THE INCENTIVES FOR CONTRIBUTING DIGITAL CONTENTS OVER P2P NETWORKS: AN EMPIRICAL INVESTIGATION

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ABSTRACT. In this paper, we examine the determinants of sharing behaviour by envisaging two types of behaviour, namely contribution against free riding. In doing so, we evaluate the theoretical predictions about reciprocity and altruism in the presence of non-rival goods and anonymity. We use a probit model and primary data from a survey that collects information about P2P sharing behaviour of more than 2000 individuals. Our econometric results suggest that the motivations for contributing are poorly determined by rational self-interested behaviour. We then envisage policy implications in terms of copyright enforcement and business.

1. INTRODUCTION

There are at least two major reasons for analyzing behavior on P2P networks: designing new business models based on this transfer protocol and fighting against unauthorized file-sharing of copyrighted works in P2P networks. In both cases, it is crucial to understand why people actually contribute resources for the benefit of other participants. In the first case, inspiring users to contribute more resources could enable promoters of P2P solutions to support the development of the network and enhance its performance. In the second case, governments and copyright owners might seek to lead people to contribute less and less digital contents until the P2P sharing networks eventually dissappear for lack of utility.

Our paper aims to evaluate the theoretical predictions about reciprocity and free-riding in the presence of non-rival goods and anonymity. If, on one hand, motivations for downloading are quite well explored by empirical studies, on the other hand, there is much less written about why people actually contribute. In short, why do individuals keep on contributing to the commons in the presence of massive free-riding and when this behaviour proves costly for them?

We investigate empirical regularities on the illegal P2P sharing of copyrighted contents. The originality of our study is that we use data that contains information about the level of individual contribution from a large heterogeneous sample. We are able to link this behaviour to the characteristics of individuals: demographics, internet skills and perceptions towards cultural diversity, legal and technical risk, ethical concerns, and the value of P2P networks. Our study then identifies the differential impact of the determinants of contribution against free-riding that are deemed to be crucial for the persistence of P2P networks.

The rest of the paper is organized in four sections. The next section provides a brief survey of the literature that seeks to explain the sharing behaviour and highlight the determinants of contribution behaviour over P2P networks. The third section presents the variables and econometric model. Section four presents the main results. Section five concludes and envisages some policy implications.

2. Literature review

2.0.1. *The nature of contribution.* When investigating P2P sharing networks, researchers mainly focus on downloading behaviour. They generally address two main questions: the actual impact of downloading on sales (for instance, Oberholzer and Strumpf, 2007, Liebowitz, 2006) and the motivations for downloading (Holm, 2003, Rochelandet and Le Guel, 2005). Surprisingly, few empirical papers[1] examine the opposite behaviour, contribution, although it also proves crucial to the very existence of P2P networks.

Most of the research in this area attempts to explain either free-riding or cooperation on the basis of some theoretical predictions. In particular, they envisage the theoretical conditions for sustainability of P2P networks. In other words, they ask why self-interested members of such communities keep on contributing despite high levels of free-riding. A prominent approach in this literature has been to apply game-theoretic frameworks to analyse the stability of cooperative behaviour when agents with unlimited capacity of calculation and foresight are concerned only about their own interests.[2]

This paper, rather, explores the motivations for contributing contents. Notions such as altruism, reciprocity and other-regarding self-interest can be used to explain this behaviour. In particular, two approaches can be mobilized. A first approach is the utilitarian perspective by considering that individuals try to solve a trade-off between the utility derived from contributing and associated costs of sharing their contents. Another perspective is the social psychology that explores the influence of social environment and norms: How do individuals acquire norms of behaviour and how this process of acquisition will in turn influence their behaviour? To what extent does their acceptance of specific social/private norms, beliefs, social status, mimetic propensity, and social pressure influence their behaviour?[3]

In this paper, we adopt a utilitarian approach. We consider contributions of digital contents over P2P networks as resulting from rational (hedonic) decision. Contributors are considered to derive some satisfaction and incur costs when participating in P2P networks. We explore to what extent such a general proposition is relevant. This approach seems particularly interesting to investigate since current copyright enforcement is grounded on the argument that individuals might react positively to legal sanction. In particular, the legal measures against file-swappers mainly target those who contribute by uploading copyrighted contents.[4] We then examine the underlying assumption of regulators according to which P2P users make some trade-off.

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[1]See Ripeanu et al. (2007).

[2]See Ranganathan et al. (2003), Krishnan et al. (2004), Dang Nguyen and Pénard (2007), and Xia et al. (2007).

[3]See for instance Strahilevitz (2003) and Shang et al. (2008).

[4]See the recent bill ('réponse graduée') of French government to fight against P2P networks.

Empirical studies suggest the predominance of free-riding over P2P networks without specific technical design to limit it (Adar and Huberman, 2000, Feldman et al., 2003, Asvanund et al., 2004). P2P sharing networks are 'loose-knit' communities characterized by civil anonymity, lack of social ties between users before joining the networks, and little discussion between them. Moreover, most of P2P networks are a non-excludable good. Each user can benefit from shared contents without contributing to the common-pool. Nobody is compelled to feed the networks with contents and enhance the diversity of supply. Thus, providing files can be analysed as a private provision of public good.

Consequently, P2P networks are potential candidates for the tragedy of the commons. Free-riding is likely to prevail and threaten the whole utility of P2P services by drying up the commons.[5] Users of P2P networks are more likely to be free-riders since they can benefit from the service without risk (or with small risk) of retaliation from contributors of new contents. Consequently, any rational self-interested user in the neoclassical perspective will tend to free-ride more since the cost of contribution is perceived as being positive. The dominant strategy could lead to an equilibrium in which the size of the network is zero.

However, in spite of such a massive free-riding, some users keep on contributing enough for P2P networks to expand. The question then is to explain why do P2P communities thrive? Of course, free-riding can be hindered by its own costs. For instance, circumventing the 'by-default' sharing option of P2P software can be costly in terms of time and skills (Golle et al., 2001).[6] But, even though P2P contributors perceive a high cost of free-riding, this does not explain why they actually contribute contents instead of giving up the network. From a self-interest standpoint, rational users will contribute (and not free-ride) if their net gain of contribution is positive and higher than the payoff resulting from free-riding.

2.1. **The gain from contributing.** In this paper, we define contribution as the act of feeding a P2P network with new contents. By contrast to technical sharing, ripping a CD and a DVD, taking it from one folder of the hard-disk to a P2P shared folder is not compelled by P2P software. Individuals can simply let their computers contribute to the efficiency of the P2P sharing network without, in fact, contributing new titles and hence enhancing the diversity of the P2P shared resource. In this case, they actually share common resources but they do not renew the commons by feeding new titles. In short, if everybody free rides in such a way (without contributing new titles), then the value of the P2P networks will tend to zero for

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[5]Note that, by contrast to the whole literature on this subject, free-riding can be considered as a key element of the attractiveness and reputation of sharing network. Free-riding generates a positive externality by attracting more participants and hence more contributors. Conversely, the disappearance of free-riders due to strong extrinsic motivations (individual rating, exclusion if not contributing...) can reduce the size of the network below the sustainable level in terms of reputation and diversity of titles!

[6]P2P architecture can design each user as a contributor and accordingly, every downloaded file is automatically shared with other peers connected to the network. Thus, free-riding requires a technical manipulation (copying the files from the shared directory, shutting down the sharing option) that can be a disincentive for non-contribution. Nonetheless, this opting-out is quite easy to achieve and may represent a non-significant cost for skilled users of P2P networks. And if these skilled users perceive a positive cost of contribution, they are very likely to opt-out.

the installed base of users who will no longer find anything new.[7] Consequently, this paper considers pure free-riding as feeding no new contents.

Let the net gain of contribution be denoted by $v_i = u_i - c_i$ where u_i is the utility derived from contributing and c_i is the cost of contribution. A user will be willing to contribute if she derives a positive v_i that is also higher than the gain from free-riding. So it becomes important to understand the determinants of u_i and c_i.

P2P users can incur costs through the perceived risks of being caught (Bhattacharjee et al., 2006)) and of being infected by virus or spyware. Also, they can suffer from download speed congestion when uploading contents (Feldman et al., 2003).[8] Finally, contribution requires adequate skills and time to digitalize contents as well as resources to store the sharing files. For instance, contributing movies requires time and skills associated with finding files or ripping DVD/CDs.[9]

As for the utility of contribution, we can first express it by $u_i = u_i(x_i, G)$ ('pure altruism', Andreoni, 1990) where x_i is the consumption of a composite good and G is the total amount of 'resources' available on the P2P network. G captures the number of available contents. Here, we suppose that contributing is motivated by the increase in the utility derived from the increase in G. So the level of contribution will depend on the perception of the impact of one's own contribution on the total value of the P2P network. For instance, contribution can be motivated by expectation for a generalized or sequential reciprocity: individual A anticipates that her contribution will entail contribution from B that will in turn lead C to contribute and so on. An individual, then, will have no incentive to contribute if he anticipates that this increase in G will occur with or without her own contribution (crowding out effect).[10]

Another way is to consider the individual contribution g_i (similar to the economic analysis of donations and bequests) so that it directly enters the utility function; $u_i = u_i(x_i, g_i)$. Gu and Jarvenpaa (2003) test this 'warm glow' effect ('impure altruism', Andreoni, 1990) according to which an individual can get a private benefit derived from the social recognition and demonstration effects of her contribution. However, in contrast to other sharing communities, the actual contributions in the P2P networks are rarely public information making it difficult to conceive as a repeated game. Even when using a pseudonym, most of the participants of a P2P network tend to change their virtual identity for legal concern. In this respect, the rating experimentation of Kazaa was far from being conclusive.

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[7]The questions we asked in the survey administered in 2005 are explicit regarding this question: "How frequently do you contribute new titles on P2P networks?"

[8]Concerning this last cost, it can be minimized by a traffic redistribution effect designed to favour the sharing peers. Introducing this opportunity cost for non-sharers would act as a direct incentive to contribute (Krishnan et al. 2004). However, in a four-period game Jian and MacKie-Mason (2006) suggest that such an 'offload effect' might be insufficient to lead to a sufficient level of sharing because the inherent benefits decrease in the size of the network of sharers. They show that, in a network with k sharing nodes, a user, who decides to share her content, increases the probability of getting one unit of content by only 3,3%. Their findings confirm the more general result in public economics based on the logic of collective action of Olson (1965).

[9]Ethical concerns associated with contribution can be also considered as a psychological cost that can reduce the gain associated with contribution and decreasing the likelihood for a P2P user to be a contributor. However, we suppose that this factor is a social norm adopted by individuals that constrains their behaviour without any calculation (see also Shang et al., 2008).

[10]Individuals choose the level of their contributions only if their contributions impact the aggregate levels of contribution and so the provision of public good (Bernheim, 1986).

In the absence of private benefit from sharing, Jian and MacKie-Mason (2006) apply the notion of *generalized* reciprocity (Mead, 1934) to explain why some users actually contribute to the P2P networks.[11] P2P networks are computer-mediated communities whose members are interconnected and plan to participate without precise term. In this peculiar context, contributions are motivated by the expectation of contributions from the set of other participants (the sharing community). Voluntary contributions to non-excludable public goods are often favoured by the knowledge that the other participants and beneficiaries also do their fair share. Jian and MacKie-Mason (2006) then show analytically how generalized reciprocity can sustain P2P networks with equilibrium free-riding.

Finally, users can have a pure taste for contributing. Altruism can be captured in this approach by taking into account the utility of peers in the utility function of a participant. In this case, $u_i = u_i(x_i, u_j)$ where u_j is the utility of some other participant j and $\frac{\partial u_i}{\partial u_j} \geq 0$. Individuals are motivated to cooperate because they take pleasure in others' pleasure.[12] More precisely, contributors derive utility from meeting the needs of the recipients. Their objective can also be to influence the nature of the supply available by providing the works they like very much or by contributing rare titles (bootlegs) they want to be known. They simply take pleasure in sharing the works they have enjoyed. They can also believe that the preferences of some peers are the same as their own.

Some limitations to this last explanation can be mentioned. Altruism generally is based on the information about the nature and the level of needs. In the case of P2P communities, Strahilevitz (2003) notes that a file-sharer does not know the social identity of the (potential) recipients. Another problem is to determine the boundaries for the level of contribution with such a specification. Moreover, contribution is simply explained by its effect (Dawes and Thaler, 1988) and not by the very reasons that lead to this result. Why do people incorporate the utility of others in their own utility function? In the case of P2P contribution, social norms can be incorporated in the preferences of individuals.

Finally, from an empirical standpoint, all those factors often operate simultaneously $(u_i = u_i(x_i, G, g_i, u_j))$ because each argument can impact the others and consequently, their relative effect proves difficult to distinguish. In other words, their modes of interaction are difficult to distinguish not only because of the limitation of directed survey but also because individuals themselves can have difficulties to make a conscious trade-off between their private interest and the general good.

3. Econometric framework

3.1. **Variables and Hypotheses.** Our model identifies and analyses the determinants of the contribution to a P2P sharing network. Since a random sampling

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[11]They summarize their idea by quoting Putnam (2000): "I'll do this for you without expecting anything specific back from you, in the confident expectation that someone else will do something for me down the road."

[12]Conversely, the knowledge of the misfortune of others decreases one's pleasure. It corresponds to the concept of 'sympathy' defined by Sen (1977) as a motivation for self-interested behaviour since acting in this case increases the conditions of the person who acts. Sen distinguishes this concept from the altruist behaviour of 'commitment' when someone morally acts to improve the condition of others without seeking to enhance her own condition.

design is used for data collection, the survey collects information from both non-participants and participants of P2P network. The sample can be divided into two broad groups: P2P participants and non-participants. The former group can be further divided into two behavioural groups:[13]

   (1) free-riding: A user receives contents without contributing, that is she only downloads;

   (2) Contribution: She always contributes contents, whether or not she receives anything.[14]

It is possible to imagine that technological constraints make pure free-riding impossible. However, in our study, the major distinction between the two groups is that the 'free-rider' does not add new contents to the network whereas the 'contributor' uploads new contents to the network.

According to the literature reviewed in previous section, the main factors that may explain these different behaviours can be grouped into three categories. The first one evaluates the utilitarian assumptions using four independent variables, namely the value of the sharing network, the perceived utility from cultural diversity available on P2P networks, and the cost associated with contribution, and legal and technical risks. The second group refers to a socio-psychological approach using two variables: the social neighbourhood and the ethical concerns relating to the perceived impact of unauthorised P2P sharing on artists and content industries. The third and last group of variables is made up of demographics and individual skills.

The first factor (*Willingness to pay*) represents the sum that the individual would accept to pay to have an unlimited access to music contents through a P2P network. It is expected that this variable is positively correlated with being reciprocal or altruistic over P2P network. The underlying hypothesis is that the more individuals value a sharing network, the more they derive utility from its existence (and persistence), and then the more they may contribute to feed it.

Similarly, the second variable (*Cultural diversity*) evaluates the value of the sharing network for each participant in terms of diversity of titles. If she considers it as crucial, she is more likely to contribute by feeding the P2P network with new titles. This binary variable equals one if the respondent considers that there is not enough cultural diversity associated with offline or online music sellers in comparison with P2P networks, and zero otherwise.

The third variable (*Legal risk*) refers to the perceived risks associated with unauthorised sharing, namely the perceived likelihood of being caught and sanctioned. It is assumed to impact negatively on the contribution to a P2P network.[15] The underlying assumption is that the greater the perceived legal risk of using P2P file-sharing networks, the greater is the perceived cost associated with contributing, and then the smaller is the net gain (or the greater the net loss) of sharing for

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[13]Our statistical taxonomy does not exactly parallel the precise concepts of 'reciprocity' – that generally refers to gift exchange and labour market decisions – and 'altruism' – that has been mainly invoked to explain contributions to charities and intergenerational transfers.

[14]According to the above-mentioned literature, the contribution behaviour can be explained by purely altruistic motivations or by reciprocity.

[15]Respondents chose between four perceived ordered levels of risk: "no risk", "low risk", "medium risk" and "high risk". One key fact to be noted is that a wide campaign against copying was carried out shortly before we began our survey. So it is likely that respondents were quite aware of the risks associated with illegal sharing.

individuals. Legal risk is assumed to be perceived as higher with contributing than with receiving contents because this generally constitutes the act that gives rise to copyright lawsuits.[16]

The fourth variable (*Technical risk*) is similar to the previous one. The computer risk associated with sharing digital contents corresponds to the perceived likelihood of being infected by virus or spyware. Similar to legal risk, the greater the technical risk, the greater is the perceived cost associated with contributing, and then the smaller is the net gain (or the greater the net loss) of sharing for individuals.

The fifth variable (*Herding*) accounts for the social norms that can influence the choice of individuals. It refers to the impact of social interaction on sharing behaviour on P2P network. The question is to envisage to what extent the number of copiers in the social neighbourhood of an individual (whom he can observe and/or with whom he can communicate and share experiences) influences positively his cooperative behaviour over P2P networks. The underlying assumption is that P2P users acquire cooperative routines in their direct social networks.

The sixth variable (*Ethics*) is an index accounting for the ethical concerns of the individual regarding the copying of copyrighted works. It indicates the psychological 'costs' the individuals bear when they feel they are acting against ethics while copying.[17] This variable is usually assumed to impact negatively on all uses of P2P file-sharing networks.[18] Nevertheless, contributors can feel that their sharing is positive when they consider that they contribute to an increase in the value of the works they share and hence the reputation of their favourite artists.

The last group of variables represents demographics (age, gender, education, socio-professional group/occupation, and income) and Internet skills (past experience in using Internet). The effect of demographic variables could be positive, negative or zero. Internet skills can have a positve influence on contributing. This positive effect can be interpreted in the utilitarian perspective. Indeed, computer-skilled individuals are more likely to know how (or may incur less time) to make copies from originals thanks to a better knowledge of software enabling them to rip a DVD and to circumvent DRM protection. So the lower costs they incur would increase the likelihood of them benefitting from a net gain from contribution. Another way to explain this positive influence can be that Internet-skilled people are more likely to adhere to the social norms of reciprocity and sharing conveyed through Internet and then to contribute.

3.2. **Estimation strategy.** We observe the copying behaviour of individuals who participate in P2P network in two mutually exclusive behavioural traits – 'Free-ride', and 'Contribute'. We use a probit model in order to estimate the effect of the factors mentioned above on the probability of contributing to a P2P network.

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[16]Of course, other factors can contribute to increase the costs of sharing such as the decrease in the downloading capacity. But our survey did not include questions relating to this specific technical problem. In addition, we suppose that, in 2005, high-speed Internet already permitted to overcome such a technical constraint.

[17]It is built by requesting respondents to scale – between "do not agree", "partially disagree", "agree" and "fully agree" – their ethical concerns through four questions: "According to you, copying (1) endangers the movie and record markets; (2) affects the income of authors and artists; (3) does not respect the work of authors and artists; (4) is harmful in itself." We assign the values 1, 2, 3, 4 for each scaled variable and then add them up to construct the index.

[18]For a recent contribution, see Shang et al. (2008).

Since we are interested in explaining contribution behaviour we can use a binary outcome model. Let y_i denote our dependent variable defined as follows

$$y_i = \begin{cases} 1 \text{ if individual } i \text{ contributes to a P2P network} \\ 0 \text{ otherwise} \end{cases}$$

Let y_i^* denote the latent variable underlying the observed variable y_i. Assuming a single index specification of the latent variable we have

$$y_i^* = X_i\beta + u_i$$

where X is a set of explanatory variables including individual characteristics, the β's are the parameters to be estimated, and u is a random error. The model can be presented as

$$y_i = \begin{cases} 1 \text{ if } y_i^* = X_i\beta + u_i \geq 0 \\ 0 \text{ otherwise} \end{cases}$$

For the probit model u is assumed to be normally distributed. Hence the choice probability is given by

$$\Pr(y_i = 1 \,|\, X) = \Phi(X_i\beta)$$

where $\Phi(\cdot)$ stands for the standard normal distribution. The estimates of the parameters β are obtained by maximizing the log likelihood function given as

$$LL(\beta) = \sum_{i=1}^{n} y_i \ln[\Phi(X_i\beta)] + (1 - y_i) \ln[1 - \Phi(X_i\beta)]$$

Often interest lies in determining the marginal effect of the independent variables. The marginal effect of a variable is calculated as follows

$$\frac{\partial \Pr(y_i = 1 \,|\, X)}{\partial x_{ij}} = \phi(X_i\beta_j)\beta_j$$

where ϕ stands for standard normal density function.

4. DATA AND RESULTS

4.1. **Sample.** We base our analysis on primary data regarding individual sharing behaviour in P2P collected by a survey in January and February of the year 2005. The survey collected information from 2533 individuals using both a pen and paper survey and a Web-based survey. To simplify missing data correction, we chose to use the list-wise deletion approach (Allison, 2001). The sample bias due to the Web-based survey has been corrected using a post-stratification method implemented with an SAS software macro named CALMAR and developed by the French National Institute for Statistics and Economic Studies (INSEE). There is considerable variation in the data in terms of socio-demographics and sharing behaviour in P2P networks.

Table 1 presents the descriptive statistics and distribution of copying behaviour in P2P networks for different individual characteristics. For a complete definition of the variables refer to Table A1 in the appendix.

After deleting for missing values a sample of 2068 individuals is used for the descriptive analysis. The first row of numbers in Table 1 shows the distribution of total sample into P2P non-participants and participants (further into free-rider and contributor). There are 48.6% individuals who do not participate in P2P networks, 28.82% who free-ride, and 22.58% who contribute to P2P networks.

Table 1: Descriptive statistics

		P2P participants		Total
	Non-participants	Free-ride	Contribute	(N=2068)
Percentage				
All	48.60	28.82	22.58	100.00
Gender				
Female	11.32	3.97	3.58	18.87
Age				
age <= 24 yrs	5.32	4.93	3.87	14.12
25 yrs <= age <= 40 yrs	23.26	15.33	12.67	51.26
age > 40 yrs	20.02	8.56	6.04	34.62
Education				
less than BAC	4.11	2.85	2.90	9.86
BAC/BAC Pro	7.01	5.08	3.92	16.01
BAC+1+2	12.81	8.61	5.27	26.69
BAC+3+4	10.49	6.09	4.26	20.84
more than BAC+5	14.17	6.19	6.24	26.60
Occupation				
Freelance	18.28	9.43	7.83	35.54
Intermediate occupations	17.36	12.09	9.04	38.49
Retired	3.48	1.74	0.92	6.14
Student	2.85	2.22	1.84	6.91
Unemployed	6.62	3.34	2.95	12.91
Monthly household income				
less than 1000 euro	5.08	3.63	2.47	11.17
b/w 1000 and 1500 euro	7.50	5.03	4.88	17.41
b/w 1500 and 2000 euro	8.27	4.84	4.01	17.12
b/w 2000 and 2500 euro	7.50	4.35	2.85	14.70
b/w 2500 and 3000 euro	6.67	3.48	3.48	13.64
b/w 3000 and 3500 euro	3.82	3.05	1.35	8.22
b/w 3500 and 4000 euro	3.53	1.98	1.31	6.82
b/w 4000 and 5000 euro	3.29	1.50	1.06	5.85
more than 5000 euro	2.95	0.97	1.16	5.08
Herding				
none	7.06	2.22	1.55	10.83
b/w 1 to 5	15.76	6.72	3.97	26.45
b/w 6 to 15	9.48	6.38	5.56	21.42
more than 15	16.30	13.49	11.51	41.30
Cultural diversity	15.14	12.77	11.51	39.41
Experience with internet				
less than 1 year	6.82	3.38	1.79	11.99
b/w 1 to 2 years	10.25	4.40	3.00	17.65
b/w 2 to 3 years	13.01	8.46	6.62	28.09
more than 3 years	18.52	12.57	11.17	42.26
Mean value				
Ethics	6.52	5.81	5.64	6.11
Willingness to pay	5.94	6.49	5.84	6.08
Legal risk	1.62	1.67	1.68	1.65
Technical risk	1.67	1.54	1.53	1.60

Going down the list of variables in Table 1 we observe that there are around 19% of females in the sample. For females the distribution of participation and sharing behaviour is the following: 11% "Non-participant", 4% "Free-ride" and 4% "Contribute". Deducting these percentages from full sample distribution of sharing behaviour we find that among the male individuals 37% are "Non-participant", 25% "Free-ride" and 19% "Contribute". Dividing the percentage of different sharing behaviour by the total percentage we obtain the proportions of a group in different behavioural types. In terms of proportion, females are more likely to be non-participants than are males, and males are more likely to be free-riders and contributors to P2P than are females.

The table also shows that there is considerable variation in the data and in sharing behaviour in terms of age, education and occupation of the individuals. A careful reading of the numbers reveals that, in terms of percentage, the higher is the age the higher is non-participation, and the lower is the age the higher is the participation (both free-riding and contribution). The distribution in terms of education shows that the higher is the education the higher is "Non-participant". For the lowest and highest categories of education "Contribute" is slightly higher than "Free-ride", but for other (middle) educational groups "Free-ride" is higher than "Contribute". For all the occupational groups the most prevalent behaviour is "Non-participant", followed by, in the order of less prevalence, the behavioural types "Free-ride" and "Contribute".

We also have considerable variation in terms of household income of the individuals. The pattern that emerges from the distribution of sharing behaviour for different household income categories is that the higher is the household income the higher is "Non-participant" and the lower is the household income the higher is participation (both "Free-ride" and "Contribute"). The distribution of copying behaviour in terms of herding shows that the higher is the number of copiers in a social neighbourhood the higher is the likelihood of participation (both "Free-ride" and "Contribute"), and vice versa. There are 39% of individuals who think that the legal market does not provide enough variety. However, 38% of them do not participate in P2P networks, 32% "Free-ride" and 29% "Contribute" to P2P networks.

Internet experience seems to be positively associated with participation in P2P networks. The full sample average value of the variable of ethical concern is 6.11. It is interesting to see that the average value is higher for non-participants and that there is little difference between the average values of two types – "Free-ride" and "Contribute". For willingness to pay, surprisingly we find that the type "Free-ride" has the highest willingness to pay of all types. As one might expect, we find that participants (both "Free-ride" and "Contribute") perceive higher legal risk than non-participants. However, it is interesting to see that the individuals who participate (type "Free-ride" and "Contribute") perceive a lower technical risk than the non-participants.

4.2. **Econometric results.** In this subsection, we present our estimation results. The estimation is done for the P2P participants. The estimation sample consists of 1063 individuals who participate in P2P network. The probit estimates correspond to the probability of contribution to P2P networks taking free-riding as the reference group. Here we present the 'marginal effect' of independent variables which is interpreted as the effect of a variable on the probability of contribution to P2P

networks. The coefficient estimates are reported in Table A2 in the appendix. Table 2 gives the marginal effect from the estimation of contribution behaviour in P2P networks. The estimation model incorporates the variables that have theoretical relevance, demographics and Internet skills.

Table 2: Estimates of contribution behaviour in P2P network (marginal effect)

	Marginal effect		S. E
Gender			
Female	0.051		0.048
Age			
25 yrs <= age <= 40 yrs	0.019		0.054
age > 40 yrs	0.038		0.063
Education			
BAC/BAC Pro	-0.058		0.059
BAC+1+2	-0.135	***	0.054
BAC+3+4	-0.104	*	0.058
more than BAC+5	-0.018		0.062
Occupation			
Freelance	-0.019		0.058
Intermediate occupations	-0.038		0.055
Retired	-0.099		0.085
Student	0.003		0.083
Monthly household income			
b/w 1000 and 1500 euro	0.109	*	0.061
b/w 1500 and 2000 euro	0.059		0.064
b/w 2000 and 2500 euro	-0.005		0.067
b/w 2500 and 3000 euro	0.110		0.068
b/w 3000 and 3500 euro	-0.094		0.074
b/w 3500 and 4000 euro	0.025		0.082
b/w 4000 and 5000 euro	0.010		0.089
more than 5000 euro	0.134		0.094
Herding			
b/w 1 to 5	-0.021		0.068
b/w 6 to 15	0.068		0.068
more than 15	0.056		0.065
Cultural diversity	0.061	**	0.032
Experience with internet			
b/w 1 to 2 years	0.070		0.066
b/w 2 to 3 years	0.106	*	0.060
more than 3 years	0.132	**	0.059
Ethics	-0.005		0.008
Willingness to pay	-0.005	*	0.002
Legal risk	0.002		0.018
Technical risk	0.011		0.016
Number of observations			1063
Log likelihood			-703.74

Notes:
*, ** and *** stand for significance at 10%, 5% and 1% level, respectively.

Our main results are the following:

(1) The value of P2P networks is marginally significant. However, the marginal effect is negative and very low.
(2) The quest for cultural diversity makes individuals more likely to be a contributor than a free-rider in P2P networks.
(3) The perception of legal and technical risks associated with sharing behaviour has no significant effect on contribution.
(4) A moderate level of education is associated with a lower likelihood of being a contributor in P2P.
(5) Age, income and occupation do not have a significant impact on behaviour in P2P networks.
(6) Higher internet experience has significant positive impact on contribution behaviour.

These results are summarized in the following table:

Table 3: Effects on contribution behaviour

Favourable effects	Unfavourable effects	Neutral effects
Cultural diversity	Willingness to pay	Legal and technical risks
Internet experience	Moderate level of education	Social status (income, occupation)

According to results 1, 2, and 3, factors likely to influence utilitarian decision-making have no impact, except for the quest for cultural diversity. The economic value of the service associated with P2P networks (the provision of contents in a sharing network) does not matter. Rather, people contribute to enhance the diversity of contents. In doing so, they can follow a principle of general reciprocity by expecting the same behaviour from the set of other peers participating to the networks. Or they are guided by purely altruistic motivations by feeling that the cultural diversity prevailing in the legal market is insufficient and contribution in alternative networks can compensate this lack.

The second set of results (4, 5 and 6) suggests that social status variables (age, income and occupation) do not explain sharing behaviour. By contrast, a moderate level of education has a significant effect. This result is consistent with the socioeconomic literature about cultural practices (see Seaman, 2006). Finally, the higher is the experience with Internet the higher is the probability that an individual contributes to P2P networks.

5. CONCLUSION

Explaining why people contribute to P2P networks is crucial to the understanding how these sharing networks actually work and, above all, the conditions of their (non)viability. Indeed, the availability of files and diversity on P2P networks depend strictly on the willingness of some peers to upload copies. Our econometric results suggest that the motivations for contributing are poorly determined by rational self-interested behaviour.

A major way to fight against P2P networks is to try to influence the utility they generate for participants. One such strategy can consist in reducing their absolute utility by increasing the costs associated with contribution in order to dry up the

supply of contents on P2P networks. But our findings suggest that this strategy might be inefficient. Our results are sharply in contrast to the assertion of Krishnan et al. (2004) that "increasing the cost of sharing can reduce the number of sharers and above a certain point lead to network collapse [...]. Increasing the implicit cost of sharing is by increasing the legal risks to individual network users from sharing copyrighted information."[19] In fact, our findings suggest the opposite: copyright enforcement (in particular, increased sanctions, legal suits against individual copiers) has no impact on contribution behaviour. This might explain the failure of current enforcement strategies.

In particular, our findings cast some doubts on the efficiency of the recent bill of the French government aiming at putting an end to unauthorized P2P file-sharing. The 'réponse graduée' consists of, firstly, sending a warning by email to the copyright infringers who upload content on P2P networks; then – if the P2P user keeps on uploading – sending a warning by registered mail; and finally – if the infringer continues uploading – imposing a fine on her. At best, this new form of copyright enforcement could eliminate the current P2P technology used to share contents. But, according to our results, any new sharing technology that would replace current P2P technology might be fuelled by the 'supply' of contents contributors.

Another strategy is to decrease the relative utility of P2P networks by increasing the quality of services and diversity of contents available in the legal markets. Content industries should try to build innovative business models to compete efficiently with P2P content-sharing or even to extract the value from these sharing communities (Le Guel and Rochelandet, 2006). Copyright law could stimulate innovation by implementing compulsory licences in order to facilitate the acquisition of copyrights and increase the size of catalogue supplied to consumers on legal markets.

Finally, our paper suggests that contribution behaviour is not well explained by an utilitarian approach. In contrast, it can be motivated by social influence. In particular, these practices are embedded in a social context. A further step will then consist in exploring the mechanisms by which this social influence explains the behaviour of contributors over P2P networks.

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[19]In the same way, Asvanund et al. (2004) put that "The more recent strategy adopted by copyright holders of bringing legal action against violators may be more successful even though the proportion of users who are targeted is a small fraction of the total number of users. The success of this strategy depends on raising the implicit cost of sharing for users by raising their legal risks. Increased sharing costs will then raise their propensity to free-ride and may ultimately reduce the utility offered by "illicit" file trading over P2P networks enough to make the legitimate purchase of the music an attractive option for users." Or Strahilevitz (2003) states that "If my account is correct, it suggests that the copyright industries' efforts to control copyright infringement on peer-to-peer networks have been wrongheaded. Rather than moving sequentially against the various post-Napster networks, the copyright industries might have adopted various strategies to create a norm of free-riding, thereby cutting off the cooperative uploading on which these networks rely."

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Appendix

Table A1: Definition of Variables

Variable	Definition
P2P	
Non-participant	equals 1 if the individual does not exchange contents in P2P networks, 0 otherwise
Free Ride	equals 1 if the individual receives content from P2P networks but does not provide, 0 otherwise
Contribute	equals 1 if the individual contributes content to P2P networks, 0 otherwise
Gender	equals 1 if female, 0 otherwise
Age	
age ≤24 years	equals 1 if the individual is less than 25 years old, 0 otherwise
25≤age≤40	equals 1 if the individual is aged between 25 and 40, 0 otherwise
age>40	equals 1 if the individual is more than 40 years old, 0 otherwise
Education	
less than BAC	less than BAC/BAC Pro
BAC/BAC Pro	high school graduate, business, technical
BAC+1+2	some college (not 4 year degree)
BAC+3+4	BS or more
more than BAC+5	MA
Occupation	Options: Freelance (executive), intermediate occupations (skilled and unskilled workers), retired, student, and unemployed

Table A1 (cont.): Definition of Variables

Variable	Definition
Monthly household income	Options: less than 1000 euros per month, between 1000 and 1500 euros per month, between 1500 and 2000 euros per month, between 2000 and 2500 euros per month, between 2500 and 3000 euros per month, between 3000 and 3500 euros per month, between 3500 and 4000 euros per month, between 4000 and 5000 euros per month, over 5000 euros per month
Hearding	Number of copiers in neighbourhood. Options: none, between 1 and 5, between 6 and 15, more than 15
Cultural diversity	Do you think the legal market for music does not offer enough variety? 1 for agree and completely agree, 0 otherwise
Experience with internet	Options: less than 1 year, between 1 and 2 years, between 2 and 3 years, and more than 3 years.
Ethics	An index of ethical concerns. It is the sum of four coded aspects: copying (i) threatens the existence of the market for music and CDs, (ii) threatens the income of artists and others involved, (iii) does not respect the work of the artists and others involved, and (iv) is bad in general. Coding: 1 for 'do not agree', 2 for 'partially agree', 3 for 'agree', and 4 for 'strongly agree'.
Willingness to pay	Willingness to pay for a P2P network that gives unlimited access to music (in Euros).
Legal risk	Perceived legal risk of being caught copying: 0 for 'no risk', 1 for 'low risk', 2 for 'medium risk', and 3 for 'high risk'
Technical risk	Perceived legal risk of contamination by virus or spyware: 0 for 'no risk', 1 for 'low risk', 2 for 'medium risk', and 3 for 'high risk'

Table A2: Estimates of contribution behaviour in P2P network (Coefficient)

	Coeffcient		S. E.
Gender			
Female	0.129		0.121
Age			
25 yrs <= age <= 40 yrs	0.048		0.136
age > 40 yrs	0.097		0.160
Education			
BAC/BAC Pro	-0.148		0.153
BAC+1+2	-0.350	**	0.143
BAC+3+4	-0.269	*	0.154
more than BAC+5	-0.046		0.159
Occupation			
Freelance	-0.048		0.148
Intermediate occupations	-0.097		0.139
Retired	-0.258		0.231
Student	0.008		0.211
Monthly household income			
b/w 1000 and 1500 euro	0.274	*	0.154
b/w 1500 and 2000 euro	0.149		0.160
b/w 2000 and 2500 euro	-0.013		0.170
b/w 2500 and 3000 euro	0.277		0.171
b/w 3000 and 3500 euro	-0.244		0.197
b/w 3500 and 4000 euro	0.064		0.207
b/w 4000 and 5000 euro	0.024		0.226
more than 5000 euro	0.337		0.240
Herding			
b/w 1 to 5	-0.054		0.174
b/w 6 to 15	0.171		0.172
more than 15	0.141		0.166
Cultural diversity	0.156	**	0.080
Experience with internet			
b/w 1 to 2 years	0.178		0.166
b/w 2 to 3 years	0.269	*	0.151
more than 3 years	0.337	**	0.152
Ethics	-0.014		0.020
Willingness to pay	-0.012	*	0.006
Legal risk	0.004		0.045
Technical risk	0.028		0.041
Constant	-0.420		0.315
Number of observations			1063
Log likelihood			-703.74

Notes:
*, ** and *** stand for significance at 10%, 5% and 1%
level, respectively.

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