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Piracy on the Internet: Accommodate it or fight it? A dynamic approach

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ABSTRACT

This paper uses a dynamic stochastic model to solve for the optimal pricing policy of music recordings in the presence of P2P file-sharing networks eroding their sales. We employ a policy iteration algorithm on a discretized state space to numerically compute the optimal pricing policy. The realistically calibrated model reflects the real-world figures we observe and provides estimates of the optimal pricing policy as well as comparative statics figures. The pricing policy is such that, for a given P2P network size, prices are increasing in the number of buyers of the product and, for a given number of buyers of the product, prices are non-monotonic in the P2P network size. Surprisingly, in the presence of P2P networks, increases in production costs and decreases in the valuation of the product increase the consumer and total surplus. A higher valuation of the product leads to a lower steady state price. Increased switching costs have a negative effect on prices and profits, so the long term incentive to attract new consumers dominates the short term incentive to harvest loyal consumers. The full enforcement of intellectual property rights has adverse effect on both consumer surplus and total welfare.

1. Introduction

Ever since Napster emerged in 1999, P2P (peer-to-peer) file-sharing networks have been the center of piracy on the Internet. We have seen different generations of P2P technology come and go thanks to the legal pursuits launched by various authorities and interest groups alike and the development of new technologies that help evade them. The content providers try to defend their creations from free riding; whilst the online communities try to preserve the true free and sharing spirit of the Internet. The battle goes on and on, but we cannot ignore the impact it has had on the markets of information goods, particularly the music industry.

Numerous studies, especially empirical ones, over the years have tried to explain the relationship between the decline in music sales and the rise of P2P networks. Blackburn (2004), Liebowitz (2004), Rob and Waldfogel (2006), and Zentner (2006) find that downloading (via P2P file-sharing networks) is at least partially responsible for the decrease in music sales. Liebowitz (2006) concludes that file-sharing has clearly brought significant harm to the recording industry. In contrast, Oberholzer-Gee and Strumpf (2007) and Peitz and Waelbroeck (2004) find little robust evidence that P2P has caused the decrease in music sales.

The classical theoretical literature on piracy and network effects include, among others, Economides (1996), Katz and Shapiro (1985), Katz and Shapiro (1986), Johnson (1985), and Takeyama (1994). Recent papers that study P2P in specific include, among others, Gayer and Shy (2003), Sundararajan (2004), Bae and Choi (2006), Peitz and Waelbroeck (2006), Herings, Peeters, and Yang (2010), Dewan and Ramaprasad (2014), Chang and Walter (2015), and Zhang (2017).

Gayer and Shy (2003) show how publishers of digitally-stored products, including music, can utilize P2P to enhance sales of their product sold in the store or online. This result is mainly attributable to the positive consumptive externality ingredient in their model. Sundararajan (2004) addresses the issue of optimal digital rights management systems in markets with digital piracy. Using a sample comprising 5864 albums from 634 artists sold in the years 1992–2011, Zhang (2017) shows that the effect of digital rights management on sales highly depends on the album's age and position on the sales distribution, with new popular albums suffering and older niche or unpopular albums benefitting from a removal of digital rights management. Peitz and Waelbroeck (2006) show that under sufficient taste heterogeneity and product diversity, the positive effect of downloading on

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sales due to sampling may compensate the direct negative effect. This result is mainly driven by the information asymmetry between the buyers and the sellers of the product, and downloaded files can help buyers identify their favorite products more easily and hence encourage sales. A recent empirical investigation on the impacts of social media on music sales is provided by Dewan and Ramaprasad (2014). Herings et al. (2010) analyzes the different market structures that may form. The paper concludes that, depending on different circumstances, the firm will employ pricing strategies either to deter the entry of a network or to accommodate it. Moreover, music industry profits decrease when the generic cost factor of downloading declines, i.e. when the society is more downloader-friendly, whereas total welfare increases. Chang and Walter (2015) extends the analysis of Herings et al. (2010) by making the investment by the P2P network to improve the quality and accessibility of the information goods an endogenous variable.

All the theoretical studies on this subject have been of a static nature. This implies that in the presence of demand side externalities there may be multiple equilibria due to coordination issues related to network size. The literature has always focused on the maximally achievable network size. However, these models lack insights on how such networks actually form, step by step, from zero to a steady-state network size; how the firm prices strategically to compete with the network every step of the way; and how society is affected during the process. This makes it impossible for such models to address the dynamic development of the P2P network as we see it in reality.

Only a dynamic model can bring such insights, which is what this paper is designed to achieve. Dynamic stochastic models with network externalities have been recently studied in the industrial organization literature, mainly using numerical methods. Examples are Markovich (2008) and Markovich and Moenius (2009) which study the dynamics caused by the iterations between hardware and software; Jenkins, Liu, Matzkin, and Mc (2004) studies a stylized version of the browser war between Netscape and Microsoft, where the entrant may have "grabbed" market shares from the incumbent and thereby tipped the market; Chen, Doraszelski, and Harrington (2009) studies competing firms' incentives to make their products compatible and the possible effects that may prevent market dominance; and Arie and Grieco (2014) investigate the effect of switching costs on market dominance and equilibrium prices. A framework for numerically analyzing dynamic interactions in imperfectly competitive industries is proposed by Doraszelski and Pakes (2007), which provides an excellent summary of the main approach for models of this kind. Doraszelski and Satterthwaite (2010) show how this class of models can be formulated to ensure the existence of a computationally tractable Markov-perfect equilibrium.

In this paper, we use a dynamic model to solve for the optimal pricing policy of a firm that releases music products while being exposed to a competing P2P file-sharing network on the Internet. In the model, there is a firm who sets the price of its music product every period and a continuum of consumers who decide whether to make a legal purchase of the music product, to download the music from P2P, or to not acquire the music at all. The timing involves discrete periods with infinite horizon. The firm is forward looking and strives to maximize the present value of all future profits by choosing a state-dependent pricing policy; the state being the shares of legal sales, the P2P network, and the unserved market. The consumers make one of the three choices in order to maximize their utility while taking into account the price and the state. Consumers are *ex ante* identical, but receive random utility shocks prior to their purchasing decision every period anew. Switching costs are imposed on the consumers who switch to a product, from previously consuming the other product or not consuming at all. The firm's optimal pricing policy is derived numerically and provides insight in the market share dynamics.

Other work on the optimal pricing policy of a firm selling information goods while dealing with piracy has been done by Khouja and Smith (2007) and Waters (2015). In these papers, the emphasis is on the sales of a single product with a limited life time and the use of skimming strategies to maximize the firm's profit by first selling the legal product to consumers with high valuations for it. Piracy is modeled by assuming that some multiple of legal sales will lead to illegal sales. This reduces demand for the legal product, since consumers buy only once. In our model, the demand for the legal product renews in every period and the extent of piracy is endogenously determined as a consequence of consumers' choices.

To illustrate our model, we have calibrated its parameters to real-world data. To do so, we use data from the period between 1999 and 2007. The year 1999 has been chosen as the starting point of appearance of illegal P2P networks since, as argued in Waldfogel (2010), in 1999 the appearance of Napster made it convenient for consumers to download music illegally from P2P networks. According to the RIAA (2009) year-end report, the year 2007 is the last year in which legal downloads and streaming of music were not very significant yet and the main revenues for music companies were coming from physical CD sales. Although our model is by no means restricted to the legal music sales taking the form of CDs, it would be unreasonable to assume that the model's parameter values are the same before and after 2007.

Although we calibrate the model to data coming from the period 1999–2007, it is by no means the case that new technological developments like legal downloads, streaming services, or Internet radio have eliminated piracy after 2007. For instance, the report (MUSO, 2017) of the content protection company MUSO recently revealed data showing that during 2016, 191 billion visits to piracy websites were made globally, out of which 34.2 billion were visits to music piracy sites. This represents a modest decline of 6% compared to music piracy in 2015. Although by now web streaming sites are the most popular method for consuming illegal content, public torrent sites are still the second most popular method for doing so. As IFPI (2017) puts it: "Protecting music from being illegally distributed – and therefore undermining the recovering legitimate music market – remains a key priority for the industry."

Switching costs turn out to be quite important to match the development of the real-world data during 1999–2007. We use calibration to estimate the value of switching costs to be equal to $12. We think of a significant part of these switching costs as being mental costs of switching and time needed to evaluate a change in behavior. Indeed, there is a substantial empirical literature suggesting a status quo bias. Values for switching costs as found in the empirical literature for a wide spectrum of applications are well in line with the value found for our application. To give some examples, Shy (2002) examines the Israeli mobile phone industry and finds switching costs equal to $269 on average. In the Finnish demand-deposit banking industry, he finds average switching costs equal to $331. Shcherbakov (2009) estimates switching costs in the paid TV industry to be $109 for cable subscribers and $186 for satellite subscribers. Just to give an example from a market that does not have any kind of technologically determined lock-in effects, Shum (2004) estimates the average switching costs for breakfast cereals to be $4.33. For a nice survey of recent empirical work that estimates the size of switching costs in a variety of markets, we refer to Arie and Grieco (2014).

An interesting point of our approach is that we can study how networks develop in a dynamic process without having to make any assumptions on consumer coordination as in the conventional

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