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THE ECONOMICS OF IPR PROTECTION POLICIES

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THE ECONOMICS OF IPR PROTECTION POLICIES

Ricard Gil*

Abstract

In this paper, we model competition between legal and pirate products. In our framework, the government affects this competition through police spending and taxes on legal products. Therefore, the government can choose the combination of spending and taxes that best fits its goals. We find that governments that focus entirely on eradicating piracy use lower levels of taxes and police spending than governments that focus on maximizing consumption, consumer surplus, welfare or government size. This result highlights the importance of demand side policies in the fight against piracy and posts a challenge to the traditional solo approach of supply side policies.

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THE ECONOMICS OF IPR PROTECTION POLICIES

Introducción

The growing scale of piracy has become a major concern for governments around the world and media industry managers. The continuous violation of international Intellectual Property Rights (IPR) laws in developing countries scares away investment from multinational firms, resulting in lower growth and consumption paths. Similarly, domestic piracy lowers the return on investment of firms in the media industry, driving firms out of business and eventually lowering industry revenues and increasing unemployment.

Even though piracy in the movie industry has existed for many years (through home-made copies of video tapes), this has increased lately with the appearance of DVDs and the Internet (pirate DVDs and Internet downloads). Similarly, the music industry has also suffered the effect of piracy: according to the International Federation of the Phonographic Industry (IFPI), global sales increased in the '90s from US$24.1 billion to US$38.6 billion. Nevertheless, global sales fell 5% in 2000, 8.8% in 2001 and 7.1% in 2002, reaching a low of US$30.9 billion (Zentner, 2004).

Although Internet piracy has received most publicity in this matter (due to the Napster case), there are other types of piracy that are at least as important as Internet piracy. An example would be illegal street sales (IFPI, 2001, 2002). This has been an important problem all around the world (it is easier to find any given CD in the streets of Bangkok than it is to find it in a music store in the same city). For example, the Sociedad General de Autores y Editores (SGAE, Spanish body that looks after the interests of authors) reports that Spanish music sales went down by 17 million CDs due to illegal street sales. This means that artists collected 10 million euros less than they should have, while record companies collected 150 million euros less. Even though this effect has decreased in size recently, it is still big and has raised many concerns among artists and media entertainment companies.

In response to these concerns, governments around the world have established different policies to protect artists' IPR and so preserve the incentives for intellectual creation and technological innovation. These policies have focused mainly on prosecuting those who benefit from piracy and raising awareness among potential buyers as to the effects of piracy on the producers of entertainment, the artists. Only very recently, there has been a proposal to decrease the sales tax on these products as a way to make pirate copies less competitive. As yet, we know very little about the effectiveness of these policies, individually or in combination, in lowering the level of music piracy. This paper is intended to shed light on what would be the optimal policy to protect IPR.

To study this problem, we use an extension of the Shaked and Sutton (1982) model as our framework. In this extension, we limit the number of products to two: legal and pirate products. These two products compete directly with each other and have different qualities (legal products have higher quality) and different production technologies. We assume that legal producers have a fixed cost of production and linear marginal cost, whereas pirate producers face only a linear marginal cost of production, which is presumed to be lower than the marginal cost of legal producers. The two products also differ in their respective competitive environment. Legal producers are monopolistic, while producers of pirate products face perfect competition. We believe these assumptions resemble reality and therefore should not alter our interpretation of the results.

In addition to modeling the private sector, we model the public sector and its interaction with the private producers (both legal and pirate producers). The government can affect market outcomes through two channels: sales tax and spending. Sales tax affects only legal products, while government spending affects the probability of pirate products being confiscated and so reduces the expected profitability of such products. The government must balance the use of these two channels to achieve its desired goals. In this paper, we examine five different types of goals a government may have in dealing with piracy as modelled: maximize total consumption regardless of the product type; maximize consumer surplus; maximize society welfare; maximize government size (tax revenue); or minimize piracy.

We find, not surprisingly, that different goals lead to different types of policy with respect to sales taxes and government spending. Governments that aim to maximize consumer surplus or society welfare impose higher taxes and spend more on monitoring than do governments that aim to maximize consumption or tax revenues. Finally, governments that aim only to eliminate piracy regardless of everything else impose the lowest taxes and have the lowest levels of spending. These results suggest that if governments are worried mainly about the long-term effects of piracy on current innovation and therefore want to minimize the incidence of piracy, they should rely more on demand side policies than on supply side policies. This goes against the traditional government approach, which has never involved the use of taxes (or other demand shifters) as a tool to fight piracy. Results here also suggest that governments must balance the two channels to achieve their goals. Balancing the two channels is important because governments face a trade-off: if a government decides to fight piracy by increasing police spending, it may increase taxes to finance that extra spending; but the tax increase will make pirate products more attractive to consumers, as legal products will now be more expensive.

This paper contributes to an existing literature on the economics of IPR policies (Varian, 2005; Klein, Lerner and Murphy, 2002). The distinctive feature of this paper is that government decisions are modelled explicitly and are included in the competitive interaction between legal and pirate products. Therefore, this is a purely theoretical paper that has no direct application to existing data sets, despite the fact that we obtain several policy implications and recommendations.

The paper is organized as follows. In the following section, I present the literature review. In section 3, I introduce the theoretical model used in the paper. Section 4 unravels the theoretical implications of the model. In section 5, I compare outcomes across different types of goals that a government may target. Finally, section 6 concludes and provides policy implications.

2. Literature Review

This paper contributes to two recent streams of the Economics literature. Both literatures treat the emergence of piracy in the world. They differ in that while one treats this problem from a theoretical point of view, the other examines it from an empirical perspective and focuses on different realizations of the piracy problem.

Most of the papers in this part of the literature take as a reference seminal papers on product differentiation. Examples are Shaked and Sutton (1982) and Wauthy (1996). This paper is no different and takes Shaked and Sutton (1982) and Tirole (1991) as main references. Another paper that uses this framework to analyze the market for legal and pirate products is Grgeta (2004). Grgeta models the interaction between original and copied products in a dynamic, horizontally and vertically differentiated market. Another paper is Blackburn (2002), where network externalities are introduced in the study of original and copied goods. Blackburn finds, not surprisingly, that a monopolist should only allow casual copying in the presence of large network externality effects. Our paper differs from Grgeta (2004) and Blackburn (2005) in that we focus on government intervention in these markets and not on private sector decisions. Very recently, Varian (2005) has surveyed the literature and describes some of the insights from previous work. He proposes that a combination of free content policy and traditional copyright policy should be sufficient to satisfy society's demand for information goods.

Most of these papers are a direct consequence of the current intellectual debate on the extent of protection of intellectual property rights. Lessig (2004) is a clear example of the existing debate on what is the optimal degree of intellectual protection and the side benefits of the "free dissemination of culture". Other examples of this debate are Besen and Raskind (1991), Dam (1999), Slive and Bernhart (1998), Takeyama (1994, 1997), Klein, Lerner and Murphy (2002), and Romer (2002).

To the best of my knowledge, we can divide the empirical literature on this topic in two broad groups: papers discussing on-line piracy and illegal downloads through file-sharing, and papers treating all other types of piracy. The first group of papers received a lot of attention due to the importance of the Napster case. Fine (2000) and Landes and Lichtman (2003) provide direct discussion of the case. The main (and almost the only) empirical papers in this area are Zentner (2004), Blackburn (2005), Oberholzer and Strumpf (2004) and Rob and Waldfogel (2004). Zentner (2004) uses a European cross-section data set to estimate the effect of music downloads on purchasing probability. He finds that peer-to-peer usage reduces the probability of purchases by 30%. Blackburn (2005) examines the effect of on-line downloads on music retail sales and finds that on-line downloads work as demand advertisements for small artists, but as demand substitutes for big artists. Rob and Waldfogel (2004) collect data on album purchase and download, and find that each download decreases purchases by 0.2. They also find, thanks to valuation data, that downloading decreases expenditure and increases the welfare of those downloading (not of the musicians, of course). Finally, Oberholzer and Strumpf (2004) find that downloading has no statistical nor significant economic impact on music purchases. This evidence goes against all the other papers described before and certainly leaves the door open to new papers that can help answer the larger question of what is the appropriate level of property rights protection.[1]

[1] There are, of course, other papers treating the Napster case and related issues. Examples are Fine (2000) and Liebowitz (2003a, 2003b, 2004).

The second group provides evidence from piracy other than on-line downloads. Examples of these are Chen and Png (2004) or Hui and Png (2003). Chen and Png (2004) document how legalization of parallel imports reduces CD prices by 7.2%. Hui and Png (2003) estimate losses from piracy to be lower than claimed by the industry. They add the result that in the absence of piracy, prices would have increased. Therefore, losses in revenue are larger than actual losses. From a more general perspective, Hann, Hui, Lee and Png (2002) estimate the value of on-line information privacy.

As commented above, our paper is among the first to model explicitly the role of the government in the provision of policies to protect intellectual property rights. Examining the trade-offs that the government must take into account when designing policies and depicting how different policies manifest in tax levels and government spending are the goals of this paper.

3. Theoretical Model

Following the model developed in Tirole (1991),[2] we model individuals with a utility function such that

$$U = \theta_s - p$$

where θ is the quality of the product consumed by the individual, s is the individual's taste for quality and p is the price paid for the product. We assume that there are 2 different types of products, legal and illegal products, which have different quality levels θ_2 (legal) and θ_1 (illegal). We assume also that $\theta_2 > \theta_1$.[3] Given this notation, the legal product will have a price of p_2 and the illegal product will have a price p_1. We also assume that the population's taste for quality is uniformly distributed such that $s \tilde{} U[0,k]$. Finally, for simplicity we assume the population size is k.

Given this characterization, any given individual will choose to consume the legal product over the illegal product if

$$\theta_2 s - p_2 > \theta_1 s - p_1$$

therefore all consumers with taste higher than $s^* = \frac{p_2 - p_1}{\theta_2 - \theta_1}$ will consume the legal product, and all those with taste lower than s^* will choose to consume the illegal product or not to consume at all. If we assume that individuals that do not consume anything obtain 0 utility, then only those with taste higher than $s' = \frac{p_1}{\theta_1}$ will choose to consume the illegal product over nothing. See Figure 1 for a graphical exposition of this. Therefore, legal and illegal products face the following demand functions, which we shall call expression (1) and expression (2)

$$D_2 = [k + \frac{p_1}{\Delta\theta}] - \frac{p_2}{\Delta\theta} \tag{1}$$

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[2] The model in Tirole (1991) is a version of the model in Shaked and Sutton (1982).

[3] This difference in "quality" can capture the morals of people, differences in reliability or just differences in simple quality.

and

$$D_1 = \frac{p_2}{\Delta\theta} - [\frac{\theta_2}{\theta_1 \Delta\theta}]p_1 \qquad (2)$$

where $\Delta\theta = \theta_2 - \theta_1$.

All said, $D_1 > 0$ if $s^* > s'$, that is, if $\frac{p_2 - p_1}{\theta_2 - \theta_1} > \frac{p_1}{\theta_1}$, or $\frac{p_2}{p_1} > \frac{\theta_2}{\theta_1}$. These are all well-known results in the product differentiation literature and constitute the characterization of the demand side in this paper.

3.1. Public Sector

In this economy, we assume there is a public sector or government. The government spends a fixed amount *R* on services provided to consumers. The government can also spend a variable amount *G* on prosecuting crime (producers of illegal products). The more the government spends, the higher the probability the government will capture the producers of illegal products. This probability depends on *G* through the function $h(G)$, where $h(0) = 0$, $h(\infty) = 1$ and $h' > 0$, $h'' \leq 0$.

The government collects a quantity of tax *t* to finance all its spending $G + R$. Therefore, when the government decides what tax to collect and how much to spend on fighting crime, it has to obey a budget constraint such that

$$q_2 t = G + R \qquad (3)$$

where q_2 is the quantity of units sold of the legal product. We shall call this government budget constraint expression (3).

Notice that the government can only collect tax revenue from the sale of legal products, as the definition of an illegal product entails that its price escapes any government control, including taxes. This means that when the government increases its spending *G*, it will most likely increase q_2 and therefore its tax revenues. There is a trade-off between *G* and *t* that the government must be aware of: increases in *G* must be financed through increases in tax collection. When this increase in tax collection comes from increasing the tax *t*, the demand for illegal products increases, possibly more than the opposite effect of increasing spending *G* in the first place.

3.2. Private Sector

As said before, there are two types of products, legal and illegal ones. Since the aim of the paper is to depict ultimately a simplified version of reality, we characterize the legal sector as one where a monopolist takes care of all production. This is a plausible assumption since legal producers create a new product for which they have monopolistic power. On the other hand, we assume that there is perfect competition in the illegal sector and therefore there is firm entry until profits are driven down to zero. Once the invention is introduced by the legal monopolist, illegal producers instantly get access to a copying technology that allows them to produce an imperfect copy of the legal product. This copying technology is accessible by everybody and, for this reason, the market for imperfect copies (illegal products) is perfectly competitive.

We can depict the profit function of the legal firm with expression (4),

$$\Pi_2 = D_2\,(p_2)p - C_2\,(D_2\,(p_2)) \tag{4}$$

where $p_2 = p + t$ and $C_2(.)$ is the cost function of the legal producer. See that the legal producer optimally sets p, but t is given exogenously to the legal producer by the government. Similarly, the profit function for any of the firms in the illegal sector will be

$$\Pi_1 = d_1\,(p_1)p_1\,[1 - h(G)] - C_1\,(d_1\,(p_1)) \tag{5}$$

which we shall call expression (5). Here d_1 is the demand for each firm in the illegal sector, C_1 (.) is the cost function for each firm, and $h(G)$ is the probability of getting caught by the government. If caught, the illegal producer must still pay the cost of production (the goods are produced *ex ante*) and must give away all revenues from the sale.[4]

Even though we describe profit functions above, technology and cost structure need further discussion. For simplicity, we assume the cost function of the legal firm will be one such that

$$C_2 = c_2 q_2 + F$$

and that of the illegal firms will be one such that

$$C_1 = c_1 q_1$$

where q_2 and q_1, are quantities produced by legal and illegal firms respectively, F is the fixed cost incurred by the legal firm to create the innovation, and c_2 and c_1 are marginal costs where $c_2 > c_1$ due to the lower quality of the illegal product.

Following the theoretical framework in this section, I examine the interaction of private and public sector agents in the following section. We first examine pricing decisions by firms, and then we look into the different policies that the government can follow. The optimal policy will depend on the ultimate goal of the government.

4. Theoretical Implications

In this section we develop the theoretical framework presented in the previous section. We first start analyzing the decisions of the private sector, and then we proceed to analyze the decisions of the public sector.

4.1. Private Sector Decisions

As described above, the illegal sector is perfectly competitive. This means that profit will be driven to zero, and therefore we can arrange expression (5) into

$$\Pi_1 = d_1\,(p_1)p_1\,[1 - h(G)] - C_1\,(d_1\,(p_1)) = 0$$

[4] Another possibility is to add a fine if captured by the police. Results do not change from the analysis here when the government sets a fine per unit of illegal product confiscated. It does not hold if fine size is independent of the number of units of illegal product.

This equation transforms into

$$\Pi_1 = d_1\,(p_1)\,(p_1\,[1 - h(\mathrm{G})] - C_1) = 0$$

when including the cost function described above. We can then find the price for the illegal sector such that

$$p_1 = \frac{c_1}{1 - h(G)} \tag{6}$$

We shall call this expression (6).

On the other hand, the monopolistic legal producer takes into account the price set by the illegal producers p_1 and the tax t set by the government. From expression (4), we find that the legal producer maximizes profits such that

$$\max_p \; D_2\,(p + t)(p - c_2) - F$$

where $D_2 = [k + \frac{p_1}{\Delta\theta}] - \frac{p_2}{\Delta\theta}$ (expression (1) from above). Out of the first order condition of the legal producer problem, we obtain expression (7), which defines p in terms of p_1 such that

$$p = \frac{k\Delta\theta + p_1 + t + c_2}{2} \tag{7}$$

This means that once we include the equilibrium p_1, the equilibrium price is

$$p = \frac{k\Delta\theta + \frac{c_1}{1 - h(G)} + t + c_2}{2} \tag{8}$$

This solution establishes that taxes (t), costs (c_1 and c_2), probability of being caught ($h(G)$), market size (k) and quality differential ($\Delta\theta$) increase the price charged by the monopolistic legal producer.[5]

4.2. Public Sector Decisions

Once the government knows how firms react to its decisions on sales tax (t) and police spending (G), it can set the optimal tax and optimal level of spending that will best achieve its goals. Therefore, defining a government's different types of goals also defines the optimal policy.

We must take into account that the monopolistic legal firm must always obtain positive profit, since the illegal sector copies from their invention. This assumption can be relaxed if we think

[5] If we assume the illegal producer is also a monopolist of the lower quality product, the results do not change much as $p = \dfrac{2k\Delta\theta + \frac{c_1}{1 - h(G)} + (2 + \frac{\theta_1}{\theta_2})t + 2c_2}{4 + \frac{\theta_1}{\theta_2}}$

that local pirate producers are copying the products from foreign legal producers. This eventually will lead the local legal producers out of business and the illegal producers will prevail.

4.2.1. Maximizing Consumption

Take the case where the government wants to maximize overall consumption, that is, joint consumption of legal and illegal products. This is a case where the government values all consumers alike and therefore weighs each of the consumers the same. In that case, the government maximizes

$$\max_{t,G} D_1\,(p_1) + D_2\,(p_2)$$

subject to $p_2 = p + t$, and expressions (3), (8) and (6).

Once we substitute in the values of p_2, p and p_1, the problem transforms to

$$\max_{t,G} k - \frac{c_1}{(1-h(G))\theta_1}$$

subject to

$$\left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]t = G + R$$

As a result to differentiating this problem we obtain three first order conditions (t, G and λ) such that

$$-\frac{c_1 h'(G)}{\theta_1(1-h(G))^2} + \lambda - \lambda\frac{tc_1 h'(G)}{2\Delta\theta(1-h(G))^2} = 0$$

$$-k\Delta\theta - \frac{c_1}{1-h(G)} + 3t + c_2 + 3t = 0$$

and

$$\left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]t = G + R$$

In this particular case, t does not appear in the objective function and it only appears in the government budget constraint. On the other hand, G directly affects both the objective function and the budget constraint. This conditions the resulting first order conditions. In particular, the first order condition with respect to G shows how increases in G directly decrease consumption, but it indirectly favors consumption through the budget constraint and the marginal utility of government spending λ. In the case of the first order condition with respect to t, the maximization problem only maximizes the budget constraint and, therefore, the optimal tax t is the tax that maximizes tax revenue for any given G. Therefore, in the consumption maximizing case, the government is taxing at the maximum of the Laffer curve for any given G, and we can say that the government is over or under-taxing the consumers of legal products. Finally, our last first order condition makes sure the optimally chosen G and t are consistent with the government budget constraint.

4.2.2. Maximizing Surplus

A second possible case is where government maximizes the consumer surplus. This case differs from the first one we analyzed in that the government no longer values all consumers the same. Here, the government values more those consumers that have a higher valuation of consumption and, therefore, the government will favor them when making decisions on tax and expenditure levels. In that case, the government maximizes

$$\max_{t,G} \int_{s^*}^{k} (\theta_2 v - p_2) dv + \int_{\frac{p_1}{\theta_1}}^{s^*} (\theta_1 v - p_1) dv$$

subject to $p_2 = p + t$, and expressions (3), (8) and (6).

Note that there will be a share of consumers that choose not to consume any good (we made this assumption above). These obtain 0 surplus (utility) from consumption and therefore do not enter into the government's objective function.

After plugging values of p_2, p and p_1, the problem transforms into

$$\max_{t,G} \theta_2 k - \frac{c_1}{(1-h(G))\theta_1} - [\frac{k\Delta\theta - \frac{c_1}{1-h(G)} + 3t + c_2}{2}]$$

subject to

$$[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

This problem will yield three first order conditions, such as

$$-\frac{c_1 h'(G)}{\theta_1 (1-h(G))^2} + \frac{c_1 h'(G)}{2(1-h(G))^2} - \lambda \frac{t c_1 h'(G)}{2\Delta\theta (1-h(G))^2} + \lambda = 0$$

$$-\frac{3}{2} + \lambda - [\frac{3t}{2\Delta\theta} - \frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}] = 0$$

and

$$[\frac{k\Delta\theta - \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

In this case, both *t* and *G* affect the objective function directly and indirectly (through the budget constraint). We note that when the government maximizes consumer surplus, it is implicitly valuing consumers with a high value of consumption more than those with a lower value of consumption. Because of this, even with the loss of consumers experienced when *G* increases, and holding tax *t* constant, there is a benefit to be obtained by increasing spending *G* because more consumers will choose the legal product over the pirate product. On the other hand, since *t* now affects directly both the objective function and the government budget constraint, the first order condition with respect to *t* differs from the one in the consumption-maximizer government case. Since an increase in tax harms those consumers that value consumption the most (consumers of legal products), there is a constant negative effect of an increase in taxes $(-\frac{3}{2})$. This constant negative effect is compensated by the marginal effect of an increase in taxes on revenue weighted by the marginal utility of government spending λ. Notice then that the tax used by this government will differ from the tax that maximizes tax revenue for a given G. Again, the last first order condition makes sure that the optimally chosen levels of G and t are consistent with the government budget constraint.

4.2.3. Maximizing Welfare

The objective function does not differ much from the surplus-maximizing case when the government wants to maximize welfare. The objective function will now include the profits of the legal and illegal producers. Therefore, the new objective function will be

$$\max_{t,G} \int_{s^*}^{k} (\theta_2 v - p_2)dv + \int_{\frac{p_1}{\theta_1}}^{s^*} (\theta_1 v - p_1)dv + \Pi_2(p_2, p_1) + \Pi_1(p_2, p_1)$$

subject to $p_2 = p + t$, and expressions (3), (4), (8) and (6).

Note that Π_1 (p_2,p_1) = 0 since the market for illegal products is assumed to be perfectly competitive. Then, after plugging values for the prices p_2, p and p_1, we obtain the following problem

$$\max_{t,G} \theta_2 k - \frac{c_1}{(1-h(G))\theta_1} - [\frac{k\Delta\theta + \frac{c_1}{1-h(G)} + 3t + c_2}{2}] + [\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}][\frac{k\Delta\theta + \frac{c_1}{1-h(G)} + t - c_2}{2}] - F$$

subject to

$$[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

This problem yields the following first order conditions (and simplifying a bit),

$$-\frac{1}{\theta_1} + \frac{1}{2} + [\frac{k\Delta\theta + \frac{c_1}{1-h(G)} + t - c_2}{4\Delta\theta}] + [\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{4\Delta\theta}] - \lambda\frac{t}{2\Delta\theta} + \lambda\frac{(1-h(G))^2}{c_1 h'(G)} = 0$$

$$-\frac{3}{2} - \frac{3}{2\Delta\theta} + [\frac{k\Delta\theta + \frac{c_1}{1-h(G)} + t - c_2}{2}] + \frac{1}{2}[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}] + \lambda[\frac{3t}{2\Delta\theta} - \frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}] = 0$$

and

$$[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

Similarly to the previous case, t and G here directly and indirectly affect the welfare objective function. In this case, increases in G (first order condition) not only favor consumption of the legal product (and therefore increase consumer surplus) but also decrease the competition that the legal producer faces. This increases the legal producer's profits and therefore society's welfare. On the other hand, increases in tax t would reduce society's welfare through decreases in the legal producer's profits and a reduction of legal product consumption by consumers with a high valuation of consumption. The first order condition above tells us that the net effect of increasing tax t is ambiguous and depends on the values of $\Delta\theta$, c_1, c_2 and λ. Similarly to the two cases above, the last first order condition makes sure that the optimally chosen t and G satisfy the government budget constraint.

4.2.4. Maximizing Government Size

A fourth case would be where the politician in charge of making decisions cares about the size of the government because that reflects her power in society. Here, the government no longer cares about the surplus or consumption of individuals, but only about the revenue collected from the legal producer. In such a case, the government will maximize tax revenue such that

$$\max\ tD_2(p+t)$$

subject to $p_2 = p + t$, and expressions (3), (8) and (6).

Note that in a case like this, the bureaucrat would be involuntarily eliminating piracy since it is in her interest to increase the demand for the legal product and diminish the demand for the illegal product.

After plugging in values for p_2, p and p_1, we are left with the problem

$$\max_{t,G}\ \left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]t$$

subject to

$$\left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]t = G + R$$

Hence we obtain the following first order conditions

$$\frac{c_1 h'(G)t}{2\Delta\theta(1-h(G))^2} + \lambda - \lambda\frac{c_1 h'(G)t}{2\Delta\theta(1-h(G))^2} = 0$$

$$-\frac{3t}{2\Delta\theta} + \left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right] - \lambda\left(-\frac{3t}{2\Delta\theta} + \left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]\right) = 0$$

and

$$\left[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}\right]t = G + R$$

See that the solution to this problem needs $\lambda = 0$.[6] This result sets the tax first order condition equal to that of the government that maximizes consumption. That value, as suggested above,

[6] Since we assumed $h' \geq 0$, there is no positive value of λ that.

is the value that maximizes tax revenue for any given G. The last first order condition makes sure the government budget constraint is binding.

4.2.5. Minimizing Piracy

Finally, the government could have an active direct policy to eliminate piracy as much as possible. In this case, the government's only objective would be to minimize the demand for the illegal product. This case is analogous to a situation where the government cares about the future incentives to innovation, and therefore decides to eradicate current piracy at all costs. Here again, the government will pursue its goal regardless of the consequences for consumer welfare or the profits of legal producers. Therefore, the government's minimizing problem would become

$$\min D_1(p_1)$$

subject to $p_2 = p + t$, and expressions (3), (8) and (6).

This problem transforms into

$$\min_{t,G} \frac{k\Delta\theta - \frac{c_1}{1-h(G)} + 3t + c_2}{2\Delta\theta} - \frac{c_1}{\theta_1(1-h(G))}$$

subject to

$$[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

After differentiating, we obtain the following first order conditions

$$-\frac{c_1 h'(G)}{2\Delta\theta(1-h(G))^2} - \frac{c_1 h'\ G)}{\theta_1(1-h(G))^2} + \lambda - \lambda\frac{tc_1 h'(G)}{2\Delta\theta(1-h(G))^2} = 0$$

$$\frac{3}{2\Delta\theta} + \lambda(\frac{3t}{2\Delta\theta} - \frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}) = 0$$

and

$$[\frac{k\Delta\theta + \frac{c_1}{1-h(G)} - 3t - c_2}{2\Delta\theta}]t = G + R$$

Note that in this case we are minimizing, so we must check that the solution we are looking for is actually a minimum and not a maximum.[7] See from the first order condition with respect to G that an increase in G is going to reduce demand of the pirate product at decreasing rates, whereas a decrease in tax t decreases the demand for pirate goods linearly. Therefore, governments minimizing piracy will choose their optimal levels of t and G such that the marginal unit of spending G decreases piracy by the same amount as the last unit of tax

[7] The second order conditions will take positive values as long as $\lambda \geq 0$, which is the case always.

revenue collected increases piracy. From the second first order condition, we see that when we decrease taxes we decrease piracy (positive factor $\frac{3}{2\Delta\theta}$), and therefore the optimal tax t will be below the tax level that maximizes tax revenues. As usual, G and t will be such that the government budget constraint is binding.

5. Comparing Policies

To evaluate and compare the different government policies presented above, we must give a definite functional form to $h(G)$. We choose the following function

$$h(G) = 1 - \frac{\alpha}{G}$$

This function fulfills all the initial assumptions about $h(G)$, that is, $h(0) = 0$, $h(\infty) = 1$, $h' > 0$ and $h'' < 0$.

Using this function for the probability function $h(G)$ simplifies the first order conditions above with respect to government spending G. Despite this simplification and because of the quadratic form of the government budget constraint, there is no close solution to G and t for each one of the government examples set above.[8] Still, we can analyze the different policies and compare them against each other. We do this by comparing objective functions and the first order conditions above.

5.1. Government Spending

The objective function of the government that maximizes consumption depends negatively on the level of spending $G(-\frac{c_1}{\theta_1(1-h(G))})$. That differs from the objective function of the government maximizing surplus in that this negative relationship is softened by an extra term that depends positively on the level of spending G $(-\frac{c_1}{\theta_1(1-h(G))}+\frac{c_1}{2(1-h(G))})$. In this second case, the whole objective function would depend positively on G for all values of $\theta_1 > 2$. As I mentioned above, there is no clear solution to the systems of equations presented in the previous section, but we can compare how the different objective functions depend on the level of spending G. When comparing governments that maximize consumption and governments that maximize surplus, the former's objective function is more strongly negative related to spending G than the latter's objective function. This means that $G^s > G^c$.

When examining the objective function of the government that maximizes welfare, it is the same as that of the government maximizing surplus with the addition of the profit of the legal producer. These profits increase with the level of spending G, since government spending increases the price of pirate products, harms pirate profits and increases the profits of the legal producer. Therefore, this objective function has a stronger positive relationship to G than the

[8] When substituting into the first order conditions our function for $h(G)$, G disappears from the first order conditions. G does not disappear from the first order conditions with respect to t. This leaves us with one equation that solves λ in terms of t and other parameters of the model, one equation that sets t in terms of G and possibly λ, and the budget constraint. The lack of closed solutions comes from the quadratic form of the government budget constraint.

objective function of the government maximizing surplus. This circumstance makes it obvious that $G^w > G^s$.

The objective function of the government maximizing tax revenue is the least definite of all. It contains only one term depending on $(\frac{tc_1}{2\Delta\theta(1-h(G))})$. This term is positively dependent on G, but we cannot compare it with respect to the terms found in the objective functions of the governments maximizing surplus and welfare. If anything, we can establish that $G^r > G^c$.

Finally, the objective function of the government minimizing piracy depends negatively on G, even more strongly than the objective function of the government maximizing consumption $(-\frac{c_1}{2\Delta\theta(1-h(G))} - \frac{c_1}{\theta_1(1-h(G))})$. Therefore, the level of spending G of such government will be lower than that of the government maximizing consumption.

In conclusion, two inequalities summarize our discussion in this section,

$$G^w > G^s > G^c > G^p$$

and

$$G^r > G^c > G^p$$

5.2. Consumption Tax

Even though we do not have close solutions, we can say much more about taxes by looking at the first order conditions of maximizing the respective objective functions with respect to the tax t. We find the following tax profiles,

$$t^c = \frac{\frac{c_1}{1-h} - c_2}{6} + \frac{k\Delta\theta}{6},$$

$$t^s = \frac{\frac{c_1}{1-h} - c_2}{6} + \frac{k\Delta\theta}{6} + \frac{3\Delta\theta}{\lambda},$$

$$t^w = \frac{2(1+\lambda)}{\lambda-1}\left(\frac{\frac{c_1}{1-h} - c_2}{6} + \frac{k\Delta\theta}{6}\right) + \frac{\Delta\theta-\lambda}{\lambda-1},$$

$$t^r = \frac{\frac{c_1}{1-h} - c_2}{6} + \frac{k\Delta\theta}{6}$$

and

$$t^p = \frac{\frac{c_1}{1-h} - c_2}{6} + \frac{k\Delta\theta}{6} - \frac{1}{2\lambda}$$

where t^c is the optimal tax profile if the government maximizes consumption, t^s the tax profile if the government maximizes consumer surplus, t^w the tax profile when the government maximizes welfare, t^r the optimal tax profile if the government maximizes tax revenue, and t^p the optimal tax profile when the government minimizes piracy.

From comparing these five different optimal tax profiles, we can see that holding expenditure *G* constant, taxes can be compared to each other such that

$$t^p < t^c = t^r$$

$$t^c = t^r < t^s$$

and

$$t^c = t^r < t^w$$

Our third inequality holds as long as $\lambda > 1$. This will always be the case because a value $\lambda \leq 1$ will yield negative tax values and in this paper we do not consider the case where the government offers subsidies for consumption of legal products.

6. Policy Implications and Conclusions

This paper analyzes the competition between legal and pirate products. In this paper this competition is influenced by the government through taxes on legal products and spending on the prosecution of illegal products. The former favors pirate products and the latter favors legal products. Despite the fact that governments tend to design policies that favor legal products, government spending needs to be financed through taxes and therefore the government faces a trade-off between the two instruments.

As we can see from our results above, the optimal level of spending and taxes varies from policy to policy. Despite these discrepancies across policies, there are some general results that are equal across policies. We find that taxes on legal products increase the higher $\Delta\theta$, the higher c_1 and the lower c_2. All three conditions state that in more advantageous situations for the legal producer, it is optimal for the government to set a higher level of taxes regardless of the goal it is pursuing.

We find differences across policies. Policies where the government maximizes consumer surplus or society welfare require the highest level of taxes and spending. Policies targeting the minimization of piracy require the lowest levels of taxes and spending. Finally, policies aimed at maximizing consumption (regardless of whether it is legal or pirate production) or tax revenue require a medium level of taxes and spending.

If we consider that the value that maximizes tax revenue regardless of the budget constraint is t^r and t^c, then we can compare all the other values to these two and determine under which regimes the government is taxing too much or too little and therefore obtaining less tax revenue than it would with t^r and t^c. In this case, since t^s and t^w are higher than t^r and t^c, we can affirm that the government is imposing higher taxes and still collecting less money. Similarly, since t^p is lower than t^r and t^c, we can affirm that the government is imposing less taxes and collecting less money. Even though the latter assertion makes perfect sense, the former is in direct contradiction with our previous findings on the level of spending. These two contradictory results are only consistent with each other if the higher level of spending diminishes the demand for the pirate product to the point where the increase in demand for the legal product is greater than the decrease in demand due to the increase in tax. See a graphical representation of this explanation in Figure 2. Here the increase in *G* bumps up the Laffer curve and increases tax revenue per unit of tax. Unfortunately, this increase in *G* must be financed with an increase in t and the government faces a trade-off between tax revenue (G) and efficient taxation (t higher than the maximum point in the Laffer curve). This occurs because an extra unit of spending G increases the demand of legal products by less than one unit, and therefore the government must increase tax levels to finance such spending increase.

These results denote that different government goals require different level of taxes and spending. Therefore, from our results we can say that when governments are most concerned to eliminate piracy so as to provide incentives for future inventions or foreign licensing, the best tool to achieve such a goal is to lower taxes and act through the demand side (consumption tax) and not through the supply side (spending on police). This goes against the traditional approach where governments tend to use only measures to restrict the supply through the increase of regulation and spending towards the monitoring of such new regulation. Varian (2005) specifies very clearly that when the cost of sharing is very low (as it is on the Internet or in street sales), piracy will emerge naturally. In such a case, not even regulation or policing will deter the emergence of demand for pirate products.

Interestingly the results obtained here denote that a government more interested in increasing future consumption will have the lowest level of taxes and spending. By doing this, governments eradicate piracy and foster innovation, which will increase future consumption. This changes when the government is more concerned about consumer surplus and society welfare. This is because there is a shift of preferences from consumers with low consumption value to consumers with high consumption value and firms' profits. This is consistent with well-spread evidence that poor countries have less incisive policies on IPR protection. Therefore, these low-income countries could even be acting optimally.

In conclusion, this paper analyzes the need for coordination between demand and supply policies when governments try to prevent the emergence of pirate markets and foster invention of new products in the future that will ultimately speed overall economic growth. Results in the paper suggest that policies valuing high-value consumers and firms' profits will tend to rely more on supply side policies (increase spending on monitoring policies), while policies targeting the elimination of piracy will tend to rely more on demand side policies (reducing taxes on legal products). Policies aimed at maximizing tax revenue (due to political aspirations of government officials) or maximizing society's consumption (regardless of the value of consumption) will balance their use of taxes and spending and will use medium levels of each.

Future extensions of this research should involve the treatment of time and international borders. In this paper, we use a static model to study the interactions between legal and pirate products in a world with differentiated products. Including the dimension of time in a setting like this is the next step. Doing so we would observe how the incentives to innovation and production vary as the importance of piracy changes. Similarly, most of the inventions in the world occur in a few countries, which license away these innovations to other countries that do not have the resources to produce the innovations themselves. Future research should model the possibility of observing innovation abroad and within the same country and study how piracy abroad and within the same country affects innovation incentives. These are important questions that fall outside the main scope of this paper, and that therefore we can only hope to treat indirectly here. Future research should approach these and related topics appropriately.

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Figure 1

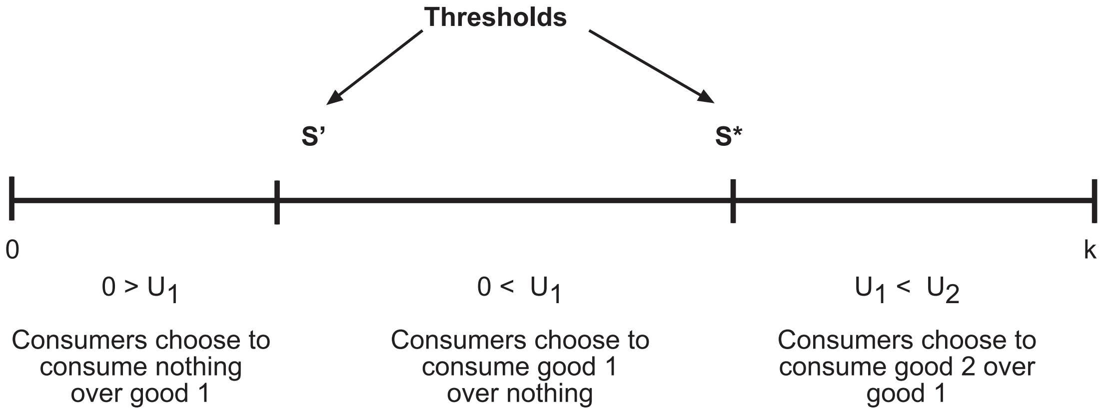

Figure 2