fact do better when IPR protection increases?

To properly answer this question, for each industry, we run a set of regressions where welfare losses predicted by the model are the left hand side variable, and the initial condition index (ICI) is the explanatory variable. We expect to find that the estimated coefficient would be positive, reflecting the fact that countries with the worse initial conditions are the ones bearing the greatest losses when increasing IPR protection¹⁹.

When running OLS regressions, problems of heteroskedasticity arise, probably because relevant information, such as the piracy rate²⁰, is omitted in the model. Nonetheless, piracy rate is used as a weight to estimate the model under GLS. The final results from GLS regression for all types of experiments are:

¹⁹ Recall that since the left hand side variable is always negative, the relationship between losses and ICI can be depicted in the third and fourth quadrant.

²⁰ Theoretically, piracy rates should also explain part of the variations in welfare losses. Omission of this variable might cause a bias in the values of estimators. However, estimation including this variable is not appropriate, especially in the case of the software industry, because of the high correlation between the piracy rate and ICI.

Table 7. Regression estimates for the music industry

Music industry	ΔWC_1	ΔWC_2	ΔWC_3
C	-0,03 (0,003)	-0,22 (0,000)	-0,09 (0,053)
ICI	0,04 (0,000)	-0,05 (0,000)	0,10 (0,034)
Adjusted R²	0.901	0.985	0.612

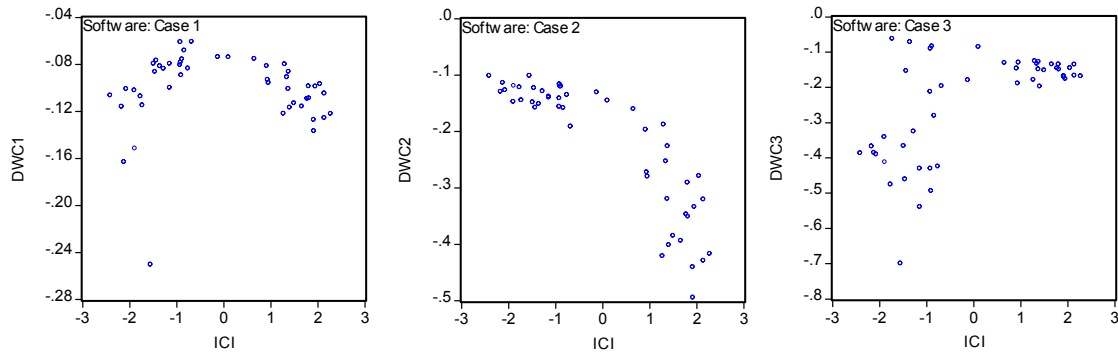
p-values in parenthesis. GLS estimation. Weighting series: 1/piracy²

In the music industry, positive coefficients for the ICI are found only in the first and third experiment (when the IPR is increased in absolute terms and when variations in the market shares are allowed respectively). The magnitude in which country's initial conditions explain losses is greater when reductions in the piracy rate occur (case three). Again, the fact that countries with low income, unequal income distribution and weak IPR protection suffer the greater losses is because, a large portion of individuals consuming the counterfeit good will be forced to consume the state of the art good, which is a relatively more expensive. Most probably, the increase in IPR protection will lead to a reduction in the piracy rate only in the long run, while smaller losses will occur in the short run. This follows from the fact that the slope coefficient in case 3 is greater than the one in case 1.

For the experiment where IPR protection is increased in relative terms (case 2), countries with the best initial conditions are the ones bearing the greater losses. This is most likely related to how the experiment is designed: countries with already high IPR protection are the ones driven to increase it more. In other words, countries with the strongest IPR protection rise (in absolute terms) will tend to suffer the biggest losses.

For the software industry, initial simple linear regressions like the ones run in the music industry did not exhibit an appropriate fit. A visual examination of the scatter plots between welfare losses and the ICI show a non-linear relationship.

Graphic 2. Scatter plots for the software industry



To estimate the non-linear relationship between losses and ICI, spline-regressions for the slope coefficient are used, discriminating between positive and negative values of the ICI²¹. This entails including a dummy variable to distinguish between above average and below average ICI countries, to take into account the fact countries with above average initial conditions the average will have a different performance than below average countries. This fact did not arise for the music industry since all countries in the sample exhibited a negative ICI, that is, all of the countries exhibit below average initial conditions.

For estimation, since heteroskedasticity problems are present, we again apply GLS, using the piracy rate and the ICI as weights.

Table 8. Regression estimates for the software industry

Software industry	ΔWC_1^*	ΔWC_2^{**}	ΔWC_3^{***}
C	-0,06 (0,001)	-0,15 (0,000)	-0,06 (0,016)
ICI	0,03 (0,003)	-0,01 (0,041)	0,11 (0,000)
ICI*DUM_ICI	-0,06 (0,004)	-0,11 (0,000)	-0,16 (0,000)
Adjusted R²	0.569	0.874	0.941

p-values in parenthesis. GLS estimation. *Weights: piracy
 Weights: piracy². * Weight: ici/piracy².
 dum_ICI: takes value 1 when ICI>0.

²¹ Another possible non-linear model could use the ICI variable squared. The spline-regression model turned out to be slightly superior in terms of the Akaike and Schwarz criteria.

For countries with below average initial conditions, slope coefficients are similar to the ones found in the music industry: positive for experiments one and three, with larger positive coefficient for case three. For countries with above average initial conditions, slope coefficients are given by the sum of the coefficients of the ICI and the interaction term (i.e. $ICI * DUM_ICI$). Slope coefficients are negative for all three types of experiments: -0.03; -0.12 and -0.04 respectively. This negative sign implies that the better the initial conditions, the greater the losses borne. However, diversely from below average countries, the largest significant coefficient appears in case two (when IPR protection is increased in relative terms). Again, this is consistent with the way the experiment was designed: countries with higher IPR protection are the most affected.

It is interesting to note, that when market share / piracy rates are allowed to vary (case three), the magnitude of the slope coefficient for above average countries is much smaller than for below average countries. This means two things: first, that average countries are the ones bearing the smallest losses, and second, that lower initial conditions induces greater welfare losses in the long term. This stems from the fact that when a country has high average income, more equal income distribution and strong IPR protection, the proportion of people consuming the state of the art good is already high. Therefore, reducing piracy rate through an increase in IPR protection will be welfare reducing, but not as strongly as in countries where a big part of the population must give up consuming the counterfeit good. In the first experiment, variations of initial conditions from the average will have a symmetrical impact on welfare: both the “best” and the “worst” countries lose in the same way.

The above results lead one to think that in the short run, when only variations in prices occur, “highest” and “lowest” ICI countries are the ones bearing the greater welfare losses. The magnitude of losses are alike for both types of countries. This probably occurs because, the reduction in quality of the counterfeit good (mostly affecting below average countries) is similar to the increase in the price of the state of the art good (mainly affecting above average countries).

In the long run, losses in welfare associated to the reduction in piracy rates occur more strongly in below average countries, mainly because of the larger reductions in purchasing power that consumers have to endure.

Conclusions

We construct an experiment to analyze the effect of increasing IPR protection across a diverse sample of countries by focusing on two high piracy industries: music (CDs) and software. We propose that differences in welfare effects are driven, at least in part, by differences in average income, in income distribution and in ex ante IPR protection. To include these variables in the analysis, an Initial Conditions Index is constructed including these three variables. Such an index is shown to be significant in explaining the effects of an increase of IPR protection on consumer welfare.

The case of the software industry is most interesting, in as it contains a diverse sample of 48 countries. The effect of increasing IPR protection in this case appears to be nonlinear, with average countries bearing the lowest welfare losses and losses increasing as we move farther from the mean in both directions. In the short run, when only variations in prices occur, top above and bottom below average countries are the ones bearing the greater welfare losses. The magnitude of losses are alike for both types of countries. In the long run, losses in welfare cause a reduction in piracy rates that affect more strongly below average countries.

The results for the music industry seem to confirm these results. Although the sample is limited to the “bottom half” of the ICI ranking, results are consistent with those associated with below average income countries in the case of software.

Although these results are exclusively associated with the demand side for innovation and counterfeit goods, it is interesting to note how they fit in with the view that given the differing incentives for innovation and imitation, the optimal level of IPR protection may vary with IPR protection.²² In fact, in less developed countries, innovation is almost non-existent, so authorities have an incentive to allow imitation through lax IPR legislation and enforcement. As a country’s level of development increases and innovation

²² See for example Maskus (2000) for a discussion of how the welfare effects of IPR protection varies according to a country’s level of development.

activities begin, authorities face the trade of allowing imitation and its related benefits or increasing IPR protection and promoting innovation, this case corresponds to the “average ICI countries” in our experiment. Finally, the more industrialized countries already have IPR regimes in place that represent an equilibrium between the need to promote innovation and the desire to disseminate knowledge: increasing IPR protection in this case is counterproductive by inducing excessive protection.²³

A further experiment that would be of interest would be that of considering a harmonization of IPR protection across countries, as is often proposed in international arenas. Furthermore, the ICI index could be used to examine the effect of increasing IPR protection on trade flows of piracy liable goods or of foreign direct investment.

²³ There are various arguments, both in the economic literature, such as Boldrin and Levine (2002), and in the law literature, such as Reichman (1998), that advocate that IPR protection levels in industrialized economies are already too high.

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Appendix 1

To obtain the aggregate utility function, we sum up the utility of all individuals in the economy, those consuming the counterfeit good and those consuming the state of the art good, such that:

$$W_C = \int_a^{y_s} U(y,c) dF(y) + \int_{y_s}^b U(y,s) dF(y) \quad (\text{A1})$$

Rewriting individual utility functions for the two types of consumers as $U(y,c) = \lambda^{k-\delta} pc \left[\frac{y}{pc} - 1 \right]$ and $U(y,s) = \lambda^k ps \left[\frac{y}{ps} - 1 \right]$ respectively, the aggregate utility function can be written as:

$$W_C = \lambda^{k-\delta} pc \int_a^{y_s} \frac{y}{pc} dF(y) + \lambda^k ps \int_{y_s}^b \frac{y}{ps} dF(y) - \{ \lambda^{k-\delta} pc F(y_s) + \lambda^k ps [1 - F(y_s)] \} \quad (\text{A2})$$

where $F(y_s)$ represents the market share of the counterfeit good or equivalently, the piracy rate of the industry considered.

Expressing aggregate utility in terms of units of the state of the art good, we have:

$$\tilde{W}_C = \Phi(\lambda, \delta) \int_a^{y_s} \frac{y}{pc} dF(y) + \int_{y_s}^b \frac{y}{ps} dF(y) - \{ \Phi(\lambda, \delta) F(y_s) + [1 - F(y_s)] \} \quad (\text{A3})$$

where $\Phi(\lambda, \delta) = \frac{pc}{ps} \lambda^{-\delta}$. Since $F(y_s) \in (0,1)$ and by construction $\Phi(\lambda, \delta) \in (0,1)$, the expression in brackets is of small order of magnitude respect to the rest of the terms in (A3). Therefore, the aggregate utility function can be approximated simply by:

$$\tilde{W}_C \approx \Phi(\lambda, \delta) \int_a^{y_s} \frac{y}{pc} dF(y) + \int_{y_s}^b \frac{y}{ps} dF(y) \quad (\text{A4})$$

Finally, substituting out ps in $\Phi(\cdot)$ by expression (9), it can be shown that

$$\lim_{\lambda \rightarrow 1} \Phi(\lambda, \delta) = \lambda^{-\delta}, \text{ being } \frac{\partial \Phi(\cdot)}{\partial \lambda} < 0 \text{ and } \frac{\partial \Phi(\cdot)}{\partial \delta} < 0.$$

Appendix 2

Starting with a Pareto's income function, the derivation by Chaves (1996) is sketched as follows:

$$y = A x^{1-\alpha} \quad \text{for } 1 < \alpha \leq 2; \quad 1 \leq x \leq P \quad (\text{A5})$$

where y is personal income and x is the number of persons in a population of size P that receive an income higher to y . A is interpreted as the maximum income that an individual can earn (when $x=1$). It also can be shown that $A \approx \frac{(2-\alpha)Y}{P^{2-\alpha}}$ when P is large enough, and Y defines the total income of the economy. The implicit Pareto distribution in (A5) has

$$\text{the form } f(y) = \frac{1}{\alpha-1} \left(\frac{B}{y} \right)^{\frac{1}{\alpha-1}} \text{ for } B \approx (2-\alpha) \frac{Y}{P}.$$

Integrating (A5) in the interval 1 to x , we obtain the proportion of the aggregate income that is earned by a given proportion of the population:

$$\frac{Y(x)}{Y} = \left[\frac{x}{P} \right]^{\alpha-2} \quad \text{for } 1 < \alpha \leq 2; \quad 1 \leq x \leq P \quad (\text{A6})$$

where $Y(x)$ is the aggregate income earned by x individuals.

By definition, the Gini coefficient is twice the area between the 45° line and the path described by function (A6) in the interval zero to one, such that:

$$G = 2 \int_0^1 \left[\frac{Y(t)}{Y} - t \right] dt = \frac{\alpha-1}{3-\alpha} \quad \text{for } t \equiv \frac{x}{P} \quad (\text{A7})$$

From (A7), given the Gini coefficient, we can retrieve a unique value for α .