



Peer-to-Peer File Sharing: The Case of the Music Recording Industry

PETER J. ALEXANDER*

Federal Communications Commission, Washington, D.C., 20554, U.S.A.

E-mail: palexand@fcc.gov

Abstract. The music recording industry is a highly-concentrated five firm oligopoly. Much of the dominance achieved by larger firms in the industry results from control over the distribution and promotion of the products of the industry. Alexander (1994b), predicted that new compression routines would facilitate the efficient transfer of digital music across the internet. MP3 compression routines have made such transfers relatively simple and efficient. While smaller new entrants have not yet been able to exploit this new technology in terms of market share, an element of uncertainty exists regarding the sustainability of the prevailing structure, due to large scale non-sanctioned file sharing. Despite the industry's legal efforts to suppress non-sanctioned file distribution, peer-to-peer networks may render these efforts futile. However, peer-to-peer networks must overcome structural and institutional problems, in particular, free-riding.

Key words: Digital file sharing, free riding, MP3, music industry, Napster, SDMI.

I. Introduction

In this paper, we explore the relationship between digital distribution and market structure in the music recording industry. While standard theory predicts that new technology generates increasing scale and hence increased concentration, there are salient anomalies that have emerged, especially in the arena of electronic commerce. Such is the case with the music recording industry. In fact, new digital distribution technologies threaten to undermine the prevailing structure of the industry by facilitating the free exchange of digital music files between consumers with computers and internet connections (Alexander, 1994b).

The industry has responded to large-scale organized digital file sharing by taking legal action against the most prominent and sizable digital file distributors, notably MP3.com and Napster.com, and has received some legal relief. For example, MP3.com was found liable in U.S. District Court for infringing the

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copyrights of the Recording Industry Association of America (RIAA).¹ Moreover, a federal judge rejected Napster's contention that it is protected by the digital copyright law² and issued a preliminary injunction requiring Napster.com to stop distributing copyrighted materials. While these remedies provide some relief in the shortrun (MP3.com removed all major label content from its online database before settling with four of the five major record distributors), it is becoming obvious that the established business model in the industry may indeed have a relatively short life span.

This is so, in part, because even newer distribution technologies pose a greater potential threat to the prevailing industry structure. MP3.com and Napster.com both rely on a series of central servers to facilitate distribution of music files. This made it possible to target these firms and obtain specific legal relief. However, a new generation of software that does not rely on central servers is emerging. These new products, among them Gnutella and Freenet, utilize a decentralized pure peer-to-peer distribution network in which each user of the system is a stand alone client and a host. That is to say, each user can both receive files from others, and can give files to others, without the intermediation of a central server. Importantly, these systems facilitate the exchange of a wide variety of file types or formats, so that users can exchange any type of digitized products. This clearly has implications for other industries, including motion pictures. However, in the case of Gnutella and Freenet, free-rider and scalability issues may attenuate, at least in the shortrun, their use as large-scale venues for digital distribution.

This paper is organized as follows. In Section II, we give a brief historical overview of the music recording industry. In Section III, we explore new digital compression technologies, and discuss how they have substantially reduced the costs of reproduction and distribution in the industry. In Section IV, we explore the legal issues associated with the new technologies, in particular the lawsuits involving MP3.com and Napster.com. In Section V, we examine the possibility that an emergent decentralized digital file distribution system may be significantly diminished by a potential free-rider problem.

II. A Brief History of the Music Recording Industry

The music recording industry is approximately one hundred years old. In its infancy, the industry was dominated by a handful of firms who were responsible for the production of most of the industry's technological advancements (Alexander, 1994a, b). These early innovators fought to establish dominance over the way music would be produced and played. The earliest systems used wax cylinders on which sound waves were scribed. This original industry standard was overtaken

¹ "Judge Finds against MP3.com in Copyright Infringement Case", Larry Neumeister, Associated Press, 4/28/00.

² "Napster Set Back in Copyright Lawsuit by Music Industry", Ron Harris, Associated Press, 5/09/00.

around 1914 by flat disks, the manufacture of which was less costly per unit than wax cylinders. This change in standard led to increasing but still modest levels of competition in the industry (Alexander, 1994a, b).

Real competition in the industry would arise in the 1950s with the advent of magnetic tape recording. Magnetic tape was easy to edit (unlike recording technology prior to the development of tape), and the recording devices themselves were inexpensive to purchase. Moreover, the introduction of magnetic tape production technology coincided with the popular introduction of a genre of music generally known as rock-and-roll. During this period, concentration in the industry fell dramatically, and the number of new firms increased rapidly. Re-concentration in the industry resulted from numerous mergers and acquisitions, which, in part, left the network for independent distribution thin (Black and Greer, 1987; Alexander, 1994a, b). Currently, just five large multi-national firms account for approximately 95% of the (distributor level) sales in the music recording industry.

III. Digital Technologies and Decreasing Costs

Prior to digital technology, music was produced and distributed using vinyl disks and magnetically encoded tape. Compact disks, introduced to consumers in the 1980s, were the first element in the industry's shift to digital technology. A compact disk player uses a sequence of 0's and 1's to reproduce sound waves. As a result, many consumers were able to use computers to play compact disks, as well as transfer songs from compact disks for storage and replay on their computers. Still, the files were generally not shared with large numbers of other users, since, as late as 1997, the transfer of three minutes of music required fifty megabytes of hard drive storage space and an enormous amount of time and bandwidth to transfer them across the internet.

Development of the MP3 file format dramatically changed these storage and bandwidth requirements. MP3, created by engineers at the German company Fraunhofer Gesellschaft, is short-hand for Motion Picture Experts Group-Layer 3. MP3 is an audio compression format that generates near compact disk quality sound at approximately 1/10 to 1/20 the size. For example, while each minute of music on a compact disk requires the equivalent of 10 megabytes of computer storage space, an MP3 format of the same piece could be stored on 1 megabyte or less. MP3 achieves this reduction in overall file size in two ways: (1) discrete sampling of continuous sounds waves, and (2) passing the resulting samples through high and low band filters. To give a practical example of the compression savings achieved by MP3, consider that Elvis Presley's "Hound Dog" on compact disk requires 24 megabytes of hard disk space, but when converted to MP3 the storage requirement falls to 2 megabytes.

On a 28.8 kilobit per second modem, the compact disk version of "Hound Dog" would take at least one and one-half hours to download from another computer. On the other hand, if the file were first converted to MP3, it would take approximately

eight and one-half minutes. Clearly, MP3 technology has made digital file distribution more efficient. This increased efficiency is amplified by the fact that more and more computers are connecting to the internet via cable rather than modem, which significantly improves the speed at which files can be transferred.

The transition from analog to digital production and reproduction has had a potentially significant effect on costs within the industry. With digital products the cost of reproducing and distributing perfect copies is functionally zero. Unlike the case where the tape player made production cheaper but did not alter the costs of distribution, digital technology has reduced both reproduction and distribution costs.

IV. Technology, Copyrights, and Recent Lawsuits

Firms in the music recording industry, as well as firms in other culture-based industries such as motion pictures, have traditionally preferred technological stability, but have ultimately benefited from technological change.³ For example, radio was 'threatened' by television, television by motion pictures, motion pictures by video cassette players, music recording by tape technology and so on. In each of the examples, predictions of the imminent demise of the industry as a result of a new technology were wrong. In most instances, the new technologies displayed strong complementarities within the existing structure.

The Sony case is illuminating in this context.⁴ Sony produced the first widely-available home video cassette recorders. Shortly after these products were introduced, the television and motion picture industry charged that Sony's Betamax would be used to reproduce their products, thus inducing substantial economic harm. In a 5-4 decision, the Supreme Court found that the plaintiffs failed to show that the defendant's product would cause any likelihood of non-minimal harm. In fact, the court concluded, the Sony Betamax home video recorder was capable of substantial non-infringing uses, and thus its sale did not constitute contributory infringement. Importantly, the video cassette recorder has substantially contributed to the profitability of the motion picture industry.

The general contours of the music recording industry's lawsuits against MP3.com and Napster.com are analogous in certain aspects to the Sony case. However, unlike the Sony case, in *UMG Recording, Inc. et al. v. MP3.com, Inc.* (United States District Court, Southern District of New York), United States District Court Judge Jed S. Rakoff concluded that "defendant's infringement of plaintiffs' copy-

³ According to Patricia Zimmermann, "There is a mythology about Hollywood: that it is technophobic and sees any technological innovation ... as a market threat" [Sam Costello, 7/26/00, www.cnn.com]. Consider however (one of many) statements like that of Jack Valenti, president of the Motion Picture Association of America (MPAA) regarding the Sony Betamax: "The VCR is to the American film producer as the Boston Strangler is to the woman alone" [Ibid].

⁴ *Sony Corporation of America v. Universal City Studios, Inc.*, Supreme Court of the United States, argued Jan. 18, 1983.

rights is clear” (p. 1, 00 Civ. 472). During the case, MP3.com argued that its repository of legally purchased copyrighted material, which it distributed to registered users, was protected by “fair use”. However, Judge Rakoff concluded that the “defendant’s ‘fair use’ defense is indefensible and must be denied as a matter of law” (p. 9, 00 Civ. 472).

In the Napster.com case, United States District Judge Marilyn Hall Patel refused a motion by Napster.com to dismiss the lawsuit against them, ruling that Napster.com was not entitled to “safe harbor” status as provided in the Digital Millennium Copyright Act (DMCA) of 1998 (Section 512 (a)).⁵ The safe harbor provisions of the DMCA were established to protect internet service providers from liability and court-issued injunctions regardless of their knowledge, in the case that users of the service committed illegal actions. Judge Patel subsequently issued a preliminary injunction against Napster.com, ordering them to stop distributing copyrighted materials.⁶

How damaging is this digital file sharing activity? The RIAA asked the court to enjoin Napster.com because “Napster is causing irreparable harm to plaintiffs and the entire music industry”.⁷ In their motion, the RIAA presented a study conducted by the Field Research Corporation that suggested that the use of Napster displaces compact disk sales.⁸ According to Lee Rainie, Director of the Pew Internet Project, technologies like Napster are “a huge threat to the music industry and a harbinger of the trouble the internet will pose to other entertainment forms like the movies”.⁹

However, it is not clear what level of material harm the industry suffers from these activities. A survey by Jupiter Communications found that Napster users are 45% more likely to increase their purchases of prerecorded music than those who do not use the service.¹⁰ Further, a study by Reciprocal Inc. showed that while sales of recorded music fell by 4% near college campuses over the past year, sales at 67 colleges that had banned Napster fell by 7%.¹¹ Moreover, the dollar value of compact disk sales grew by 9.9% over the first two quarters of 2000.¹² Finally, U.S. District Court Judge Jed S. Rakoff, in establishing damages in the MP3.com case noted that:

The size and scope of defendant’s copyright infringement was very large and the potential for harm was similarly large. But on the other hand, plaintiffs have made not any attempt at this trial to prove actual damages they may have

⁵ “Napster Set Back in Copyright Lawsuit by Music Industry”, Ron Harris, Associated Press, www.digitalmass.com, 5/09/00.

⁶ “Judge Orders Napster to Halt Online Music Distribution”, www.cnn.com; 7/26/00.

⁷ “Napster Faces Injunction”, Reuters, www.cnnfn.com, 6/13/00.

⁸ Ibid.

⁹ “Survey: 13 Million Americans Have Downloaded Music for Free”, www.cnn.com, 6/9/00.

¹⁰ “Court Showdown in Suit Against Napster”, Ron Harris, Associated Press, 7/25/00.

¹¹ Music Industry Says Downloaded Music Hurts Record Sales”, www.cnn.com, 5/25/00.

¹² “Napster Isn’t Affecting CD Sales”, Reuters, www.zdnet.com, 8/28/00.

suffered. The court views the absence of any proof of actual damages as a mitigating factor favorable to the defendant.¹³

V. Digital Distribution Systems

MP3.com and Napster.com share many common features, the most important of which may be that as distribution systems they rely on a series of central servers to guide the distribution of digital products. So, for example, if a user of either system sends out a request for a file, the request is routed through one of their servers. Because requests for information relating to the location of MP3 files are routed through their servers, and because a federal judge has ruled such activity in violation of existing copyright law, companies like MP3.com and Napster.com are obvious targets for legal remedy.

More insidious, at least from the perspective of the major firms in the music recording industry, are decentralized systems that do not rely on a centralized server. In this section we explore two such systems, Gnutella and Freenet. First, we examine the distinction between centralized and decentralized server systems, and then we explore a potential free-rider problem in the context of peer-to-peer systems. It is precisely this potential free-rider problem that may support the music recording industry's goal of significantly diminishing non-sanctioned digital distribution.

The architecture of distribution systems like MP3.com and Napster.com are structured around a series of centralized servers that direct electronic traffic and rout requests for files. In the case of MP3.com, the servers hold and also distribute the files. On the other hand, Napster presents a list of sites where a file is hosted, and the choice of site is left to the client. In contrast, newer distribution systems, such as Gnutella (and its clones) and Freenet are decentralized, and do not utilize a central server. Thus, the type of legal remedies currently utilized by the firms in the music recording industry against Napster and MP3.com will be far less effective on a cost basis against Gnutella or Freenet users.

Each individual computer that has the Gnutella or Freenet software installed on it becomes a server via a continuous series of pure peer-to-peer connections. So, for example, if one machine has the required software and internet connection, it can connect with another machine, which itself is connected to another machine, and so on. This decentralized one-to-one or pure peer-to-peer structure is precisely what makes these systems a threat to firms in the music recording industry. The lack of centralized servers means that there are few, if any, reasonable targets for litigation.

Moreover, tracing the users of the Gnutella system is difficult. While users are only pseudo-anonymous on the system and hence can conceivably be traced, the

¹³ "U.S. District Court for the Southern District of New York, Judge Jed S. Rakoff's Ruling in the MP3.com case, Unofficial Version", www.nylj.com, 9/6/00.

general use of dynamic rather than static IP addresses means that every time a user logs on the system they are assigned a new address, thus rendering traces less useful. Perhaps more importantly, Freenet users are simply impossible to trace, which precludes detection and the potential for subsequent litigation.

What then, is the future for the major firms in the music recording industry? The answer has at least several elements, one of which was hinted at above: it is not obvious that sharing music files over the internet has thus far had an adverse effect on sales. Moreover, firms may be able to encrypt their products, rendering sharing impossible. Finally, it is not clear whether pure peer-to-peer digital distribution systems can overcome the free-rider problem common to many public goods.

As we noted in Section IV, there is insufficient evidence to support the proposition that MP3.com and Napster have had a significant negative effect on the profitability of firms in the industry. For example, the claim that Napster is causing irreparable harm to the entire music industry is apparently contradicted by the fact that compact disk sales in the industry increased by 9.9% in the first two quarters of 2000. In fact, Offspring, a popular group under contract with Sony, decided to put their newest material on the internet for free release. Although Sony ultimately disallowed this move, Offspring stated that releasing their product over the internet helps them get to better know their customers. Thus, a plausible scenario is that the internet supplements radio and television as a means to inform consumers and generate publicity for the firms in the industry.¹⁴

Can the firms in the industry use encryption to protect their products? There have been numerous attempts by firms in the music recording industry, as well as software producers, to encrypt their products over the past fifteen years. The vast majority of protection schemes have failed. According to Gene Kan, a software programmer (and creator of Gnutella) who provided testimony to the Senate Judiciary Committee:

Protection schemes seldom work. Encryption for Microsoft WMA format files was broken almost immediately after its release. The process was incredibly simple. One would purchase the right to listen to the encrypted audio file (and then) play it back through special software which records the decrypted audio file, and mission accomplished. You now have on your hard disk a permanently decrypted audio file.

Kan goes on to say that:

SDMI, or the Secure Digital Music Initiative, is what many record companies are betting on to preserve their control over music distribution.¹⁵ My suspicion

¹⁴ It was reported in testimony before the Senate Judiciary Committee that firms in the industry were selectively "leaking" MP3s of new songs to Napster. Testimony of Gene Kan, Before the Senate Judiciary Committee, Remarks Prepared for Delivery, 7/11/00.

¹⁵ In September 2000, the backers of SDMI issued a public challenge, asking that "contestants" attempt to break the SDMI encoding techniques. Edward Felton, a professor in the Department of Computer Science at Princeton University and a group of colleagues were able to easily defeat the system. The results of their efforts can be found at <http://www.theregister.co.uk/extra/sdmiattack.htm>.

is that people in significant numbers will choose to re-encode SDMI into MP3, or some other freely distributable format. In fact if even a few people re-encode and distribute a song, the fluidity of information-sharing communities will ensure its rapid and extensive duplication. The only way to make music that cannot be copied is to make music that cannot be heard.

Let us assume, for sake of example, that non-sanctioned file sharing using systems like Gnutella or Freenet would ultimately erode industry structure or profitability. The important question then becomes one of whether file sharing, on a peer-to-peer basis, is in fact sustainable. We assume that the sustainability of a peer-to-peer sharing system is contingent upon whether users will be willing to share their resources with others, at a cost to themselves. In fact, each peer who acts as a host yields some bandwidth and computing resources to the client, i.e., incurs some cost. Will users be willing to yield some of their scarce resources to support the peer-to-peer network?

Standard public goods theory predicts that all agents will free ride, or, as Mancur Olsen (1965) states, “rational, self-interested individuals will not act to achieve their common or group interests” (p. 2). However, a significant body of theory and experimental evidence exists relating to public goods games and experiments, much of which appears to contradict the predictions of standard theory. Of course while it is plausible that some experiments fail to capture important elements of “real” economic interactions, the substantial diversity and variety of settings and experiments would appear to militate against a systematic bias in the results (Ostrom, 2000).

So, what might explain the enormous success of a server mediated peer-to-peer file sharing system like the Napster Music Community, given that it is analogous to a toll highway without tollbooths?¹⁶ Why would large numbers of anonymous computer users contribute to the well-being of others they have never met and never will meet? Clearly, as Gintis (2000) suggests, “human groups maintain a high level of sociality despite a low level of relatedness among group members (p. 1)”. The question is of course, why? As an illustration of why one might expect the Napster Music Community to fail, consider the following very simple example. Assume that we have a system of ten linked computers in a reciprocal peer-to-peer relationship. Assume further that one peer decides to circumscribe access to their resources, i.e., they do not make their files available to their peers, and instead they free ride. This leaves nine hosts and ten clients. The removal of one host has the effect of increasing the cost (i.e., decreasing the available bandwidth) to the remaining nine cooperators. The increased cost, in conjunction with the diminished benefits, leaves everyone except, we assume, the defector unambiguously worse off. If we imagine subsequent stages, they would be part of a simple, iterative

¹⁶ Many of the peer-to-peer file sharing systems (strictly) enforce sharing through a variety of technological means that are embedded in the file sharing software.

process whereby each peer defects until the system collapses. The simple Nash equilibrium of a peer-to-peer network predicts a collapse of the network.

It is unlikely that repeating this particular game would yield a cooperative equilibrium, for several reasons. First, unless the game is infinitely repeated, end-period defection may possibly lead to an unravelling of cooperation. This may be especially the case where the game is played a relatively few times, and the players are aware of the finite nature of the game. In fact, while there are many conditions (alone or in some combination) that may induce and stabilize cooperation (e.g., fewness of numbers, altruism, the capacity to identify and punish defectors, sufficiently low discount rates, sufficiently high continuation probabilities), a cooperative equilibrium is still difficult to achieve and sustain. It seems reasonable to assume that the very large number of anonymous users (upwards of 60 million) of the Napster Music Community (or any other peer-to-peer file sharing relationship) would pose a significant additional impediment to cooperation.

Why then does the Napster Music Community continue to thrive? Cunningham, Alexander, and Adilov (2001) explore peer-to-peer file sharing and construct a non-linear dynamic optimization model consistent with observed facts regarding the Napster Music Community. The model they present is in the spirit of Becker (1976), in that the aggregate population has initially a positive (but not necessarily large) fraction of altruists. The remaining agents may be purely self-interested - in fact, the equilibrium of the model relies on the assumption of self-interest.

Cunningham et al. (2001) begin by assuming that file sharing is costly when measured in terms of bandwidth. Thus, there are positive bandwidth costs (measured in utility units) associated with uploading (sharing) and downloading (receiving) MP3 files. The costs of downloading (γ_d) are assumed linear and decreasing in the aggregate number of available files (M), since an increase in the number of available files decreases search and congestion costs. In addition, they assume that aggregate sharing (S) is a strictly concave function of individual sharing, $S(s_i)$ (although the results of the model are robust if this specification is inverted, i.e., $s_i(S)$). Given this framework, they are able to demonstrate that sharing is a steady-state of the model. In essence, Cunningham et al. model an environment where sharing emerges endogenously as an equilibrium because sharing is cost-reducing in terms of own-bandwidth, a result that emerges because users are self-interested maximizers. Interestingly, in Cunningham's model, if downloading costs increase proportionally for all levels of sharing due to some exogenous shock (for example, the closing of the Napster Music Community), aggregate sharing actually increases as users share more to decrease the increased level of sharing cost. Thus, the strategy by the music recording industry to shut down the Napster Music Community might actually lead to an increase in overall sharing, granted via peer-to-peer file sharing venues other than the Napster Music Community.

These general results are rather interesting when taken in the context of standard public goods theory: given an extremely large, anonymous population with a small

handful of altruists, self-interested behavior is sufficient to generate a sustained cooperative outcome.

What does this imply for the major firms in the music recording industry? It suggests that the music recording industry's injunctive relief against the Napster Music Community will likely be a short-lived victory, for several reasons. First, the Napster Music Community could move its servers to an off-shore location not bound by US copyright law, and continue operating much as the network has in the past. Second, the Napster Music Community server software has been pirated and widely distributed. There currently exist a series of "underground" Napster servers, and many more may arise if the formal Napster Music Community stops operations. Third, as we have just explored in this section, peer-to-peer file sharing arrangements appear to function quite smoothly, despite the rather dire predictions of standard public goods theory. A wide variety of pure peer-to-peer file sharing software systems are currently available (e.g., Gnutella, BearShare, Freenet), and are growing in usage and sophistication. Moreover, these file sharing systems will likely be far more costly for the music recording industry to combat, since they do not rely on easily identified central servers. In fact, to the extent that the major firms in the music recording industry pursues legal remedies against firms like Napster and file sharing becomes more decentralized, it becomes progressively more costly for the firms in the industry to counteract file sharing through legal mechanisms.

Given the broad empirical evidence that peer-to-peer file sharing systems are sustainable and becoming more sophisticated, it is likely that the major firms in the music recording industry will continue to face significant difficulties in controlling the reproduction and distribution of their products. However, the potential impact of peer-to-peer file sharing on market structure is ambiguous, and it is not clear as an empirical matter that digital file sharing has a negative impact on industry sales. Moreover, small firms and new entrants have not yet been able to use new digital distribution technology to gain a significant share of the market, although they may be able to exploit this technology more effectively over time.

VI. Concluding Remarks

The music recording industry is a highly-concentrated five firm oligopoly, where the major firms account for approximately 95% of sales when measured at the distributor level. Much of the dominance achieved by larger firms in the industry results from their control over the distribution and promotion of the products of the industry. Alexander (1994b), predicted that new compression routines would facilitate the efficient transfer of music across the internet. In fact, MP3 compression routines have made such transfers simple and efficient compared to older technology.

While smaller new entrants have not up to this point been able to exploit this new technology in terms of market share, an element of uncertainty exists regarding the sustainability of the prevailing structure. Despite the industry's efforts to

suppress non-sanctioned digital file sharing, these efforts have largely been futile. If peer-to-peer file sharing systems are stable, significant structural change in the industry is increasingly possible.

References

- Alexander, Peter J. (1994a) 'Entry Barriers, Release Behavior, and Multiproduct Firms in the Music Recording Industry'. *Review of Industrial Organization*, **9**, 85–98.
- Alexander, Peter J. (1994b) 'New Technology and Market Structure: Evidence from the Music Recording Industry'. *Journal of Cultural Economics*, **18**, 113–123.
- Becker, Gary (1976) 'Altruism, Egoism, and Genetic Fitness: Economics and Sociobiology'. *Journal of Economic Literature*, **14**, 817–826.
- Black, Michael, and Douglas Greer (1987) 'Concentration and Non-Price Competition in the Music Recording Industry'. *Review of Industrial Organization*, **3**, 13–37.
- Cunningham, Brendan M., Peter J. Alexander, and Nodir Adilov (2001) 'The Napster Music Community'. Working paper.
- Gintis, Herbert (forthcoming) 'Strong Reciprocity and Human Sociality'. *Journal of Theoretical Biology*.
- Ledyard, John (1995) 'Public Goods: A Survey of Experimental Research', in Alvin Roth and John Kagel, eds., *Handbook of Experimental Economics*. Princeton University Press.
- Olson, Mancur (1965) *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA: Harvard University Press.
- Ostrom, Elinor (2000) 'Collective Action and the Evolution of Social Norms'. *Journal of Economic Perspectives*, **14**, 137–158.