IT IS A THEFT BUT NOT A CRIME

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Abstract

Why do people who normally refrain from committing illegalities become digital pirates? In this paper we use a theoretical model of digital piracy combined with a game-theoretic mechanism of social norm formation to argue that no social stigma is attached to digital piracy because the latter has no perceived social cost; therefore, there is no pressure to build a norm condemning it. We note the existence of a "sophisticate" form of piracy focused on high-quality copies, and not on Internet downloads and black market purchases of low-quality copies like the most common form. Somewhat paradoxically, sophisticate piracy could help to generate a social attitude against piracy, because it is self-containing. However, it is limited in its scope, and it is difficult to predict whether it might ever become sufficiently widespread to effectively engender the formation of an anti-piracy social norm.

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1 Introduction

In a charmingly disquieting line from the Oscar-winning film *Chicago*, the women awaiting trial for having killed their misbehaving partners claim that what they did "[was] a murder but not a crime". A similar attitude seems to prevail among the millions of people who purchase or however acquire illegal copies of records, movies and software, or actually make their own copies at home; they may accept the idea that what they do is a theft, but do not appear to consider it a crime.[1] There are of course laws declaring these copies illegal, and, at least on paper, sanctions may be encountered if one is caught buying or making a copy. However, the enforcement of the rules is at best a half-hearted affair, partly because piracy of information goods is almost impossible to monitor given its scope, partly because the legal norm does not reflect the actual social attitude. Occasionally, deeper attempts at fighting piracy are made, like the offensive against P2P networks launched by the Record Industry Association of America in the summer of 2003 (on which see e.g. Peitz and Waelbroeck 2004); but these are exceptions rather than the rule. Not even countries with a high reputation for ethical behaviour are immune; for example, Sweden, a country ranking among the least corrupt in the world according to Trasparency International (see *www.transparency.org*), is home to one of the best developed networks of digital pirates in Europe.[2]

Seemingly, economists should not be surprised by the scale of the phenomenon. It is simply, we may think, the normal reaction of rational agents to the state of affairs. As just noticed, there are very little risks involved in this sort of illegal activity, while the rewards are immediate and obvious. Copying technology is cheap, easy to use and readily available; free downloads are, as it were, at your fingertips (there are an estimated 885 million music files available on line for illegal downloading)[3]; purchasing a pirated movie on the beach is the simplest thing in the world. In fact, one has the feeling that the right question to ask is not 'why are lots of people doing these things?' but 'why are there still people who don't?'.

These remarks leave however an important stone unturned. In fact, the same people who download pirated movies from the net are often perfectly honest taxpayers, do not steal beer cans from supermarkets, pay their tickets when they catch a bus, and so on. What is it, then,

[1] Just to avoid misunderstandings, let me state here that I personally own a legitimate copy of *Chicago*.

[2] I thank a referee for suggesting the example of Sweden.

[3] The estimate is supplied by the International Federation of the Phonografic Industry (IFPI) – see Grose (2006).

that motivates the individuals to take such a different perspective when it comes to digital products?

Let's try and look at the problem from the opposite angle. A commonly advocated explanation for apparent deviations from rational behaviour is the existence of social norms that imply a stigma for those who do not adhere to them. For example, dodging taxes may be quite lucrative, and still many people may refrain from it because of the psychic costs associated with violating a custom that condemns such instances of antisocial behaviour (see e.g. Myles and Naylor, 1996). Of course, one might ask why the social norm has been established in the first place. The literature on endogenous norms (see Akerlof 1980 for a path-breaking contribution) suggests that customs are accepted and become binding within a group only inasmuch as they serve some useful purpose within the group itself; to continue the above example, Balestrino (2007) argues that customs condemning tax dodging are collectively useful in that they guarantee a smoother redistribution process and favour social competition and mobility. More generally, it is easy to conceive of social norms as a sort of public good, and thus understand why they may arise. For example, the more a society is free from criminal activities like, say, thefts or burglaries, the better for everybody; less personal and social resources have to be wasted on preventing and punishing these activities. Thus, all that contributes to reduce them, including social norms stigmatising thieves and criminals in general, is similar in nature to a public good in that all the members of the society benefit from it in a non-rivalrous and non-excludible way. Just like formal procedures can be activated for the provision of actual public goods by the State, in the same way informal processes can lead to the establishment of social customs having public good properties. This is basically the core of the argument by Coleman (1990) on the incentive provided by the presence of externalities for the creation of social norms (see also Dufwenberg and Lundholm, 2001 and Falkinger, 2004).

A useful way of framing the question would then seem to be that of asking the following. Why do social customs prevent many people from cheating the government, from stealing beverages and from free-riding on buses, but *not* from acquiring illegally duplicated music, software or films, or indeed from making copies on their own? To put it in more colorful terms, why can one freely show one's collection of copied CD's to a friend, and share them, in a way one would not show one's collection of, say, stolen watches? If we adopt the above perspective, we see the answer immediately: if there is no social value attached to stigmatising illegal copies of digital

products, the stigma will not arise.[4]

In this note, we present a model of end-user piracy illustrating the above issues. In the next section, we discuss our modelling strategy; at the same time, we clarify the questions we ask, and provide a summary of the main arguments we develop. Section 3 introduces a formal model of consumption and production of digital goods in the presence of piracy. Section 4 develops an approach to the formation of social norms, and tries to discuss why under the present conditions a norm against digital piracy is tendentially weak, and whether it could become stronger. Finally, section 5 offers a concluding comment.

2 Digital piracy and social norms: a modelling strategy

Work on piracy of information goods is usually focused on two issues: i) do producers suffer from the existence of copies, and, ii) does the possibility of copying lower social welfare? Interestingly, the answer isn't univocally 'yes' to either question. Depending on a number of factors, it may well happen that firms see their profits increased because of copying, and it is also possible that piracy is welfare- or actually Pareto-improving. In fact, it may be that copying enlarges the overall number of users, thereby raising the willingness to pay for the legitimate users due to a network effect and thus enhancing the industry profits; or it may be that low-quality copies, shared e.g. within a P2P network, allow the consumer to sample the original products, so that they can get a very precise idea of what they like and then purchase it legitimately. And even if the production sector stands to lose from the existence of copies, the increase in consumer surplus may overcompensate the loss, leading to an overall welfare improvement. While we refer the reader to Peitz and Waelbroeck (2003) for details and references, it seems possible to conclude that the literature does not yield a clear-cut support to the digital industry insistence that copying is made illegal, and that the authorities crack down on digital pirates: banning piracy does not appear to be necessarily good for the society as a whole, and not even for the industry itself.

In the present contribution, we keep the above results in the background, and we refer

[4] One of the referees noted that a factor contributing to minimise the psychological discomfort of stealing from a "faraway" entity such as a recording company is the so-called "identifiable victim effect" (see Lowenstein et al. 2005). Social norms bite when the agent is tempted to steal from a specific person, with a clearly identifiable individuality, but lose strength when the victim is a faceless institution. This explanation is definitely compatible, and indeed complementary, with our analysis.

to them when necessary, but we aim to offer a complementary perspective in that we look at the very basic question of why piracy is such a common practice (unlike many other illegal activities).[5] In order to focus on this question, we simplify the model in two important respects. First, we assume that digital products are supplied by a profit-maximising monopolist; we thus avoid the complications that might arise from considering the role of strategic interactions (on which see e.g. Belleflamme and Picard 2004). Second, we ignore the important circumstance that most digital products are experience goods, as we assume that consumers are perfectly informed about what they buy; we therefore rule out *a priori* a role for piracy as a way to collect information about the product (eventually leading to legitimate purchases) as well as a role for the sale of downgraded official versions as a means for the companies to fight piracy (for a clear discussion of this issue and several references, see the already cited review by Peitz and Waelbroeck 2003).

As for modelling piracy, we start from the observation (commonly made in the literature) that it can be of two different sorts: a person can either i) make a high-quality copy from a borrowed original or, ii) acquire a low-quality copy *via* an Internet download or a black market purchase. For our purposes, it is relevant to emphasize the distinction between the quality of the product that can be obtained with the two different methods. Downloaded and black-market copies are usually low quality, for a variety of reasons: in the case of music and films, they do not come bundled with lyrics, photos, extras and other gadgets for which the consumer may care, they may not offer the best sound or video quality, they may not be compatible with all play-back devices, etc; in the case of software, consumer support may be unavailable, etc. It is sometimes possible to remedy to part of these deficiences by acquiring additional material though further searches on the Internet (there are sites for downloading CD/DVD covers; others for downloading lyrics; it is possible to find patches that make a pirated software look like the real thing, etc.); but it is of course a costly process and in the end the overall quality is not especially good anyway (the pictures of the covers are often low-definition; the lyrics have to be printed and kept separately from the CD; the patch may not work in all circumstances, etc.).[6] Of course, the quality gap is perceived mostly by agents who care about quality in the first place; our model makes a pervasive use of the fact that quality is largely subjective.

[5] We only focus on end-user piracy. References to for-profit piracy can be found in Peitz and Waelbroeck (2003).

[6] For a discussion of the different quality of copies in the case of music, see Cameron (2002).

Agents in our model are divided in two main groups; quality-indifferent consumers attracted by downgraded pirated products and quality-conscious consumers who purchase original products.[7] The latter may also, given the chance, engage in the other version of piracy, which we refer to (for want of a better term) as "sophisticate" piracy. The sophisticate digital pirates have a good knowledge of information technology and, most importantly, are members of sufficiently large social groups whose members borrow and lend original products in order to make a high-quality variety of copies using commercially available equipment and software, often sold by the same firms that are complaining about Internet piracy.[8] We may plausibly guess that, at the moment, sophisticate piracy is not especially widespread. It might become so: Peitz and Waelbroeck (2004) report e.g. that, in 2003, 90% of US household owned a computer, and 80% of these owned a CD-recorder; DVD-recorders can be expected to reach a similar penetration. Still, the availability of the devices does not automatically imply their use for sophisticate piracy purposes.

We need now to understand how informal norms against anti-social behaviour come to be established within a society. As we mentioned, customs have the important role of favouring the survival and flourishing of the group in which they become binding. We model the creation of informal rules by closely paralleling the political economy approach, commonly employed to study the establishment of formal rules. In that approach, it is assumed that different agents have different preferences over policies, and that these preferences can be reconciled by means of e.g. some voting mechanism. Here, we take the view that agents have preferences over the social norm, and that these possibly conflicting preferences are aggregated through informal procedures (social interaction, group pressure, etc.) to became a more or less well-established custom.[9] Different groups (ordinary pirates, legitimate users and sophisticate pirates) have

[7] Some influential people in the movie industry seems to believe that this partition of consumers is a good description of reality; George Lucas, the *Star Wars* director, advocates "day-and-date distribution" (i.e. movies would open in theaters and be available on DVD the same day) as a way of fighting piracy and argues that this will not affect theater attendance basically because those who go to see the movie and those who buy a pirated DVD are not the same people (Corliss 2006). Something of this sort is already happening in the music industry; to mention just an important name, Depeche Mode (a British band with more than 25 years of career and a widespread audience) put on sale, starting from April 2006, the recordings of 50 concerts from their 2006 tour, to be pre-ordered on line or at the venue (information coming from www.depechemode.com, consulted May 2006).

[8] There are of course copy-protection technologies, but software removing them (or permitting to circumvent them) is freely available on the Internet or actually on sale (personal copies are legitimate almost everywhere).

[9] There is a relevant social psychology literature on norm formation and conformism that is worth mentioning

different views on whether digital piracy should be socially condemned or not. Individuals with little taste for quality (presumably the poorest segment of the population – quality is definitely a normal good, if not a luxury) are more prone to become ordinary pirates and therefore unlikely to disapprove of digital piracy; they will adopt and disseminate a view that is consistent with this attitude. Quality-conscious legitimate users are not going to profit much from a reduction of piracy either, because, as long as it does not threaten the survival of the industry, it should help to keep prices down; they could thus be not particularly active in condemning piracy. Instead, sophisticate pirates might, somewhat paradoxically, be good advocates of a social norm since they rely on original products not only as such but also to make their copies, and hence, unlike ordinary pirates, they get some benefit from keeping piracy under control and encouraging the purchase of original products. We will also argue that, in a sense to be made precise below, the presence of the sophisticate pirates may induce legitimate users to become more alert to the dangers of piracy.

A commonly made observation is that the digital industry seems to be engaged in a sort of apparently inconsistent behaviour – fighting actively one type of piracy but not the other. This is well-know, but it may be worth pointing out that we offer here a complementary explanation to that already present in the literature. It is usually argued that the companies may devise pricing strategies apt to appropriate revenue from groups sharing originals for the purpose of making a copy – after all, it is as if they were selling to clubs; this is however not possible when piracy takes the form of entirely eschewing the purchase of original products. Hence, the two sorts of piracy do not damage the industry in the same way. The present analysis also points out that sophisticate pirates may, additionally and rather unexpectedly, contribute to establish the view that piracy is socially condemnable. We therefore see that it makes sense for the digital industry to fight ordinary pirates, and at the same time not to waste too many resources against the sophisticate ones, also in terms of favouring the creation of a social climate in which piracy is maintained within "functional" limits. Of course, it is not clear that sophisticate piracy might ever reach the critical mass that it needs to engender the creation of a strong anti-piracy social attitude; still, a strategy of indirect revenue appropriation can be expected to pay off more than one of relentless fight.

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in this respect; see e.g. the classical works by Sherif (1936) and Asch (1955). This literature studies empirically the spontaneous formation of norms, and its enforcement via the actions of the majority or otherwise influential groups. We return to this point in Section 4 below.

In the next sections, we make the above chain of arguments more precise with the help of a formal model.

3 A model of consumption and production of digital goods

There are potentially several sources of agent's heterogeneity that may be relevant in the context we are facing. For the purposes of our present approach, we focus on three sources, namely income, education, and tastes. Obviously, income matters because of the different consumption bundles that agents with different earnings may afford. Also, education matters because it is empirically plausible to suppose that better educated people are more prone to become sophisticate pirates, as they are more likely to possess the non-negligible social skills needed to establish and maintain a networks of friends for borrowing (and lending) as well as the moderate to high competence with several different types of software and hardware needed to actually make the copies. Finally, tastes matter because of our emphasis on the quality of the digital product; some agents may be relatively indifferent to such quality, while other may regard it as extremely important.

Developing a model with three-dimensional agents' heterogeneity is of course no simple matter. Luckily, in our framework, it seems natural to assume that all three traits are related to one another in a systematic way; high-income agents are tendentially better educated, and have a stronger taste for quality. We assume therefore that i) the education level (and therefore the propensity to become a sophisticate pirate), and ii) the intensity of the preference for quality, are both positively correlated with income. This way, we employ a standard model with one-dimensional differences; at the same time, we are able, as it will become clear in what follows, to assign a significant role also to the remaining two sources of heterogeneity.

Consider then an economy inhabited by a large number of agents; the total size of the population is normalised to unity. Each agent is identified by his or her (fixed) income y, which is distributed over an interval $[y^{-}, y^{+}]$ according to a density function $f(y)$. All agents have the same quasi-linear utility function

$$U = c + u(x), \tag{1}$$

where c is general consumption and x is a composite digital product that can be acquired, in general, from three different sources:

$$x = \gamma + \theta e(y) + \omega, \tag{2}$$

where γ are high-quality copies, θ are low-quality copies, ω are original products, and $e \in (0,1)$ is a factor converting the low-quality copies into equivalent units of high-quality ones. In line with the assumption made above, we suppose that e varies inversely with income, $e' < 0$ (in other words, quality is taken, very plausibly, to be a normal good); a low-income agent regards the original product as almost perfectly substitutable with a low-quality copy, while a high-income, quality-conscious, agent sees them as two quite distinct commodities. For simplicity, high-quality copies have the same quality as originals. Notice how quality is largely a subjective perception in our framework.

Copying techniques

The above formulation recognises the existence of both ordinary and sophisticate piracy. The two methods involve costs and require abilities of different sorts. In fact, the low-quality method is available to everybody (since the black market offers a ready alternative to those who are not familiar with Internet), whereas access to the high-quality one is much more difficult. As mentioned, the various skills to be employed by a sophisticate pirate are plausibly linked to education, that does not appear explicitly in the model but is proxied by the income level. We assume therefore that at each income level above a certain threshold $\widetilde{y} > y^{-}$ there is a certain fraction δ of agents endowed with the above abilities; sophisticate pirates are thus only present in income groups above $\widetilde{y}$. All pirates below $\widetilde{y}$ are instead of the ordinary variety; for them, we clearly have $\gamma \equiv 0$ in (2).

Let now $\gamma(z,n)$ be the production function of home-made copies, where z denotes the expenditure incurred for the production process (buying recordable discs, searching for copying software, etc.) and n is the number of friends who can lend the agent an original product for copying (or make the copy for him, or give him tips on how to make copies, etc.). We take $\gamma(\cdot)$ to be strictly concave and additively separable.[10] The price of ω is denoted q, while the cost of acquiring θ is taken to be t per unit; at the end of this Section we will look at how the price q is determined, but since for the consumer it is given, for now we simply proceed to write the budget constraint. To this end, we define the total cost of copies as $(z + t\theta)\, k$, where $k \in [1, k^{+}]$ is a measure of the stigma attached to the act of acquiring a copy; we will discuss in Section 4

[10] A non-separable function would not alter the general direction of the results, but it would complicate the analysis (especially the comparative statics).

below how this stigma is formed ($k > 1$), or not formed ($k = 1$), as the case may be.[11]

The budget constraint is then

$$c + (z + t\theta)\, k + q\omega = y, \tag{3}$$

where we normalised the price of c to unity and z and k are expressed in units of income. Of course, $z \equiv 0$ in (3) for the ordinary pirates. Solving for c and substituting into the utility function yields the following maximisation problem:

$$\max_{z,\theta,\omega} \; U(z, \theta, \omega; k, t, q, y) = y - (z + t\theta)\, k - q\omega + u\left(\gamma(z, n) + \theta e(y) + \omega\right), \tag{4}$$

subject to non-negativity constraints for all three choice variables (two for the ordinary pirates). First order conditions are

$$u'\gamma_z - k \leq 0;\; u'e(y) - tk \leq 0;\; u' - q \leq 0; \tag{5}$$

plus complementary slackness; the condition w.r.t. z does not apply to ordinary pirates.

Consumer types

Before investigating the solution in more detail, we need to discuss the "adjusted" *relative* price of low-quality copies vs. original products, as it turns out to be a key factor in determining the mix of digital products. If we define

$$P(k, t; y) = \frac{tk}{e(y)}, \tag{6}$$

as the adjusted price of low-quality copies, then the adjusted relative price is $P(\cdot)/q$. Due to the assumption that e decreases with income, $P(\cdot)$ increases monotonically; quality-conscious agents perceive low-quality copies as more expensive. From a simple manipulation of the first order conditions (5), it follows that there will be a cut-off income level $y^*(k, t, q)$, implicitly defined by $P(k, t; y^*)/q = 1$, such that only agents with income $y \geq y^*$ will buy originals,[12] whereas all those with income $y < y^*$ get low-quality copies. A straightforward use of the implicit function theorem shows that

$$y_k^* < 0;\; y_t^* < 0;\; y_q^* > 0, \tag{7}$$

[11] In principle, the stigma may take different values for the two types of pirates; however, as we will find out that the expected outcome involves no stigma for piracy ($k = 1$), it seemed pointless to introduce the distinction (which would have only complicated the analysis).

[12] The agents with $y = y^*$ see in fact original products and low-quality copies as equivalent, so we assume that they buy the former.

that is, the threshold income level will go down as the social norms is reinforced or the cost of low-quality copies increases, but it will go up as the price of legitimate products increases. This simply says that the group of agents willing to buy originals will become smaller if low-quality copies become relatively cheaper.

The cut-off income level y^* helps us to define the size of the network (on which to rely for copying) each sophisticate pirate has. We assume that

$$n = n\left(y, y^*\left(k, t, q\right)\right), \tag{8}$$

with $n \in (0,1)$, $n_y > 0$, $n_{y^*} < 0$. This can be interpreted as follows. First, it makes sense to assume that agents with higher income have a larger network, on grounds of the already invoked argument that social skills are positively correlated with education (proxied by income). Second, the network members must come from the group of agents who own original products; this group will decrease in size as y^* increases, and so will do the network.

The interaction between the two cut-off incomes y^* and $\widetilde{y}$ identifies various types of consumers. The analysis can be carried out for all possible cases, i.e. for y^* greater than, equal to, or less than $\widetilde{y}$. However, we choose

$$\widetilde{y} > y^*. \tag{9}$$

We regard this as the most plausible case, because it implies that all the skilled pirates are willing to purchase originals, i.e. it rules out the possibility that some agents consume the digital product only in the form of high-quality copies. The idea of a network in which all members borrow and lend makes this type of consumer somewhat implausible – the lack of reciprocity would isolate him or her from the group.

From (9) we derive then the existence of three consumer types: i) ordinary pirates, i.e. agents with income between y^- and y^* (excluded – see fn. 12), who only consume low-quality copies; ii) legitimate users, i.e. all agents with income between y^* and $\widetilde{y}$ plus a fraction $1-\delta$ of the agents with income between $\widetilde{y}$ and y^+, who only consume originals; iii) sophisticate pirates, i.e. a fraction δ of the agents with income between $\widetilde{y}$ and y^+, who buy legitimate products but also make high-quality copies. Note that the relative size of the three groups depends, among other things, on the two exogenous parameters δ and $\widetilde{y}$. We will focus mostly on the empirically plausible case in which δ is relatively small and/or $\widetilde{y}$ relatively high, so that the sophisticate pirates are a minority; however, we will sometimes investigate what might happen in case they became a substantial share of the total population.

We are now ready to consider the solution to the agent's problem for the three different consumer types.

The mix of digital products

First, take high-earners endowed with the sophisticate copying technology. For the general case of an interior solution[13] in which the agent, besides owning originals, makes copies at home, the arbitrage condition determining the equilibrium mix of digital products can easily be seen to be $\gamma_z(z, n(\cdot)) = k/q$. Using the superscript σ to identify variables pertaining to this group, we obtain the demand for original products, ω^σ, and that for the input in the copying technology, z^σ, as functions of k, t, q and y. Comparative statics results (see the Appendix for details of derivation) are:

$$z_k^\sigma < 0;\ z_t^\sigma = 0;\ z_q^\sigma > 0;\ z_y^\sigma = 0; \tag{10}$$

$$\omega_t^\sigma < 0;\ \omega_q^\sigma < 0;\ \omega_y^\sigma < 0; \tag{11}$$

while ω_k^σ cannot be signed. That is: i) when the social norm bites more, the agent spends less on copies, *but not necessarily buys more originals*; ii) when the price of low-quality copies rises, the agent's outlay on copies is the same as before, *but she buys less originals*; iii) when the price of originals rises, the agent spends more on copies and buys less originals; iv) when income rises, the expenditure on copies remains the same, *but legitimate purchases fall.*

The signs of the effects on z are as expected, whereas those of the effects on ω deserve a few words of explanation. As it is made clear in the Appendix, when either k or q changes, there are two effects to consider, a direct one which has the expected sign, and an indirect one (through n) which may have an opposite sign; when either t or y changes, we have only the indirect effect. In the case of z, the indirect effect is small or absent, but in the case of ω it may be relevant. For example, when k is marginally increased, copying becomes costlier in terms of stigma, but at the same time there are more opportunities for copying because the network becomes larger; thus, the two effects do not agree in sign for ω_k^σ. If t rises, there are more people buying originals as a result of the increase in the price of low-quality copies, hence there are more opportunities for making high-quality copies as n becomes larger, and thus the agent buys less original products; similarly, if y rises, the purchase of originals falls because the larger

[13] The standard assumption that $\gamma_z(z) \to 0$ for $z \to \infty$ and $\gamma_z(z) \to \infty$ for $z \to 0$, combined with strict concavity and additive separability of $\gamma(z, n)$, is sufficient for an interior solution.

network make copying easier.

Note that the above results concern the expenditure on copies z, not the amount of copies γ. It is however easy to see that the combined impact of the effects in (10) and (11) and of the changes in the level of n is ambiguous when either k or q varies, whereas it induces the agent to make more copies when t rises; indeed, in the first two cases z and n move in opposite directions, whereas in the third z is unchanged but n increases. Also, the number of copies γ increases with income, as z does not vary but n increases; thus, as income grows, the agent replaces originals with home-made copies.

Second, we have agents with high incomes who only buy originals. The first order condition is simply $u' = q$, from which, using obvious notation, we obtain as a solution the demand for legitimate products, $\omega^{-\sigma}$, as a function of q (due to the quasi-linearity of the utility function, $\omega^{-\sigma}$ does not depend on y); clearly, we have

$$\omega_q^{-\sigma} < 0. \tag{12}$$

Hence, the aggregate demand for legitimate products is

$$\begin{aligned} \Omega(k,t,q) &= \omega^{-\sigma}(q) \left(\int_{y^*(k,t,q)}^{\widetilde{y}} f(y)\,\mathrm{d}y + (1-\delta) \int_{\widetilde{y}}^{y^+} f(y)\,\mathrm{d}y \right) + \\ &\quad + \delta \int_{\widetilde{y}}^{y^+} \omega^{\sigma}(k,t,q;y)\, f(y)\,\mathrm{d}y, \end{aligned} \tag{13}$$

that is the demand by legitimate users plus the demand by sophisticate pirates.

Finally, we have agents with low incomes who only acquire low-quality copies. For them, the first order condition is $u' = P(k,t;y)$, and the solution is given by the demand for θ as a function of k, t and y.

Selling digital products in a world of pirates

The legitimate copies of the digital product are sold by a profit-maximising monopolist. The choice variable is taken to be quantity. In order to identify correctly the profit function, we need to invert the market demand for the original product as defined in (13). We first check

whether this is feasible by noting that

$$\Omega_q = \omega_q^{-\sigma} \left(\int_{y^*}^{\widetilde{y}} f(y)\,\mathrm{d}y + (1-\delta) \int_{\widetilde{y}}^{y^+} f(y)\,\mathrm{d}y \right) +$$
$$+ \delta \int_{\widetilde{y}}^{y^+} \omega_q^{\sigma}(\cdot; y)\, f(y)\,\mathrm{d}y - f(y^*)\, y_q^*(\cdot)\, \omega^{-\sigma} < 0; \tag{14}$$

we used the comparative statics results (10), (11) and (12) as well as (7) to ascertain the sign. The three terms in (14) have the following simple interpretation: the first and second term are the reactions to the own-price increase by the legitimate users and the sophisticate pirates, respectively; the third is the variation in demand due to the marginal change in the aggregate number of buyers of originals. Inverting $\Omega(k,t,q)$ yields the inverse demand function $q = q(\Omega; k, t)$. Then, the monopolist's profit is $\pi(\Omega; k, t) = \Omega q(\Omega) - \Omega\chi - \Phi$ where χ is the constant marginal cost, and Φ are fixed costs. This is to be maximised by choosing Ω; we assume that the monopolist's problem is well-behaved, i.e. the objective function is strictly concave. The first order condition is

$$\pi_\Omega = q + \Omega q_\Omega - \chi = 0. \tag{15}$$

Let the solution to the monopolist's problem be Ω^m; using the inverse demand function yields the equilibrium price,

$$q^m = q(\Omega^m; k, t). \tag{16}$$

4 Will piracy be socially condemned?

The digital industry would like to raise people's awareness that copying music or movies or software is against the law, and as such, a socially condemned act – a theft. Digital pirates are thus ideally depicted as social pariahs, like all thieves. This is in fact rather wishful thinking; in most environments, they are more like small-time heroes. Most people perceive that the law has been introduced upon the insistence of the digital industry, and that the bad image of the pirate is a fabrication. Why it is so? Why do most people seem to think that digital pirates are the good guys after all – the white hats?

The reaction of the market to variations in the social norm

To answer this question, we need first to discuss how the equilibrium price q^m reacts when k changes. It turns out that we cannot give a general answer. We have that

$$q_k^m = q_\Omega \Omega_k^m + q_k, \tag{17}$$

where we can only determine that $q_\Omega = 1/\Omega_q < 0$ by (14). We need to impose some (reasonable) restriction in order to proceed; in particular, we will use linear approximations. This will not entirely solve the ambiguity, but it will allow us to describe in some detail the conditions under which q_k^m takes one or the other sign. Applying the implicit function theorem to (15) yields

$$\Omega_k^m = -\frac{q_k + \Omega q_{\Omega k}}{2q_\Omega + \Omega q_{\Omega\Omega}}; \tag{18}$$

taking a linear approximation of the demand schedule in the monopolistic market for ω, and interpreting k as a shifting parameter, we modify (18) as follows:

$$\Omega_k^m \simeq -\frac{1}{2}\frac{q_k}{q_\Omega}; \tag{19}$$

and therefore we have

$$q_k^m \simeq -\frac{1}{2}\frac{q_\Omega q_k}{q_\Omega} + q_k = \frac{1}{2}q_k. \tag{20}$$

Hence, q_k^m has the same sign as q_k, which in turn has the same sign as

$$\Omega_k = \delta \int_{\widetilde{y}}^{y^+} \omega_k^\sigma f(y)\,\mathrm{d}y - f(y^*)\, y_k^* \omega^{-\sigma}, \tag{21}$$

where we used the fact that $\omega^{-\sigma}$ only depends on q.

In principle, one would expect that the demand for originals rises when the norm becomes more stringent, with a consequent increase in the equilibrium price. This cannot be proven to be always true, but it is arguably the most likely outcome: the second term in (21) tends to make Ω_k, and hence q_k^m, positive, as a stronger social norm induces more agent to become legitimate users, and, although ω_k^σ in the first term cannot be signed (see the comparative statics above), it is reasonable to suppose that, should they disagree in sign, the second term dominates the first as long as sophisticate piracy is not especially widespread (δ is small and $\widetilde{y}$ is high).

To be more precise, we can state the following:

- $q_k^m > 0$ occurs if $\omega_k^\sigma > 0$, that is if sophisticate pirates buy more originals when the norm becomes more stringent; or if $\omega_k^\sigma < 0$ and

$$\left| \delta \int_{\widetilde{y}}^{y^+} \omega_k^\sigma f(y)\,\mathrm{d}y \right| < f(y^*)\, y_k^* \omega^{-\sigma}, \tag{22}$$

that is if sophisticate pirates are few and react to a more binding norm by purchasing moderately less originals, so that the increase in the demand coming from the increase in the number of legitimate users prevail.

- $q_k^m < 0$ occurs if $\omega_k^\sigma < 0$ and the inequality sign in (22) is reversed.

Although we regard the first case as more plausible, it is instructive to investigate the conditions under which the second case obtains. From the comparative statics (see the Appendix) we learn that ω_k^σ is negative when

$$U_{\omega k}^\sigma = u'' \gamma_n n_{y^*} y_k^* < 0 \tag{23}$$

is "sufficiently" large in absolute value (exactly how large is determined in the Appendix). Note that $U_{\omega k}^\sigma < 0$ reflects the fact that whenever the psychic cost of piracy increases, originals have less value in the eyes of the sophisticate pirates. This can be seen from both their perspectives, as lenders and as borrowers in the network. As lenders, they purchase originals not only for their own consumption, but also for giving them to their network friends, and this latter use becomes less valuable when piracy becomes costlier; as borrowers, the increase in costs of piracy and, consequently, the reduction in the number of ordinary pirates, enlarges the pool from which originals can be borrowed and thus reduces their value for direct consumption. Then, if each sophisticate pirate decides to buy *less*, rather than more, originals ($\omega_k^\sigma < 0$), *and* if there are enough sophisticate pirates (large δ and low $\widetilde{y}$), we would have $q_k^m < 0$. Conditional on being sufficiently widespread, sophisticate piracy might induce a unexpected behaviour of the market price of originals. There are overall more people buying originals, but part of them express a smaller demand; if the latter effect prevails, it induces a price reduction.

The agents' opinions

We now focus on the indirect utility functions from the maximisation problems of the three consumer types. We write these as

$$v^\sigma(k, t, q^m);\ v^{-\sigma}(k, q^m);\ w(k, t) \tag{24}$$

for sophisticate pirates, legitimate users and ordinary pirates respectively – recall that q^m is defined by (16). By maximising these function w.r.t. k, we identify the preferred strength of the norm for the three agent types, labeled $k(y)$.

Let's start from ordinary pirates, whose optimal norm problem is

$$\max_{k} \; w(k,t) \text{ s.t. } k-1 \geq 0 \text{ and } k^{+}-k \geq 0; \tag{25}$$

the ensuing first order condition is

$$w_k = -t\theta < 0 \tag{26}$$

where we computed the derivative of the indirect utility function from (4). Clearly, by complementary slackness, $k(y) = 1$; low-income agents ($y < y^*$) do not obtain any benefit from a norm against piracy, it only raises their (perception of the) cost of copying.

For legitimate users, we have

$$\max_{k} \; v^{-\sigma}(k, q^m) \text{ s.t. } k-1 \geq 0 \text{ and } k^{+}-k \geq 0; \tag{27}$$

using again (4), we find that

$$v_k^{-\sigma} = -q_k^m \omega^{-\sigma} \tag{28}$$

whose sign is the opposite as that of q_k^m, which we saw to be ambiguous, although likely to be positive – check the discussion of (17). In fact, if $q_k^m > 0$, then $v_k^{-\sigma} < 0$; the legitimate users share the view of ordinary pirates that piracy should not be condemned, as this has the useful implication of lowering the price of originals – formally, $k^{-\sigma}(y) = 1$ by the complementary slackness conditions. In the less likely case that $q_k^m < 0$, then $v_k^{-\sigma} > 0$; legitimate users will become unrelenting advocates of the social norm, so as to induce a lower price for originals – formally, $k^{-\sigma}(y) = k^{+}$, as can again be easily seen using complementary slackness. It is noteworthy that a deep penetration of sophisticate piracy is necessary for the legitimate buyers to become full supporters of the norm; indeed, we noted above that $q_k^m < 0$ cannot occur unless there is a large number of sophisticate pirates (and other conditions are met).

Finally, the optimal norm for sophisticate pirates is found by solving

$$\max_{k} \; v^{\sigma}(k, q^m; y) \text{ s.t. } k-1 \geq 0 \text{ and } k^{+}-k \geq 0; \tag{29}$$

this yields

$$v_k^{\sigma} = -z - q_k^m \omega^{\sigma} + u' \gamma_n n_{y^*} y_k^* \leq 0, \tag{30}$$

plus complementary slackness. At an interior solution we thus have an optimal level of $k^{\sigma}(y)$ satisfying a "marginal benefit equals net marginal cost" condition that can be written as follows:

$$u' \gamma_n n_{y^*} y_k^* = z + q_k^m \omega^{\sigma}. \tag{31}$$

Indeed, the norm advantages the pirates in that they have a larger network on which to rely for borrowing originals (l.h.s.); hurts them because it raises the (perception of the) cost of copying (first term on r.h.s.) and normally also the price of originals (second term on the r.h.s.).[14]

The formation of social norms

Just like in ordinary political economy models one proceeds to reconcile the agents' policy preferences using e.g. a voting mechanism, we can now aggregate the agents' ideal levels of the strength of the norm by postulating the existence of informal mechanisms that create a majority view and then bring all agents to conform to that view. In order to understand and appreciate the strength of these informal mechanisms, it may be useful to review briefly the large social psychology literature on the subject (already referred to in fn. 9). A wealth of empirical studies (see e.g. Bond and Smith 1996 for a long list of references - more than 100 works) has shown that conformism to the majority is a universal tract, surfacing (with of course different strength) in the most diverse cultures. If a sufficiently large group of people share a view, and support it by their deeds and words, the others tend to conform even if they are opposed or indifferent. In fact, in one of the classical experiments, large fractions of participants conform to the opinion of the majority even if they are sure, as made clear later by personal interviews, that such an opinion is factually wrong. This is the so-called "line judgement task", originally devised by Asch (1955) and repeated many times. It works roughly as follows. An experimenter asks to the subject if he or she can guess the length of a line traced on a wall, in the presence of a group of people whom the subject believes to be exclusively other subjects but are instead in part experimenters. One of the tasks of these experimenters is to suggest inaccurate guesses as a counterproposal to the subject's guess. Even when it is clear that such counterproposal goes wildly off the mark, if a sufficiently large group of hidden experimenters supports it, the subject often agrees with the view of the majority.

There are several explanations for this behaviour that have been advanced in the literature. At least four have received widespread attention. Two of them have been proposed by Festinger (1950) and have been collectively labelled "informational social influence"; the first is the need to see our opinions and beliefs confirmed by those of the others, and the second is the presence

[14] From the discussion above we know that, under some circumstances, an increase in k might lead to a reduction in the price of originals, in which case the second term on the r.h.s. will become a benefit rather then a cost. This is why we referred to the whole r.h.s. as a "net cost".

of some relevant shared goal that can be achieved by coordinating our effort with that of the others. Deutsch and Gerard (1955) have formulated a theory of "normative influence", whereby conformism would be dictated by the desire to avoid being isolated. Finally, Turner (1987), with his "self-categorization" approach, has argued that conformism gives the agent her own social identity, helps her to find her own "category". While it is possible that all the factors identified by these authors are simultaneously at work, the one more relevant to our present intentions seems to be the second process identified by Festinger (1950) and investigated among others by Lewin (1965); if the members of the group perceive a clearly defined common aim, and identify the value of a given action or opinion for reaching that aim, they are strongly inclined to conform to that action or opinion independently from their personal attitudes.

The conformism to a social norm, whose importance for the stability and ultimately the strength of the group can be easily recognised, might be interpreted, in this light, as the informal equivalent of the process leading to the creation of binding policy rules. Agents may perceive that it is in their interest to limit anti-social behaviour, by removing the incentives that make it individually rational; depending on the circumstances, this can be achieved by introducing, say, compulsory taxation schemes in a formal procedure, or by establishing social customs against such behaviour through informal means (Coleman 1990). Of course, in our case the reasoning works, so to speak, backwards: the fact that there is little social value attached to a norm against digital piracy contributes to explain why it is not felt as binding.

Conformism and attitudes towards piracy

Some sort of informal process like the ones described above might then lead to the establishment of a social norm that prescribes a "lenient" attitude towards the digital pirates. How might this work?[15]

Given an arbitrarily fixed norm (i.e. a value of k) determining y^* and thus identifying the three consumer types, we can partition the society in several groups, each with its view of what is the correct attitude towards digital piracy. The actual partition depends on the sign of q_k^m; we saw that the most relevant case is that in which $q_k^m > 0$. Then, we have that all ordinary pirates plus all legitimate users share the view that piracy should not be condemned, the former because this is the only way they can afford to consume the digital product, and

[15] The formation of the norm as modelled in this subsection is inspired by the "conformism game" developed by Balestrino (2007).

the latter because they perceive that piracy contributes to reduce the price they pay for their high-quality originals. The exact size of this group depends on the *status quo* norm. However, it arguably constitutes the absolute majority of the population, as sophisticate pirates are few by construction, and do not even constitute a group with a common view on the norm (there as many groups as there are income levels of sophisticate pirates, each with a different opinion).

The interaction between agents will then establish a society-wide level of the norm; a sophisticate pirate readily realizes that, outside the ring of his friends, there will be nobody prone to contain the boundaries of piracy. The sophisticate pirate might wish to argue that copying should be limited, but no matter whether he is facing an ordinary pirate or a legitimate buyer, he will be hit by a counter-argument in favour of illimitate piracy. The content of the counter-argument may vary, but what counts is that the vast majority of the population will back it by its words and deeds. The psychic cost of defending one's view, when everybody else is voicing another opinion and behaving openly in accordance with this opinion, is usually very large, and there will be little to do for the sophisticate pirate other than capitulate and conform (see our discussion above).

We can model social interaction very simply as a round of two-players bargaining games. One of the two players comes from the ranks of those who support a lenient attitute towards piracy ($k = 1$); the other is a sophisticate pirate. The object of the game for player i is to convince player j that his own view of the norm is the "correct" one (and viceversa for player j). There are in principle two possible outcomes: one of the agents might convince the other or they might continue to disagree. Each agent chooses between two options, that is: i) adopting the other's opinion ("agree") and ii) staying true to his original idea ("disagree"). The pay-off to "agree" is the utility derived from conforming to a norm which is not the preferred one, therefore less than the maximised utility. "Disagree" instead implies a cost due to the effect of conformism, that is a cost that depends on the difference in size between that two groups to which the agents belong: for simplicity we normalise to zero the cost for the agent from the larger group, and take the utility loss to be $g > 0$ for the agent from the smaller group. Suppose for example that the two players are a sophisticate pirate and a legitimate buyer and that the

latter moves first and proposes his own view;[16] the pay-off matrix will be:

σ's reaction	σ	$-\sigma$
agree	$v^{\sigma}\left(1, q^{m}; y\right)$	$v^{-\sigma}\left(1, q^{m}\right)$
disagree	$v^{\sigma}\left(k\left(y\right), q^{m}; y\right) - g$	$v^{-\sigma}\left(1, q^{m}\right)$

Since sophisticate pirates are a tiny fraction of the population, g will certainly be very large; "agree" will be the action giving them the higher pay-off. More precisely, whenever

$$g \geq v^{\sigma}\left(k\left(y\right), q^{m}; y\right) - v^{\sigma}\left(1, q^{m}; y\right), \tag{32}$$

the sophisticate pirate will switch sides.

Hence, provided that g is sufficiently large, after one round of social interaction, all agents will agree that $k = 1$ is the correct norm, and this becomes the social custom. Given $k = 1$, y^{*} is determined, and the three consumer types are identified for this level of the norm.[17]

5 Concluding remarks

Our formulation of the problem is consistent with the observation that social condemnation of digital piracy is not strongly felt. As long as most piracy is of the ordinary variety, which is probably a good description of the current state of affairs, the vast majority of agents are not opposed to it, and they do not act or talk against it. It is therefore clear that an anti-piracy social norm has no collective value.

It is of some interest to consider whether and how things could change if, sometime in the future, piracy becomes prevalently of the sophisticate variety (δ becomes larger and/or $\widetilde{y}$ becomes lower). As long as this causes the majority of the agents to have something to gain

[16] Of course the same reasoning holds if the sophisticate pirate faces an ordinary pirate. It is also easy to see that the outcome does not change if the sophisticate pirate moves first, as his opponent can refuse his offer at no cost, and then make his counterproposal.

[17] A more detailed approach would have been that of assuming a sequence of rounds in which the players are randomly matched, as in Balestrino (2007). One could then investigate how, round after round, the view that digital piracy should not be condemned spreads among the members the society, and let the sequence end when all agents share this opinion. In the context of the present model, this is however unnecessarily complicated. The fact that sophisticate pirates are a small fraction of the total population makes it estremely likely that the case described in the main text (in which all games see a sophisticate pirate facing either an ordinary pirate or a legitimate buyer) occurs early on, thereby determining the end of the sequence. We simplify by assuming that this specific round comes first.

from such a norm, a mechanism leading to the establishment of a social custom against piracy might possibly be activated. Suppose then that $q_k^m < 0$. This case is more difficult to deal with, because there are now two large groups, ordinary pirates ($k = 1$) and legitimate users ($k^{-\sigma} = k^+$) plus all the groups of sophisticate pirates with different incomes ($1 < k^\sigma(y) < k^+$); social interaction requires now more than one round of simultaneous two-player games. We discuss here a specific development which might, but not necessarily will, lead to a norm against piracy being imposed; the discussion has mostly a pedagogic value, in that it highlights the more or less plausible conditions that have to be satisfied for the establishment of such a norm.

Suppose that social interactions are stronger among agents who are similar in some relevant traits; in our context, this means agents with the same income (which we also used as a proxy for education). Thus, the first round of games could involve all possible pairs of sophisticate pirates and legitimate users within the same income groups; any agent without an opponent will stay idle (supposing that $\delta < 0.5$, these will be legitimate users). In these games, the legitimate users have a much larger group backing their position, since they all share the view that piracy should carry a strong social stigma; the sophisticate pirates have only agents in their own income group sharing exactly the same opinion. So, either the legitimate users bring the sophisticate pirates to accept their point of view, or the two stay of the same opinion as before. For a sufficiently high cost of disagreeing, all sophisticate pirates will switch sides. In this case, at the end of the first round of games, all agents with income above y^* see piracy as a particularly disreputable activity, $k = k^+$. There is then a second round of simultaneous games, with ordinary pirates on one side and either legitimate users or sophisticate pirates on the other (and possibly some idle agents). If the latter constitute a sufficiently large majority, then the social custom will be $k = k^+$, that is piracy will be socially stigmatised; otherwise the custom will be $k = 1$, that is piracy will be socially accepted.

An important corollary of the analysis is that sophisticate piracy is a self-containing activity. Once it reaches a critical mass, it produces the forces that keep itself at bay, and prevent it from swallowing the whole market for digital products. This is basically a reflection of the fact that sophisticate pirates need a pool of original products from which to fish out the ones they want to copy, and are interested in guaranteeing the availability of such products almost like the wholly legitimate buyers. They thus trade-off an increase in the stigma to which they can be subjected for making copies against an enlargement of the "reservoir" of originals. Moreover, the sophisticate pirates' reaction to variations in the strength of the social norm are key, as we saw,

for making the legitimate buyers aware of the dangers of an excessive enlargement of piracy, and transforming them in the most extreme advocates of the norm. The digital industry ambivalence towards the enlargement of the group of sophisticate pirates is thus perfectly understandable in this context: they may fear an immediate loss of revenue, but it is clear that in the long run this form of piracy can remain within functional limits, unlike the ordinary sort, and thus it may make more sense to try and appropriate revenue indirectly from the sophisticate pirates rather than running an endless, and costly, campaign to eradicate them.

Appendix

As mentioned in the main text, this section presents some details of the comparative statics analysis for the sophisticate pirates (for the other groups the derivation is immediate). The first order conditions are

$$U_z^\sigma = u'\gamma_z\left(z, n\left(y, y^*\left(k,t,q\right)\right)\right) - k = 0; \tag{A1}$$

$$U_\omega^\sigma = u' - q. \tag{A2}$$

It can be checked that the second order conditions are satisfied. We have that

$$U_{zz}^\sigma = u'\gamma_{zz} + u''\left(\gamma_z\right)^2 < 0; \tag{A3a}$$

$$U_{\omega\omega}^\sigma = u'' < 0; \tag{A3b}$$

$$U_{\omega z}^\sigma = U_{z\omega}^\sigma = u''\gamma_z < 0, \tag{A3c}$$

and therefore

$$|D| = U_{zz}^\sigma U_{\omega\omega}^\sigma - \left(U_{\omega z}^\sigma\right)^2 = u''u'\gamma_{zz} + \left(u''\gamma_z\right)^2 - \left(u''\gamma_z\right)^2 = u''u'\gamma_{zz} > 0, \tag{A4}$$

with the sign following from strict concavity of $u\left(\cdot\right)$ and $\gamma\left(\cdot\right)$. We can now compute (using that $\gamma_{zn} = 0$):

$$U_{zk}^\sigma = u''\gamma_n n_{y^*} y_k^* \gamma_z - 1 < 0; \tag{A5a}$$

$$U_{zt}^\sigma = u''\gamma_n n_{y^*} y_t^* \gamma_z < 0; \tag{A5b}$$

$$U_{zq}^\sigma = u''\gamma_n n_{y^*} y_q^* \gamma_z > 0; \tag{A5c}$$

$$U_{zy}^\sigma = u''\gamma_n n_y \gamma_z < 0, \tag{A5d}$$

and

$$U^{\sigma}_{\omega k} = u''\gamma_n n_{y^*} y^*_k < 0; \tag{A6a}$$

$$U^{\sigma}_{\omega t} = u''\gamma_n n_{y^*} y^*_t < 0; \tag{A6b}$$

$$U^{\sigma}_{\omega q} = u''\gamma_n n_{y^*} y^*_q - 1; \tag{A6c}$$

$$U^{\sigma}_{\omega y} = u''\gamma_n n_y < 0. \tag{A6d}$$

Note that $U^{\sigma}_{\omega q}$ is ambiguous; however, it makes sense to assume

$$U^{\sigma}_{\omega q} < 0, \tag{A7}$$

on grounds that $u''\gamma_z n_{y^*} y^*_q$ is a second-order effect. Also, note that

$$U^{\sigma}_{zk} = U^{\sigma}_{\omega k}\gamma_z - 1; \tag{A8a}$$

$$U^{\sigma}_{zt} = U^{\sigma}_{\omega t}\gamma_z < 0; \tag{A8b}$$

$$U^{\sigma}_{zy} = U_{\omega y}\gamma_z. \tag{A8c}$$

Now, straightforward applications of the Kramer's rule and the use of (A8) imply (after some manipulations) that

$$z^{\sigma}_k = \frac{-U^{\sigma}_{zk}U^{\sigma}_{\omega\omega} + U^{\sigma}_{\omega k}U^{\sigma}_{z\omega}}{|D|} = \frac{u''}{|D|} < 0; \tag{A9a}$$

$$z^{\sigma}_t = \frac{-U^{\sigma}_{zt}U^{\sigma}_{\omega\omega} + U^{\sigma}_{\omega t}U^{\sigma}_{z\omega}}{|D|} = 0; \tag{A9b}$$

$$z^{\sigma}_q = \frac{-U^{\sigma}_{zq}U^{\sigma}_{\omega\omega} + U^{\sigma}_{\omega q}U^{\sigma}_{z\omega}}{|D|} > 0; \tag{A9c}$$

$$z^{\sigma}_y = \frac{-U^{\sigma}_{zy}U^{\sigma}_{\omega\omega} + U^{\sigma}_{\omega y}U^{\sigma}_{z\omega}}{|D|} = 0; \tag{A9d}$$

and

$$\omega^{\sigma}_k = \frac{-U^{\sigma}_{zz}U^{\sigma}_{\omega k} + U^{\sigma}_{zk}U^{\sigma}_{z\omega}}{|D|}; \tag{A10a}$$

$$\omega^{\sigma}_t = \frac{-U^{\sigma}_{zz}U^{\sigma}_{\omega t} + U^{\sigma}_{zt}U^{\sigma}_{z\omega}}{|D|} = \frac{-u'\gamma_{zz}U^{\sigma}_{\omega t}}{|D|} < 0; \tag{A10b}$$

$$\omega^{\sigma}_q = \frac{-U^{\sigma}_{zz}U^{\sigma}_{\omega q} + U^{\sigma}_{zq}U^{\sigma}_{z\omega}}{|D|} < 0; \tag{A10c}$$

$$\omega^{\sigma}_y = \frac{-U^{\sigma}_{zz}U^{\sigma}_{\omega y} + U^{\sigma}_{zy}U^{\sigma}_{z\omega}}{|D|} = \frac{-u'\gamma_{zz}U_{\omega y}}{|D|} < 0, \tag{A10d}$$

where the signs follow from the strict concavity of $u(\cdot)$ and $\gamma(\cdot)$, and from (A3), (A5) and (A7). These are the results given in the text as (10) and (11). It is clear from the derivation the role

of what we called the direct and indirect effects in determining the signs of the comparative statics.

In the main text, we discussed at some length the sign of (A10a). The formal analysis here indicates that $U^{\sigma}_{zz} < 0$ and $U^{\sigma}_{z\omega} < 0$ by (A3), and that $U^{\sigma}_{zk} < 0$ by (A5); moreover, we see from (A6) that $U^{\sigma}_{\omega k} < 0$. Then, if

$$|U^{\sigma}_{\omega k}| > \left| \frac{U^{\sigma}_{zk} U^{\sigma}_{z\omega}}{U^{\sigma}_{zz}} \right| \tag{A11}$$

(A10a) will be negative; otherwise, it will be positive.

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