

2014/19



Digital piracy: an update

Paul Belleflamme and Martin Peitz



CORE

The logo for CORE (Center for Operations Research and Econometrics) features the word 'CORE' in a bold, black, sans-serif font. A thin, light blue arc curves over the letters, starting from the top left of the 'C' and ending at the top right of the 'E'.

DISCUSSION PAPER

Center for Operations Research
and Econometrics

Voie du Roman Pays, 34
B-1348 Louvain-la-Neuve
Belgium

<http://www.uclouvain.be/core>

CORE DISCUSSION PAPER
2014/19

Digital piracy: an update*

Paul BELLEFLAMME ¹ and Martin PEITZ ²

April 2014

Abstract

This note summarizes and updates our previous survey of the economics of digital piracy (Belleflamme and Peitz, 2012).

Keywords: information good, piracy, copyright, IP protection, internet, peer-to-peer, software, music.

JEL classification: L11, L82, L86.

¹ Université catholique de Louvain, CORE and Louvain School of Management, B-1348 Louvain-la-Neuve, Belgium. E-mail: paul.belleflamme@uclouvain.be

² Department of Economics, University of Mannheim, D-68131 Mannheim, Germany; CEPR, CESifo, ENCORE and ZEW. E-mail: martin.peitz@googlemail.com

* To be published in Backhaus, J. 'ed.), *Encyclopedia of Law and Economics*. Springer (in print). This version: January 2014.

Introduction

The objective of this note is to provide a comprehensive and up-to-date overview of digital piracy. Although we put the emphasis on the economic analysis, we also briefly present the legal context and its recent evolution. As digital piracy consists in infringing intellectual property laws, it is important to start by understanding the rationale of such laws. That allows us to define more precisely what is meant by digital piracy. We can then move to the economic analysis of piracy. We start with the basic analysis, which explains why piracy is likely to decrease the profits of the producers of digital products; we also examine how the producers have reacted to digital piracy when it started to grow. We review next more recent contributions that point at possible channels through which piracy could improve the profitability of digital products. These channels have inspired new business models for the distribution of digital products, which we describe in the last part of the essay. Throughout the essay, we report the results of some of the most recent empirical studies, so as to quantify the impacts of digital piracy.

The IP protection of information products

Information products (such as music, movies, books, and software) are often characterized as being hardly excludable, in the sense that their creators face a hard time excluding other persons, especially non-payers, from consuming these products. This feature may undermine the incentives to create, because of the difficulty in appropriating the revenues of the creation. The production of information products may then be insufficient compared to what society would deem as optimal. One solution to this so-called “under-production” problem is to make intellectual creations excludable by legal means. This is the objective pursued by intellectual property (IP) laws, which most countries have adopted. IP refers to the legal rights that result from intellectual activity in the industrial, scientific, literary and artistic fields. IP laws generally distinguish among four separate IP regimes, which are targeted at different subject matters: information products (and more generally literary, musical, choreographic, dramatic and artistic works) are protected by copyrights; the three other regimes (patents, trade secrets and trademarks) aim at protecting industrial property (such as inventions, processes, machines, brand names, industrial designs).

It is important to note, from an economic perspective, that IP laws alleviate the “underproduction” problem at the cost of exacerbating an “underutilization” problem. To understand this second problem in the context of information products, we need to refer to another characteristic of information products, namely their nonrivalness, which refers to the property that their consumption by one person does not prevent their consumption by another person (for instance, the fact that some person listens to the performance of an artist does not reduce the possibility for anyone else in the audience to listen to the same performance). A consequence of this nonrivalness is that the marginal cost of production of information products is zero (that is, taking the artist’s viewpoint in the previous example, once the show has started, it costs nothing to have one extra spectator viewing it). From the point of view of static efficiency, the price of information goods should therefore be equal to zero. However, because IP laws endow them with some market power, the creators of information products are able to set a positive price, which reduces social welfare by preventing those consumers with a low, but positive, valuation of the information products from consuming them.

In other words, IP laws aim at striking the balance between providing incentives to create and innovate, while promoting the diffusion and use of the results of creation and innovation. To do so, IP rights are granted only for a limited period of time and for a limited scope. In particular, copyright protection usually lasts for a number of years (currently, 70 in both the European Union and the United States) after the creator’s death; in terms of scope, copyrights protect only the expression but not the underlying ideas.

Defining digital piracy

IP laws are effective only if they are properly enforced and respected. Yet, as far as information products are concerned, one observes a large-scale violation of the laws protecting them, a phenomenon known as “piracy”. What is striking is that the illegal reproduction and distribution of copyrighted works is not only the act of criminal organizations (so-called “commercial piracy”) but also the act of the consumers themselves (so-called “end-user piracy”).¹

¹We do not review here factors that influence the piracy decision; one can indeed wonder what motivates such large-scale violation of IP laws by individuals who are normally law-

Commercial piracy does not need much analysis, as the motivation is easily understood: criminal organizations are simply attracted by the high profit margins that the large-scale reproduction and distribution of copyrighted products generates. On the other hand, end-user piracy raises a number of issues that the fast penetration of the Internet and the digitization of information products have made much more pressing. Digital technologies have indeed drastically reduced the cost of making and distributing illegal copies, while increasing their quality; thereby, they have deeply modified the interaction between end users, copyright holders, and technology companies. End-user piracy in the digital age, or for short digital piracy, is thus a major phenomenon that requires a thorough analysis.

The basic economics analysis: digital piracy decreases profits

The main consequence of digital piracy is that it seriously limits copyright owners in their ability to control how information products get to consumers. As a result, the availability of digital copies is likely to reduce the copyright owner's profits. This is the prediction that can be drawn from the basic *theoretical modeling* of piracy (see, for instance, Novos and Waldman, 1984, Johnson, 1985, and the references in Belleflamme and Peitz, 2012). These models simplify the analysis by focusing on the market for a digital product supplied by a single producer. One can justify this assumption by arguing that digital products within a given category are highly differentiated in the eyes of the consumers; the demand for any product is therefore hardly affected by the prices of other products. Even though the copyright owner acts as a monopoly, she faces nevertheless the competition exerted by the availability of (illegal) digital copies. Copies are seen as imperfect substitutes for the original digital product, insofar as their quality is generally lower than the quality of original products. In particular, the quality of copies primarily depends on technological and legal factors, which can be affected by public authorities (through the definition and the enforcement of IP protection) and/or by the copyright owner herself (through technical protective measures). In this setting, it is possible to analyze the copyright owner's decisions about the pricing and the technical protection of original products, as well as public policy regarding IP laws.

abiding citizens; for a review of the literature on this topic, see Novos and Waldman (2013).

The main results of these analyses can be summarized as follows. First, because consumers with a low cost of copying or with a low willingness to pay for quality prefer copies to original products, the copyright owner is forced to charge a lower price (than in a world where digital piracy would not exist). That clearly decreases the copyright owner's profits but increases the surplus of the consumers of original products; moreover, a number of consumers who were not willing to purchase the original product at the monopoly price get now some utility from the pirated copies. As the increase in consumer surplus outweighs the profit reduction, digital piracy results in an improvement of welfare from a static efficiency point of view (like any erosion of market power does). However, the lower profits may reduce the incentives of copyright owners to improve the quality of existing products or to introduce new products on the market; this is detrimental to welfare from a dynamic perspective. Moreover, total welfare may decrease because of a number of avoidable costs that digital piracy entails (e.g., the costs for producers to implement technical protective measures, or the costs for public authorities to enforce copyrights).

Looking at the profits of copyright owners, it is an undisputed fact that they started to decrease when end-user piracy started to grow (i.e., around 1999 with the launch of Napster, a peer-to-peer file-sharing service). This was particularly acute in the music industry where physical music sales (that is to say, CDs) dropped significantly. Numerous *empirical studies* (for a survey, see Waldfogel, 2012a) have tried to estimate the extent to which this decrease in sales could be attributed to digital piracy. These studies converged on the conclusion, now widely accepted, that digital piracy has "displaced" physical sales (i.e., legal purchases were substituted for, mainly, illegal downloads). However, it is also established that the estimated "displacement rate" is slightly above zero and nowhere near unity, reflecting the observation that the vast majority of goods that were illegally consumed would not have been purchased in the absence of piracy (contrary to what the recording industry would have liked the general public to believe by counting any download as a lost sale).

Very little empirical work has been devoted to the long-term effects of piracy (i.e., to dynamic efficiency considerations). One notable exception is Waldfogel (2012b), who tries to estimate the extent to which digital piracy has affected the incentives to bring forth a steady stream of valuable new

products. To address this issue, he uses three different methods to assess the quality of new recorded music since Napster. The three resulting indices of music quality show no evidence of a reduction in the quality of music released since 1999; two indices even suggest an increase. One explanation could be that the digital technologies that have made piracy easier have also reduced the costs of bringing creative works to market, and that the latter effect is at least as important as the former.

Reactions of copyright owners

In the face of digital piracy and of the reduction of sales, the first reaction of copyright owners was to try and prevent the existing business models from crashing down. As these models were relying on controlled distribution and broadcast channels, the main strategies consisted (i) in pursuing more heavily copyright infringers, (ii) in using digital technologies as protective measures, and (iii) in lobbying for more restrictive IP laws.

The music industry started the fight against illegal downloading. In 2001, the Recording Industry Association of America (RIAA) obtained the closure of Napster but the victory proved short-lived as a number of other file-sharing systems (such as Kazaa, Limewire, and Morpheus) quickly replaced Napster. The industry started then a campaign of litigation against individual P2P file sharers: between 2003 and 2008, legal proceedings were opened against about 35,000 people. The software and the movie industries also engaged in similar legal battles.

A far as technical measures are concerned, a common tactic was to protect digital products through so-called digital rights management (DRM) systems, which inhibit uses of digital content not desired or intended by the content provider. DRM systems were meant to fight digital piracy but also, more generally, to manage how digital products can be used. Well-known examples of DRM systems are the Content Scrambling System (CSS) employed on film DVDs since 1996, so-called ‘copy-proof’ CDs introduced by Bertelsman in 2002 (which could not be played on all CD players and were later abandoned), and the FairPlay system used by Apple on its iTunes Music Store. Such systems were gradually abandoned in the music industry (but are still used in other industries, such as in the case of ebooks).

Finally, lobbying efforts were met with success as stronger copyright laws were passed in a number of countries. In the U.S., in 1998, the Copyright

Term Extension Act extended the duration of existing copyrights by 20 years, while the Digital Millennium Copyright Act reinforced copyright protection by making it a crime to circumvent the technological measures that control access to copyrighted work. In Europe, a number of EU directives led EU member states to harmonize their national copyright laws in the first half of the 1990s; also, the European Union Copyright Directive (EUCD) of 2001 required member states to enact provisions preventing the circumvention of technical protection measures. In the late 2000s, some countries (led by France and the UK) passed so-called “three-strikes anti-piracy laws”, which authorize the suspension of Internet access to pirates who ignored two warnings to quit. Finally, actions were also directly taken against platforms that were hosting and sharing illegal content (the most famous cases being the shutdowns of Napster in 2001, of Megaupload in 2012 and of the Pirate Bay in 2013).

In sum, the first reaction of copyright owners in the face of digital piracy was to enforce and reinforce both the legal and technical excludability of their products. However, these measures turned out to be of little effectiveness and sometimes even counterproductive. On the one hand, technical measures were not only quickly circumvented but they also irritated legitimate consumers, thereby decreasing their willingness to pay for copyrighted products. Zhang (2013) gives an indirect proof by showing that the decision by various labels to remove DRM from their entire catalogue of music increased digital music sales by 10%. To establish this point, she compares sales of similar albums with and without DRM before and after DRM removal; her sample includes a large selection of hits and niche albums, from all four major record labels and from multiple genres.

On the other hand, a number of empirical studies have tried to assess the effectiveness of anti-piracy interventions by governments on the sales of digital products. The results obtained so far are rather mixed. For instance, two papers examine the impacts of French “three-strikes anti-piracy law” (known as HADOPI law) introduced in 2009 and reach opposite conclusions: Danaher et al. (2014) find that the law caused a 20-25% increase in music sales in France, whereas Arnold et al. (2014) conclude that the law was ineffective not only in deterring individuals from engaging in digital piracy, but also in reducing the intensity of illegal activity of those who did engage in piracy. Similarly, different approaches to estimate the impacts

of the shutdown of Megaupload in 2012 lead to contrasting conclusions. Peukert et al. (2013) compare box office revenues before and after the shutdown for two sets of movies with matching characteristics but presenting one main difference: the first set could be accessed illegally through Megaupload, while the second set could not. Using a quasi difference-in-differences approach, they establish that the shutdown of Megaupload did not have any positive impact on box office revenues across all movies in the sample. In contrast, Danaher and Smith (2013) exploit the fact that there exists cultural variation across countries in the degree to which Megaupload was used as a channel for piracy. They show that digital movie revenues for two studios were 6.5-8.5% higher over the 18 weeks following the shutdown (across 12 countries) than they would have been if Megaupload had continued to operate.

Even if further empirical research is called for to refine the analysis of the effectiveness of anti-piracy measures, some of the existing results suggest that digital piracy may also have some positive impacts on the copyright owners' profits, which may balance the negative 'business-stealing' effect. We therefore turn to a second set of economic models that present piracy under a more favorable angle.

Further developments: digital piracy may increase profits

A number of theoretical studies (see Peitz and Waelbroeck, 2006, and the references in Belleflamme and Peitz, 2012) have demonstrated the positive effects that piracy may have on the profits of copyright owners. Three mechanisms have been identified. First, illegal copies of a digital product can play a *sampling* role by attracting consumers and driving them to purchase a legitimate copy later. This argument is based on the observation that digital products are complex 'experience goods'; that is, consumers do not know the exact value that they attach to particular digital products before consuming them. Buying a legitimate copy may thus appear as risky, which inevitably reduces demand. However, if an illegal copy can be accessed free of charge, consumers may learn their valuation of the product and if the latter is large, they may want to purchase the legitimate product (which is often, as argued above, of a higher perceived quality).

The empirical results of Zhang (2013) are consistent with this theory. As we noted above, her analysis shows that the removal of DRM had a positive

impact on digital music sales; yet, this impact was much more pronounced for niche than for hit albums, which suggests that more flexible sharing increased sales because it lowered search costs (which are arguably larger for lower-selling than for top-selling albums).

The second mechanism originates in the fact that many digital products generate *network effects*; that is, the attraction of the product increases with the number of consumers of that product. This is so with software (the wider is the community of users, the easier it is to exchange files, and the larger is the supply of complementary products) or with cultural products (whose popularity increases with word-of-mouth). As it is the cumulated number of consumed copies that matter and not whether these copies are legitimate or not, digital piracy contributes to increase the willingness to pay for legitimate copies. An anecdotal evidence of the importance of this mechanism can be found in the reaction of one of the directors of the series "Game of Thrones" (produced by the American premium cable network HBO) when interviewed about the huge illegal downloading of the first episode of the third season (estimated to over one million times in the space of 24 hours); he basically stated that the series benefits from piracy because it feeds the "cultural buzz" that allows this kind of program to "survive".²

Finally, the third mechanism, called *indirect appropriation*, resembles the second by invoking the fact that piracy can increase the demand for goods that are complementary to the pirated content; the producer is then able to capture indirectly the value that consumers attach to the pirated good. This goes, for example, for increasing ticket sales for the concert of an artist, whose popularity may be partly due to a large base of fans consuming pirated copies of this artist's songs. Mortimer et al. (2012) provide some empirical evidence along these lines; combining detailed album sales data with concert data for a sample of 1806 artists on the period 1999 to 2004, they find that digital piracy reduced sales but increased live performance revenues for small artists (the impact for large, well-known artists being negligible).

²See www.huffingtonpost.com/2013/02/26/game-of-thrones-download_n_2765488.html?utm_hp_ref=entertainment&ir=Entertainment (last visited, January 2014).

Perspectives

The presence of these potential positive impacts of piracy and the inability to preserve the existing business models drove the content industries to experiment with new solutions. Because it had been the first to be hit by digital piracy, the music industry also took the lead in terms of innovative business models. The first answer to falling CD sales was to move the distribution of music online. At the forefront was the iTunes Music Store operated by Apple, which opened in 2003. These legal online channels for digital music allowed consumers not only to find and download music as easily as via illegal channels, but also to start buying individual tracks instead of being forced to buy albums. Koh, Murthi and Raghunathan (2013) suggest that the latter possibility induced a new way of consuming music, which contributed to weaken the negative effect of online music piracy on physical music sales; according to their empirical assessment, it is the legal sales of online music and not digital piracy that displaced physical music sales after 2003.

In the same vein, Aguiar and Martens (2013) conclude that the online legal sales of digital music (through online stores such as iTunes or via streaming services such as Spotify) do not seem to be displaced by illegal downloading; the opposite may even occur. To establish this result, they analyze the behavior of digital music consumers on the Internet. They use direct observations of the online behavior of more than 16,000 Europeans. The main result of their analysis is that illegal downloading has no effect on legal consumption. At best, this effect is positive: a 10% increase in clicks on illegal download websites leads to an increase of 0.2% in clicks on legal purchase websites. Piracy does not induce any displacement of the legal music purchase in digital format; it might even slightly boost sales.³

New business models in the music industry also offer market solutions to increase revenues from the segment of consumers with a low willingness to pay for music and with, therefore, a high disposition to digital piracy. As

³People in the sample have willingly accepted to be observed. This introduces two potential biases: on the one hand, it is quite likely that the "heavy downloaders" have refused to be part of the sample; on the other hand, individuals in the sample may have changed their behavior knowing that they were observed. We must also keep in mind that in the relevant time period, while increasing, online music sales accounted for only a small fraction of the overall revenues of the music industry and that physical sales have been shown to suffer from piracy (5% in 2010 and 8% in 2011 according to IFPI).

Waelbroeck (2013) describes it, the streaming services (such as Spotify or Deezer) are based on a ‘freemium’ model, which combines free and premium (i.e., paying) services. The objective is to attract users with the free offering and, later, ‘convert’ them to paying subscribers. This objective can be reached through different ways: the premium offering can include additional ‘mobility’ (e.g., the possibility to access playlists on various devices, such as a computer, a tablet or a smartphone), better sound quality, a wider library of titles, or the removal of ads.

Markets for information products are undergoing major changes due to technological innovations, which triggered digital piracy and, partly as a response, new business models. As exemplified above, in this changing landscape, some research suggests that consumer behavior exhibits several interesting features. Whether these features are stable over time and space is an interesting area for future research. Such an understanding is necessary to evaluate the impact of digital piracy on markets for information products and to develop successful new business models. It is also necessary to propose appropriate public policy responses.

References

- [1] Aguiar, L. and Martens, B. (2013). Digital Music Consumption on the Internet: Evidence from Clickstream Data. Institute for Prospective Technological Studies Digital Economy Working Paper 2013/04. European Commission Joint Research Centre.
- [2] Arnold, M. A., Darmon, E., Dejean, S. and Pénard, T. (2014). Graduated Response Policy and the Behavior of Digital Pirates: Evidence from the French Three-Strike (Hadopi) Law. Mimeo.
- [3] Belleflamme, P. and Peitz, M. (2012). Digital Piracy: Theory. In Peitz, M. and Waldfogel, J. (Eds), *The Oxford Handbook of the Digital Economy*, Oxford University Press.
- [4] Danaher, B. and Smith, M.D. (2013). Gone in 60 Seconds: The Impact of the Megaupload Shutdown on Movie Sales. Mimeo.
- [5] Danaher, B., Smith, M.D., Telang, R. and Chen, S. (2014). The Effect of Graduated Response Anti- Piracy Laws on Music Sales: Evidence from an Event Study in France. *Journal of Industrial Economics*, forthcoming.

- [6] Johnson, W.R. (1985). The Economics of Copying. *Journal of Political Economy*, 93, 158-74.
- [7] Koh, B., Murthi, B.P.S. and Raghunathan, S. (2013). Shifting Demand: Online Music Piracy, Physical Music Sales, and Digital Music Sales. *Journal of Organizational Computing and Electronic Commerce*. Accepted.
- [8] Mortimer, J.H., Nosko, C. and Sorenson, A. (2012). Supply Responses to Digital Distribution: Recorded Music and Live Performances. *Information Economics and Policy*, 24, 3-14.
- [9] Novos, I. and Waldman, M. (1984). The Effects of Increased Copyright Protection: An Analytic Approach. *Journal of Political Economy*, 92, 236-46.
- [10] Novos, I. and Waldman, M. (2013). Piracy of Intellectual Property: Past, Present, and Future. *Review of Economic Research on Copyright Issues*, 10, 1-26.
- [11] Peitz, M. and Waelbroeck, P. (2006). Why the Music Industry May Gain from Free Downloading – the Role of Sampling, *International Journal of Industrial Organization*, 24, 907-913.
- [12] Peukert, C., Claussen, J. and Kretschmer, T. (2013). Piracy and Movie Revenues: Evidence from Megaupload: A Tale of the Long Tail? Mimeo.
- [13] Waldfogel, J. (2012a). Digital Piracy: Empirics. In Peitz, M. and Waldfogel, J. (Eds), *The Oxford Handbook of the Digital Economy*, Oxford University Press.
- [14] Waldfogel, J. (2012b). Copyright Protection, Technological Change, and the Quality of New Products: Evidence from Recorded Music since Napster. *Journal of Law & Economics*, 55, 715-740.
- [15] Waelbroeck, P. (2013). Digital Music: Economic Perspectives. In Towse, R. and Handke, C. (Eds), *Handbook of the Digital Creative Economy*, Edward Elgar.
- [16] Zhang, L. (2013). Intellectual Property Strategy and the Long Tail: Evidence from the Recorded Music Industry. Mimeo.

Recent titles

CORE Discussion Papers

- 2013/53 Jean GABSZEWICZ and Skerdilajda ZANAJ. (Un)stable vertical collusive agreements.
- 2013/54 François MANIQUET and Massimo MORELLI. Approval quorums dominate participation quorums.
- 2013/55 Mélanie LEFÈVRE and Joe THARAKAN. Intermediaries, transport costs and interlinked transactions.
- 2013/56 Gautier M. KRINGS, Jean-François CARPANTIER and Jean-Charles DELVENNE. Trade integration and the trade imbalances in the European Union: a network perspective.
- 2013/57 Philip USHCHEV, Igor SLOEV and Jacques-François THISSE. Do we go shopping downtown or in the 'burbs'? Why not both?
- 2013/58 Mathieu PARENTI. Large and small firms in a global market: David vs. Goliath.
- 2013/59 Paul BELLEFLAMME and Francis BLOCH. Dynamic protection of innovations through patents and trade secrets.
- 2013/60 Christian HAEDO and Michel MOUCHART. Specialized agglomerations with areal data: model and detection.
- 2013/61 Julien MARTIN and Florian MAYNERIS. High-end variety exporters defying distance: micro facts and macroeconomic implications.
- 2013/62 Luca G. DEIDDA and Dimitri PAOLINI. Wage premia, education race, and supply of educated workers.
- 2013/63 Laurence A. WOLSEY and Hande YAMAN. Continuous knapsack sets with divisible capacities.
- 2013/64 Francesco DI COMITE, Jacques-François THISSE and Hylke VANDENBUSSCHE. Vertical differentiation in export markets.
- 2013/65 Carl GAINÉ, Stéphane RIOU and Jacques-François THISSE. How to make the metropolitan area work? Neither big government, nor laissez-faire.
- 2013/66 Yu. NESTEROV and Vladimir SHIKHMAN. Algorithmic models of market equilibrium.
- 2013/67 Cristina PARDO-GARCIA and Jose J. SEMPERE-MONERRIS. Equilibrium mergers in a composite good industry with efficiencies.
- 2013/68 Federica RUSSO, Michel MOUCHART and Guillaume WUNSCH. Confounding and control in a multivariate system. An issue in causal attribution.
- 2013/69 Marco DI SUMMA. The convex hull of the all-different system with the inclusion property: a simple proof.
- 2013/70 Philippe DE DONDER and Pierre PESTIEAU. Lobbying, family concerns and the lack of political support for estate taxation.
- 2013/71 Alexander OSHARIN, Jacques-François THISSE, Philip USHCHEV and Valery VERBUS. Monopolistic competition and income dispersion.
- 2013/72 N. Baris VARDAR. Imperfect resource substitution and optimal transition to clean technologies.
- 2013/73 Alejandro LAMAS and Philippe CHEVALIER. Jumping the hurdles for collaboration: fairness in operations pooling in the absence of transfer payments.
- 2013/74 Mehdi MADANI and Mathieu VAN VYVE. A new formulation of the European day-ahead electricity market problem and its algorithmic consequences.
- 2014/1 Erik SCHOKKAERT and Tom TRUYTS. Preferences for redistribution and social structure.
- 2014/2 Maarten VAN DIJCK and Tom TRUYTS. The agricultural invasion and the political economy of agricultural trade policy in Belgium, 1875-1900.
- 2014/3 Ana MAULEON, Nils ROEHL and Vincent VANNETELBOSCH. Constitutions and social networks.
- 2014/4 Nicolas CARAYOL, Rémy DELILLE and Vincent VANNETELBOSCH. Allocating value among farsighted players in network formation.
- 2014/5 Yu. NESTEROV and Vladimir SHIKHMAN. Convergent subgradient methods for nonsmooth convex minimization.

Recent titles

CORE Discussion Papers - continued

- 2014/6 Yuri YATSENKO, Natali HRITONENKO and Thierry BRECHET. Modeling of environmental adaptation versus pollution mitigation.
- 2014/7 Sanjeeb DASH, Oktay GÜNLÜK and Laurence A. WOLSEY. The continuous knapsack set.
- 2014/8 Simon BUCKLE, Mirabelle MUÛLS, Joerg LEIB and Thierry BRECHET. Prospects for Paris 2015: do major emitters want the same climate.
- 2014/9 Lionel ARTIGE, Antoine DEDRY and Pierre PESTIEAU. Social security and economic integration.
- 2014/10 Mikhail ISKAKOV, Alexey ISKAKOV and Alexey ZAKHAROV. Equilibria in secure strategies in the Tullock contest.
- 2014/11 Helmuth CREMER and Pierre PESTIEAU. Means-tested long term care and family transfers.
- 2014/12 Luc BAUWENS, Lyudmila GRIGORYEVA and Juan-Pablo ORTEGA. Estimation and empirical performance of non-scalar dynamic conditional correlation models.
- 2014/13 Christian M. HAFNER and Arie PREMINGER. A note on the Tobit model in the presence of a duration variable.
- 2014/14 Jean-François CARPANTIER and Arnaud DUFAYS. Specific Markov-switching behaviour for ARMA parameters.
- 2014/15 Federico GRIGIS DE STEFANO. Strategic stability of equilibria: the missing paragraph.
- 2014/16 Claudio TELHA and Mathieu VAN VYVE. Efficient approximation algorithms for the economic lot-sizing in continuous time.
- 2014/17 Yukai YANG. Testing constancy of the error covariance matrix in vector models against parametric alternatives using a spectral decomposition.
- 2014/18 Koen DECANQ, Marc FLEURBAEY and Erik SCHOKKAERT. Inequality, income, and well-being.
- 2014/19 Paul BELLEFLAMME and Martin PEITZ. Digital piracy: an update.

Books

- V. GINSBURGH and S. WEBER (2011), *How many languages make sense? The economics of linguistic diversity*. Princeton University Press.
- I. THOMAS, D. VANNESTE and X. QUERRIAU (2011), *Atlas de Belgique – Tome 4 Habitat*. Academia Press.
- W. GAERTNER and E. SCHOKKAERT (2012), *Empirical social choice*. Cambridge University Press.
- L. BAUWENS, Ch. HAFNER and S. LAURENT (2012), *Handbook of volatility models and their applications*. Wiley.
- J-C. PRAGER and J. THISSE (2012), *Economic geography and the unequal development of regions*. Routledge.
- M. FLEURBAEY and F. MANIQUET (2012), *Equality of opportunity: the economics of responsibility*. World Scientific.
- J. HINDRIKS (2012), *Gestion publique*. De Boeck.
- M. FUJITA and J.F. THISSE (2013), *Economics of agglomeration: cities, industrial location, and globalization*. (2nd edition). Cambridge University Press.
- J. HINDRIKS and G.D. MYLES (2013). *Intermediate public economics*. (2nd edition). MIT Press.
- J. HINDRIKS, G.D. MYLES and N. HASHIMZADE (2013). *Solutions manual to accompany intermediate public economics*. (2nd edition). MIT Press.

CORE Lecture Series

- R. AMIR (2002), Supermodularity and complementarity in economics.
- R. WEISMANTEL (2006), Lectures on mixed nonlinear programming.
- A. SHAPIRO (2010), Stochastic programming: modeling and theory.