ESSAYS ON THE DEMAND FOR INFORMATION GOODS

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EMMI MARTIKAINEN

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Contents

LIST OF ESSAYS

ESSAY 1

Martikainen, Emmi. Does File-Sharing Reduce DVD Sales? *Unpublished manuscript. Submitted to a journal*.

ESSAY 2

Martikainen, Emmi. The Impact of Visual Effects on Movies' Box Office Revenues. *Unpublished manuscript. Submitted to a journal.*

ESSAY 3

Laamanen, Jani-Petri– Martikainen, Emmi. The Demand for Live Performing Arts: Evidence from Opera. *Unpublished manuscript*.

ESSAY 4

Martikainen, Emmi – Schmiedel, Heiko – Takalo, Tuomas. Convergence of European Retail Payments. *Submitted to a journal. A version of this paper is published in the ECB Occasional Paper Series (ECB Occasional Paper No 147, June 2013).*

1 INTRODUCTION

Information goods are goods that can be expressed in a digital format; they are sequences of 0s and 1s which affect economic outcomes[1] (Shapiro and Varian 1999, pp. 3 and Quah 2003, pp. 4). Entertainment, such as movies, music and games, are classical examples of information goods, much like books, software and ideas. If we think about the definition in Shapiro and Varian (1999) which emphasizes that anything that *can* be expressed in a digital format is, in fact, information good, it becomes clear that the universe of information goods is actually quite large. Moreover, making the distinction between information goods and material goods becomes more difficult to make as technology progresses. Indeed, new 3D printers transform bit strings into physical material, making it possible to print three-dimensional objects, such as guns and food, for example. Even though the printed good is a material good, the bit string representation of it, the *recipe* of the good, has the properties of information good[2]. As 3D printing has become more affordable, intellectual property disputes regarding the designs and blueprints of printable products have started to rise[3].

Digitalization has changed the business models for many information good industries, leading to many dismal prophecies regarding the future of these industries. The music industry was the first entertainment business hit by digital piracy and changing consumption habits. For many decades the cornerstone of the business was the sale of physical recordings. In the digital distribution era, sales of CDs have plummeted and live concerts and ancillary products such as merchandise were predicted to become important sources of revenue. Until very recently, digital distribution and online streaming services were marginal sources of revenue. In 2012, however, the music industry experienced its first year of growth since 1999, due to growth in digital distribution (IFPI 2013). Considering the commonly held view that digitalization was the number one threat to the industry, it is somewhat surprising that Edgar Berger, the president and CEO of Sony Music Entertainment, stated in 2013 that "The reality is, digital is saving music" (BBC News 2013). Considering the speed of technological progress, it is

[1] The terms digital goods and information goods are used interchangeably.
[2] Quah (2002) uses the term *recipe* in describing digital goods.
[3] See, for example Bradshaw et al. (2010).

reasonable to assume that digital goods continue to gain in importance. According to Gartner (2012), consumers spending on digital goods and entertainment products and services will reach $2.7 trillion by 2016. This amounts to $130 billion annual growth in spending between 2012 and 2016. Understanding the unique properties of information goods, and the implications these properties have on the economy is thus increasingly important.

The elusive nature of information goods evokes constantly new legal issues as well. In the US, consumers' right to resell digital property is debated in the context of digital music (Sandoval 2012, Kravets 2012). A digital recycling service offers consumers the possibility to buy and sell legally acquired, ”used” digital music files. The first sale doctrine states in short that the owner of a copyrighted object has the right to sell it. The representatives of the recording industry are, however, against the view that digital files are objects that can be owned and resold, and argue that the service creates illegal copies of the original. Whether digital goods are treated as objects that can be owned or services that can only be licensed continues to be debated. Equally debated is the distinction between an original and a copy when both objects are digital. In Europe, the European Court of Justice has ruled that it is, in fact, permissible to resell digital goods, as long as the seller can no longer be able to use the product after the sale[4].

In the four empirical essays included in this thesis, the demand for three kinds of information goods – movies, live performing arts or more specifically, opera, and payment instruments – is estimated. The first essay concentrates on the short-term relationship between BitTorrent file-sharing, i.e. digital piracy, and movie DVD sales. The short-term displacement effect from piracy is not statistically different from zero, and even the most pessimistic estimate suggests that the sales displacement effect is small. The result is, perhaps, surprising but in line with recent empirical studies on piracy. The second essay studies the determinants of demand for movies, focusing on the role of digital visual effects in determining demand. The results suggest that visual effects are positively associated with box office revenue, but the effect differs across different conditional quartiles of the revenue distribution. Specifically, for movies in the lowest quartile of box office revenues, the effect is positive and both statistically and economically significant. In the third essay, the demand for opera tickets in the Finnish National Opera is estimated using detailed sales system data. The price elasticity of demand is shown to be negative and close to unity, a result which has been surprisingly difficult to confirm in the earlier empirical literature where positive price elasticity

[4] See the judgment of UsedSoft GmbH vs. Oracle Interational Corp.: http://curia.europa.eu/juris/document/document.jsftext=&docid=124564&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=2558320

estimates are common. The second and third essay also confirm the theory that expert reviews, awards, the presence of stars and other quality signals do have a significant impact on demand– a property that is distinctive in information goods. In the fourth essay, the demand for payment instruments in different European countries is estimated from the viewpoint of convergence. Countries are shown to converge towards more efficient payment instrument use, that is, the use of cash and cheques have been substituted by the use of digital payment methods.

The era of digitalization has been called e.g. *the New Economy*, *the Digital Economy*, *the Information Economy* and *the Internet Economy*. Broadly speaking, these terms are used to describe the rise of digital technologies, the internet, social media, knowledge-intensive work and globalization – and a myriad of other things. The viewpoint of the essays included in this thesis is microeconomic, and the issues of how digital technologies affect e.g. productivity, economic growth, employment or division of labor are not addressed.

In the following sections of Chapter 1, three properties of information goods are discussed: information goods are experience goods, they are non-rival and they have high fixed and zero marginal cost of production[5]. These issues have implications for e.g. how the goods are bought and sold (the issues of pricing, bundling and versioning) and how the incentives to produce information goods are managed (the issues of piracy and intellectual property rights). Information goods are often associated with positive network effects, the phenomenon of long tail, and the presence of superstars. These properties are also discussed briefly. The following sections are based on Shapiro and Varian (1999) and Quah (2003). Chapter 2 summarizes the included essays and discusses how this thesis contributes to our understanding of information goods.

1.1 Properties of information goods

Information goods have distinct features which have an effect on economic outcomes and economic policy. Information goods are *experience goods*, they are *non-rival* and can be *non-excludable,* and they have high fixed cost of production but *zero marginal cost*. Additionally, the economic concepts of *network effects*, *long tail* and *superstars* apply to many information goods.

[5] The purpose is not to provide a literature survey on the issue, but to discuss the general features of information goods and what implications those features have on economic outcomes.

1.1.1 Information goods as experience goods

Experience goods are goods whose quality or value is revealed only when the good is consumed (Nelson 1970, Shapiro and Varian 1999). For example, the consumer doesn't know whether or not she will enjoy a movie or a live performance of opera until she has seen the movie or experienced the performance. From the viewpoint of social welfare, limited information can lead to suboptimal consumer choices and decrease the incentives of companies to invest in quality, thus lowering social welfare (Stiglitz 1989).

To overcome the problem of unknown quality, consumers are often offered the opportunity to preview the product in some way. In the case of movies, movie trailers are a way to give the consumer the opportunity to evaluate the movie before making the decision to purchase. In addition to movie trailers, observable attributes of the film function as quality signals. Such attributes include e.g. the cast and director, the presence of star actors, size of the budget, award nominations and wins and the genre and rating of the movie. Additionally, when quality is unknown, expert reviews and word-of-mouth effects become potentially important as signals of quality.

In addition to aforementioned quality signals, free sampling, promotional discounts, branding, advertising and reputation are often used to alleviate consumers' uncertainty about the quality of the product (Shapiro and Varian 1999).

1.1.2 Non-rivalry, non-excludability, piracy and intellectual property protection

Information goods are non-rival and sometimes non-excludable. They thus share the properties of public goods, which are both non-rival and non-excludable. If a good is non-rival, the consumption by one consumer does not prevent other consumers from consuming it (Shapiro and Varian 1999). Non-excludability means that it is hard or impossible to exclude other consumers from consuming the good: an often used example of non-excludable information good is knowledge.

Non-rivalry is related to the property of zero marginal cost of production. Information goods have typically high fixed costs of production and zero

marginal cost. This means that the cost of making the original product is high, but the cost of producing additional copies is zero. This property of information goods is even more pronounced in the digital age: the fixed cost of producing e.g. an original music recording can be high, while the cost of creating a digital copy is zero. The fixed cost is also often sunk in the sense that the production investment has to be made before the demand is revealed, the demand is often hard to predict and the costs cannot be recovered if the product fails (Shapiro and Varian 1999).

In a competitive market, the prices of goods converge to the marginal cost, that is, prices approach zero. If products can be copied at no cost, there are no incentives to produce the originals. In order to create incentives to produce information goods that have zero marginal cost, some temporary monopoly power is granted for the producers. The monopoly power is realized in the form of patents, copyright and trademarks.

The temporary monopoly power has both positive and negative effects on social welfare. In the absence of monopoly, consumer surplus would be higher; on the other hand, without monopoly power, information goods might not be produced at all. Even though monopoly power is granted, it is not necessarily enforceable. The prevalence of digital piracy demonstrates the problems associated with enforcing copyright in the digital age. The effect of piracy on social welfare is not necessarily negative, however, but depends on whether or not piracy substitutes sales. If those who acquire an illegal copy of a good would not have bought the original at the market price, then piracy increases welfare: the producer is no worse off than before the piracy and the consumer has utility from consuming the pirated good. Piracy can have, in this sense, the effect of expanding the market. If piracy affects the incentives to create in such a way that the information good is not produced in the first place, the effect of piracy on social welfare is, however, negative. Piracy can also have a positive effect on overall demand if there are positive network effects in using the good or if piracy e.g. enables sampling or functions as an advertisement (see Peitz and Waelbroeck 2006a, 2006b).

1.1.3 Price discrimination and versioning

Since the marginal cost of information goods is close to zero, pricing of information goods is based on consumer value rather than marginal cost (Shapiro and Varian 1999). When pricing is not based on costs but consumer value, price discrimination and versioning are often present. Price discrimination is possible in a monopolistic or oligopolistic market or in a competitive market when products are sufficiently differentiated or there are market frictions, such as switching costs. Price discrimination can mean charging different prices for different individuals or charging different prices

for different groups. Versioning means that different versions of the same product are offered to different customers. For example, the professional networking service LinkedIn offers free access, and sells premium memberships with additional features with a price ranging from $15 to $54 per month[6]. In the free version of the music streaming service Spotify, the music is interrupted with advertisements, while the premium version is ad-free. Often used versioning strategy is to use delay. For example, movies are first released on theatres, then on pay-tv, then on home video market, video-on-demand and networked television. Customers who want to see a movie right after its release go to movie theaters, while customers who are less enthusiastic wait for the home video or networked television release[7]. Another classical example of versioning is the release of books on hardcover and later on paperback. Customers self-select themselves in two groups depending on how quickly they need to or want to acquire a book and how much they are willing to pay.

1.1.4 Additional features of information goods: network effects, long tail and product variety

For many information goods, there are positive networks associated with the use of the good. Positive network effects are present if consumer's utility from a good depends on the number of other consumers that use the good. Many information goods, such as social media, software, payment innovations, game consoles and games, mobile operating systems and even music exhibit direct or indirect network effects[8]. When positive network effects are present, it is common that the size of the network grows gradually until a critical mass is reached after which the market size suddenly explodes. The diffusion of innovation thus often resembles a so-called S-curve[9]. Closely related concepts to critical mass are tipping and standard wars. Tipping occurs when there are more than one competing goods in the market, and small initial advantage in the other good together with network effects causes one of the products to become dominant. The concept of standards and standard wars in economics refers to the socially optimal choice of standards when more than one alternatives are available: the dominance of Blu-Ray over HD discs is a relatively recent example. Choice of standards is closely related to path dependency[10].

[6] See www.linkedin.com

[7] With legal digital distribution channels gaining in popularity, and in the presence of digital piracy, the traditional release window has been criticized and the time between theatrical release and home video market is expected to become shorter (see, e.g. . Eliashberg et al. 2006).

[8] Internet business models are typically multi-sided platforms. For multi-sided platforms, network effects are particularly important. For a review on multi-sided platforms, see e.g. Rochet and Tirole (2006).

[9] For a review on the origin of economic modeling the diffusion of technological innovations by using S-curves, see David (2003).

[10] Shy (2011) presents a survey on network effects and related concepts.

Many information goods that are sold at online marketplaces possess the property of long tail in sales (see Brynjolfsson et al. 2006, 2010a, 2010b). Long tail implies that many less popular individual items are sold in small quantities, while some superstar products are sold in large quantities. The low stocking and distribution costs of information goods have abetted this phenomenon: it can be profitable to sell e.g. many different obscure books to a large customer base if the virtual stocking and distribution costs are negligible. The existence of long tail phenomenon has been studied e.g. in the market for clothes (Brynjolfsson et al. 2011), books (Peltier and Moreau 2012) and record sales (Bourreau et al. 2012).

The long tail property of information goods is related to the issue of product variety and consumer surplus. According to Bjyrnolfson et al. (2003) the number of titles available at Amazon.com was 57 times larger than the number of titles in an average bookstore. The ratio is likely to be even higher now, ten years after the study. According to the authors, the increased availability of obscure book titles increased consumer welfare between $700 million and $1 billion in the year 2000. With digital goods that have no physical stocking costs, the long tail effect and the welfare gains from increased product variety should be even more pronounced.

2 SUMMARY OF THE ESSAYS

The four essays included in the thesis are empirical studies on the demand for three types of information goods: movies, live performing arts and payment instruments.

In the first essay, the file-sharing elasticity of DVD sales is estimated using data on popular file-sharing network BitTorrent. The results indicate that digital piracy has a small short-term effect on the demand for movie DVDs: the effect is not statistically different from zero and the most pessimistic lower bound for the elasticity is -0.21. The data and estimation results support the view that the market is segmented, i.e. the customers purchasing movie DVDs and downloading illegitimate copies are in fact, two different customer groups.

In the second essay, the impact of movie-specific attributes on movie demand is estimated. To analyze if technological change in movie content is quality enhancing for the consumers, a measure of movies' digital visual effect intensity is constructed. According to the estimation results, the impact of visual effects on demand depends on the popularity of the movie: for less-selling titles, the effect of visual effects is positive and statistically significant, while for the more popular items, increasing visual effects would not lead to an increase in demand. The second essay adds to our understanding on the determinants of demand for movies, and confirms the importance of quality signals in consumer choice.

Digital technologies have expanded the audience for live performing arts with production companies offering live performances of e.g. opera to audiences by broadcasting them to cinemas or offering them via the internet (Bakshi and Throsby 2013). Much like the consumption of e.g. music and movies, the consumption of live performing art performances is likely to change in the digital era. The third essay estimates the determinants of demand for opera using detailed sales system data from the Finnish National Opera. The price elasticity of demand is negative and statistically significant, and performance and opera-specific factors influence demand significantly. The estimations results highlight the importance of quality signals in determining the demand for live performing arts. The estimated price elasticity of demand is negative, a results which is consistent with economic theory but which has been difficult to confirm in the earlier empirical literature.

In the fourth essay, the convergence of European retail payment instrument demand is estimated for the time period 1995–2011. The results indicate that while cross-country differences in payment instrument use exist in Europe, in

general the use of cash and cheques has been replaced by the use of more efficient digital payment instruments.

The data used in the first three essays are unique and collected specifically for this thesis. The first essay ”Does File-Sharing Reduce DVD Sales?” uses data on the downloads of movie files on BitTorrent, a popular file-sharing network. The essay is the first research article to use actual BitTorrent file-sharing data combined with DVD sales data to evaluate the substitution effect between piracy and sales. The second essay ”The Impact of Visual Effects on Movies' Box Office Revenues” uses a detailed data set containing several movie-specific variables, some of them which have not before been available in the empirical literature on movie demand. The variable measuring the visual effect intensity of movies is constructed following the idea in Ji and and Waterman (2011), and used for the first time in a demand estimation. The third paper, "The Demand for Live Performing Arts: Evidence from Opera”, uses detailed price and sales data from the Finnish National Opera's sales system in addition to performance-specific data collected from various sources. In the empirical literature on the demand for opera, detailed price and sales data has not been available, and the use of average prices and sales has been common. The lack of detailed data has been supposedly one of the reasons why the price elasticity estimates of demand have varied across studies. The fourth essay uses retail payments data made available by the European Central Bank (ECB). The study is the first empirical paper using data on the volume and value of retail payment instrument use in evaluating how convergence in payment method use has evolved after the introduction of euro, the creation of Single European Payments Area (SEPA), and during the recent economic crisis.

The essays increase our understanding on the demand for information goods in several ways. The use of payment instruments in Europe convergences toward more efficient, digital payment instrument use, but significant cross-country differences still exist. Quality signals, such as the presence of star performers, awards, reviews and word-of-mouth have an important role in determining the demand for movies and opera, and the impact is stronger the more uncertain the quality is before the purchase. Technological advances in the form of digital visual effects are quality enhancing for the less popular films in the sense that the demand for movies responds positively to the number of visual effects used, but the effect varies across the conditional revenue distribution. The price elasticity of demand for opera is negative, suggesting that the puzzle of positive price elasticity might be the result of poor data rather than a reflection of the actual behavior of the opera-attending public. Digital piracy does not seem to have a drastic short-term impact on movie DVD sales, a result which has been confirmed in the recent empirical literature, but which is against the commonly held view that piracy results in a substantial revenue loss.

2.1 Essay 1: Does File-Sharing Reduce DVD Sales?

The impact of digital piracy on the sales of information products is a highly debated issue, and the estimates of the magnitude of the effect vary. To quantify the market harm of digital piracy for movies, the file-sharing elasticity of movie demand is estimated using data on BitTorrent downloads and the sales of newly released movie DVDs in the USA. File-sharing is measured by using data on torrent file downloads on mininova.org, one of the most popular torrent search and indexing websites during the study period. Since torrent file-sharing via BitTorrent was during the study period the most popular way to engage in file-sharing, torrent file downloads provide a good proxy for digital piracy. To address endogeneity between downloads and sales, estimations are carried out with dynamic panel methods. After controlling for the autoregressive component and declining time trend in sales, the estimated effect of illegal downloads on sales is not statistically different from zero. The results provide an upper bound for the magnitude of the short-term sales displacement: the estimated elasticity is in the range [-0.21, 0.06] in the preferred model specification. Along with Smith and Telang (2009), the article presents a novel approach to measuring file-sharing activity on the BitTorrent network and is, to our knowledge, the first study to use data on torrent downloads and DVD sales to study the relationship between digital piracy and sales.

2.2 Essay 2: The Impact of Visual Effects on Movies' Box Office Revenues

Visual effects and especially digital visual effects are now an established part of the film industry, yet there is little to no empirical work on the impact of visual effects on movie demand. There is also little theoretical evidence on the effect of new technology on the demand for information products in general. Waterman (2007) suggests that technological change can have two effects: cost reducing and quality enhancing. With movies, cost reducing technological change occurs when new technology enables filmmakers to achieve similar outcomes than before with less costs. For example, crowd scenes can be created digitally without the need of actual people working as extras. Quality enhancing effect occurs when new technology allows the creation of more impressive visual effects than before, e.g. monsters, landscapes, architectural scenes, action sequences, or more realistic and impressive animation. Waterman (2007) shows that under some assumptions, if audience responds positively to the enhanced quality brought about by new technology, producers have an incentive to increase production investment at the cost of product variety. This result is consistent with the casual observation that movie production budgets have increased during a time when digital technologies have ad-

vanced. However, the question of whether or not audience actually does respond positively to the enhanced quality brought about by new technology is an empirical one, and the subject of the study.

The impact of visual effects on box office revenues is estimated for 248 movies released in the USA in 2011. A measure of visual effects in a film is constructed based on movies' end credit information: visual effects are measured by the share of visual effect crew on total crew. The quantile regression estimation results suggest that the impact of visual effects on demand differs across revenue quartiles: the effect is significant for movies in and below the median. For the most popular titles, the effect is not statistically different from zero. Also the effect of winning an Oscar differs across revenue quartiles, and has the strongest impact for the less popular movies.

2.3 Essay 3: The Demand for Live Performing Arts: Evidence from Opera

The empirical evidence on the demand for performing arts is mixed, especially concerning price elasticity of demand. The estimates vary and some studies even report positive price elasticity indicating that performing arts is a Veblen good. However, the lack of good data and identification problems suggest that the positive elasticity results are more of a sign of endogeneity or omitted variables problems than evidence for actual positive price elasticity.

We use detailed data on prices and quantities of tickets sold in the Finnish National Opera to estimate the demand for opera tickets. The data set is rich enough to allow us to estimate the effect of several performance-specific characteristics on demand. In addition, unlike in majority of the studies, our ticket sales data is sufficiently disaggregated to avoid the problems brought about by aggregation and construction of average price measures in estimating price elasticity. In particular, we are able to control for all performance and play characteristics that influence pricing and are likely to influence demand as well. Our data also allows us to separate between full-priced and different types of campaign tickets. This is important since low-pricing strategy is likely to be associated with anticipated demand. The number of tickets sold is limited by the capacity of the opera house, so that the actual demand is not observed for the performances that are sold out. We circumvent this problem by estimating a demand model using censored regression method, which yields unbiased results even in the presence of censoring.

We find that operas in their premiere season are more popular than reprises. Demand is higher for non-classical operas and for performances with a famous Finnish opera singer. Demand for reprises is determined partly by different factors than the demand for operas in their premiere season. Quality signals are important: in addition to star performers, the overall worldwide popularity

of the opera and critical reviews influence demand. The effect of star performers is strongest for reprises, while critical reviews have the strongest impact on operas in their premiere season. There is also evidence of seasonal effects, and competition between operas. By excluding temporarily discounted tickets and controlling for star performers, specially priced performances, and different seating areas, we are able to credibly estimate the price elasticity of demand. We find that the price elasticity is statistically significant, negative and close to unity for the whole sample. Reprises are more sensitive to own price changes and to changes in the prices of substitutes than operas in their premiere season.

2.4 Essay 4: Convergence of European Retail Payments

The article evaluates the cross-country convergence of payment behaviors in the European retail payments market. The findings increase the general understanding of how convergence has evolved since the introduction of the single currency, the creation of the Single Euro Payments Area (SEPA) and during the recent economic crisis. The analysis is based on data on the volume and the value of transactions made in cash, by debit card, credit card, direct debit, credit transfer and cheque, and in e-money, in the 27 countries of the European Union (EU) over the period 1995–2011. The paper is the first to use recent enough data to fully measure the impact of the introduction of the single currency on retail payment integration. Moreover, the study provides some preliminary results regarding the impact of SEPA and the recent economic crisis on the convergence process.

The study applies two methods to quantify convergence: sigma convergence and beta convergence. The rationale behind sigma convergence is that if countries become increasingly homogeneous over time, the cross-country distribution of transactions should become less dispersed. In estimations, this translates to the standard deviation having a negative time trend, i.e. it decreases over time. Beta convergence is based on the idea of a catching-up process; in countries which start from low-level use of a particular payment instrument, the volume or the value of transactions should grow faster than in countries which start from a higher level.

According to the estimation results, countries have become less dispersed in terms of cash, debit card, credit card, direct debit and credit transfer use in the period after the introduction of euro. However, in terms of cash use, cross-country convergence is very slow. For cheques and e-money, the standard deviation is volatile and there is no unambiguous evidence of sigma convergence, even in the period after the introduction of the euro. For beta convergence, countries that started from a low level of debit and credit card use have been catching up, when card use is measured in terms of the number

of per capita transactions. There is also evidence of beta convergence for the value of direct debits and credit transfers.

REFERENCES

Bakhshi, Hasan – Throsby, David (2013). Digital Complements or Substitutes? A Quasi-Field Experiment from the Royal National Theatre. *Journal of Cultural Economics*, DOI 10.1007/s10824-013-9201-2. Available at: http://link.springer.com/article/10.1007%2Fs10824-013-9201-2

BBC News (2013). "Digital is Saving, Not Killing Music, Says Sony Chief Edgar Berger". Retrieved 4 June, 2013. Available at: http://www.bbc.co.uk/news/technology-21594406

Bradshaw, Simon – Bowyer, Adrian – Haufe, Patrick (2010). The Intellectual Property Implications of Low-Cost 3D Printing. *SCRIPTed*, Vol. 7(1).

Brynjolfsson, Erik – Smith, Michael D. – Hu, Yu (2003). Consumer Surplus in the Digital Economy: Estimating the Value of Increased Product Variety at Online Booksellers. *Management Science*, Vol. 49(11), 1580–1596.

Brynjolfsson, Erik – Hu, Yu – Smith, Michael D. (2010a). The Longer Tail: The Changing Shape of Amazon's Sales Distribution Curve. Working Paper. Retrieved 21 October 2013. Available at: http://ssrn.com/abstract=1679991.

Brynjolfsson, Erik – Hu, Yu – Smith, Michael D. (2010b). Research Commentary: Long Tails vs. Superstars: The Effect of Information Technology on Product Variety and Sales Concentration Patterns. *Information Systems Research*, Vol. 21(4), 736–747.

Brynjolfsson, Erik – Hu, Yu – Simester, Duncan (2011). Goodbye Pareto principle, Hello Long Tail: The Effect of Search Costs on the Concentration of Product Sales. *Management Science*, Vol. 57(8), 1373–1386.

David, Paul (2003). Zvi Griliches and the Economics of Technology Diffusion: Adoption of Innovations, Investment Lags, and Productivity Growth – "Connecting the Dots". *Prepared for the Conference on R&D, Education and Productivity Held in Memory*

of Zvi Griliches (1930–1999). Available at SSRN: http://ideas.repec.org/p/wpa/wuwpla/0502002.html

Eliashberg, Jehoshua – Elberse, Anita – Leenders, Mark A.A.M. (2006). The Motion Picture Industry: Critical Issues in Practice, Current Research & New Research Directions. *Marketing Science*, Vol. 25(6), 630–661.

Gartner (2013). Market Trends: Worldwide Consumer Technology Spending. Retrieved 15 June, 2013. Available at: http://www.gartner.com/DisplayDocument?id=2058016&ref=clientFriendlyUrl

IFPI (2013) Digital Music Report. Retrieved 15 June, 2013. Available at: http://www.ifpi.org/content/library/dmr2013.pdf

Ji, Sung Wook – Waterman, David (2011). Production Technology and Long Term Trends in Movie Content: An Empirical Study. Available at: http://indiana.edu/~telecom/people/faculty/waterman/ProductionTechnology_DW_final.pdf

Kravets, David (2012). Judge Refuses to Shut Down Online Market for Used MP3s. *Wired*. Retrieved 4 June, 2013. Available at: http://www.wired.com/threatlevel/2012/02/pre-owned-music-lawsuit-2/

Nelson, Philip (1970). Information and Consumer Behavior. *Journal of Political Economy*, Vol. 78(2), 311–329.

Peitz, Martin – Waelbroeck, Patrick (2006a). Piracy of Digital Products: A Critical Review of the Theoretical Literature. *Information Economics and Policy*, Vol. 18(4), 449–476.

Peitz, Martin – Waelbroeck, Patrick (2006b). Why the Music Industry May Gain from Free Downloading – the Role of Sampling. *International Journal of Industrial Organization*, Vol. 24(5), 907–913.

Peltier, S – Moreau, F. (2012). Internet and the ‘‘Long Tail versus Superstar Effect’’ Debate: Evidence from the French Book Market. *Applied Economics Letters*, Vol. 19(8), 711–715.

Quah, Danny (2003) Digital Goods and the New Economy. *CEP Discussion Paper* (563). Centre for Economic Performance, London School of Economics.

Rochet, Jean-Charles – Tirole Jean (2006). Two-Sided Markets: A Progress Report. *RAND Journal of Economics*, Vol. 37(3), 645–667.

Sandoval, Greg (2012). Judge Denies EMI's Bid to Halt Resale of Digital Music. *CNet*. Retrieved 4 June, 2013. Available at: http://news.cnet.com/8301-31001_3-57372464-261/judge-denies-emis-bid-to-halt-resale-of-digital-music/

Shapiro, Carol – Varian, Hal (1999) Information Rules: A Strategic Guide to the Network Economy. Harvard Business School Press, Boston, Massachusettes.

Shy, Oz (2011). A Short Survey on Network Economics. *Review of Industrial Organization*, Vol. (47), 119–149.

Smith, Michael D. – Telang, Rahul (2006). Piracy or Promotion? The Impact of Broadband Internet Penetration on DVD Sales. *Working Paper*, Carnegie Mellon University, John III Heinz School of Public Policy and Management.

Stiglitz, Joseph E. (1989). Imperfect Information in the Product Market. In the Handbook of Industrial Organization, Elsevier. Edition 1, Vol. (1), 769–847.

Waterman, David (2007). The Effects of Technological Change on the Quality and Variety of Information Products. *Economics of Innovation and New Technology*, Vol. 16(8), 587–594.

ESSAY 1

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Does File-Sharing Reduce DVD Sales?

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Does File-Sharing Reduce DVD Sales?

Emmi Martikainen

Abstract The short-term effect of BitTorrent file-sharing on movie DVD sales is estimated using sales data on newly released DVDs and torrent file downloads during a 13-week period between March and May 2009 in the USA. To overcome endogeneity between downloads and sales, the analysis is carried out in a dynamic panel setting. After controlling for an autoregressive component and a declining time trend in sales, the file-sharing elasticity of sales is not statistically different from zero in the difference GMM estimations. Moreover, the results suggest an upper bound of -0.21 of elasticity, indicating that the short-term sales displacement effect is moderate at worst.

Keywords Digital piracy · File-Sharing · DVD Sales · Dynamic panel estimation

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1 Introduction

The impact of digital piracy on the sales of information products is a highly debated issue, and the estimates of the magnitude of the effect vary. To quantify the market harm of digital piracy for movies, the file-sharing elasticity of movie demand is estimated using data on BitTorrent downloads and the sales of newly released movie DVDs in the USA. File-sharing is measured by using data on torrent file downloads on mininova.org, one of the most popular torrent search and indexing websites during the study period. Since torrent file-sharing via BitTorrent was during the study period the most popular way to engage in file-sharing, torrent file downloads provide a good proxy for digital piracy. To address endogeneity between downloads and sales, estimations are carried out with dynamic panel methods. After controlling for the autoregressive component and declining time trend in sales, the estimated effect of illegal downloads on sales is not statistically different from zero. The results provide an upper bound for the magnitude of the short-term sales displacement: the estimated elasticity is in the range [-0.21, 0.06] in the preferred model specification. Along with [45], this article presents a novel approach to measuring file-sharing activity on the BitTorrent network and is among the first studies to use data on torrent downloads to study the relationship between sales and downloads.

Since the emergence of the highly popular file-sharing program Napster in 1999, the music industry has taken legal action against over 30 000 individual users for copyright infringement [24]. The motion picture industry is following suit, claiming it lost 2.3 billion dollars to digital piracy in the year 2005 [25]. Some studies estimate the loss from overall motion picture piracy to be over 20 billion dollars yearly [43]. However, both theoretical and empirical economic literature offer conflicting conclusions concerning the effects of file-sharing on the sales of the original product. Peitz and Waelbroeck [37] provide a review on the theoretical literature on the effects of copying. Theoretically, illegal copying can substitute sales and decrease industry profits. On the other hand, availability of pirated content can increase consumer's awareness of the product and promote sales. In the presence of network effects, as is the case with software, file-sharing can have positive effects on industry profits. Possibility to sample can either increase or decrease sales. In the long term illegal copying can have an impact on prices and consumers' willingness-to-pay and affect the supply of information goods. Empirical literature on file-sharing, which has concentrated on the question of whether or not file-sharing can explain the substantive drop in record sales during the last decade, reaches equally conflicting conclusions. Majority of the studies find a substantive sales decline attributed to file-sharing, whereas some studies using actual file-sharing data find no evidence of sales replacement [35].

The focus of the copyright debate has been shifting from music to the motion picture industry. Even though movie file-sharing has been rapidly increasing in popularity, the literature concerning the effects of file-sharing on movie business is still very limited. Due to the differences in music and movie

products, some differences in the way file-sharing affects the music and the motion picture industries can be expected. Unlike in music, where sampling and exposure effects might be considerable, or in software, where network effects are often present, movies are likely to be more susceptible to the negative effects of file-sharing. Even though movies can be consumed through different channels (theater, DVD sales and rentals, digital consumption, television etc.), they are often viewed only once, whereas music is typically consumed multiple times [39]. Movies are also hard to sample, and the exposure effect is not necessarily relevant.

File-sharing is related to the well-studied problem of optimal degree of intellectual property protection. At the heart of the problem is the trade-off between social welfare and incentives to create. Creating is costly, while the marginal cost of producing a digital copy from the original is zero. Without considering the incentives of creators and with zero marginal cost, social welfare would be maximized by allowing the product to be copied freely. However, if incentives to create are hampered due to piracy, there are no creative products to consume. In a dynamic setting, when incentives are considered, piracy can thus result in a welfare loss. However, piracy affects incentives to create through reduced revenue only if consumers who would have otherwise bought a legal product acquire an illegal copy, that is, if piracy substitutes sales.

From the creator's perspective the consequences of copying and thus incentives to create depend on the "market harm" of copying: the way in which the availability of unauthorized copies substitutes sales and decreases revenue. The concept of market harm is crucial from legal perspective as well. In the precedent A&M Records Inc. v. Napster case from 2001, Napster was found guilty of copyright infringement and ordered to shut down. The decision was motivated in part by the fourth factor of the doctrine of fair use, which considers the harmfulness of use of copyrighted material. The importance of "market harm" is well presented in the following quote from the court's decision:

> A challenge to a noncommercial use of a copyrighted work requires proof either that the particular use is harmful, or that if it should become widespread, it would adversely affect the potential market for the copyrighted work...What is necessary is a showing by a preponderance of the evidence that some meaningful likelihood of future harm exists. If the intended use is for a commercial gain, that likelihood [of market harm] may be presumed. *But if it is for a non-commercial purpose, the likelihood must be demonstrated.* (Original quote from Sony Corp. v. Universal City Studios (1984), cursive added.) [1]

It is exactly the estimation of the "harmfulness of use" which is the main focus of this paper. Section two presents recent developments in the home video market. Literature review is provided in section three. Section four describes the data. Estimation framework and results are presented in section five. Section six concludes.

[1] In the case of Napster, the district court concluded that Napster harmed the market by reducing the sales of CDs among college students and by raising the plaintiff's barriers of entry to the digital music business.

2 The Home Video Market and File-Sharing

The home video market is the single most important source of revenue for the motion picture industry. In 2009, the home video market accounted for 50 per cent, box office 32 per cent, pay-TV 12 per cent and online distribution 7 per cent of movie studio revenue [17]. Within the home video market, DVD sales generate the most revenue. During the last ten years or so, spending on DVDs has increased from over 1 billion dollars to its peak level of over 20 billions in 2006 [14]. By comparison, in 2006 total home video spending (spending on Blu-ray or HD-discs and digital downloads) excluding DVDs amounted to 1.4 billion dollars. During the last ten years, box office revenues have remained fairly stable at annual 9 billion dollars. The increase in box office revenues in 2009 can be attributed to 3D and IMAX -movies, which generate more revenue through higher ticket prices. Figure (1) depicts consumer spending on home video entertainment compared to USA and Canada box office revenues for the years 2003-2010. Even though spending on home video entertainment has declined slightly over the past few years, it continues to clearly surpass the box office revenues. The importance of home video revenue for the motion picture industry is magnified by the high profit margin of the DVDs: movie studios have to split the box office revenue with movie theatres, which is not the case with home video spending.

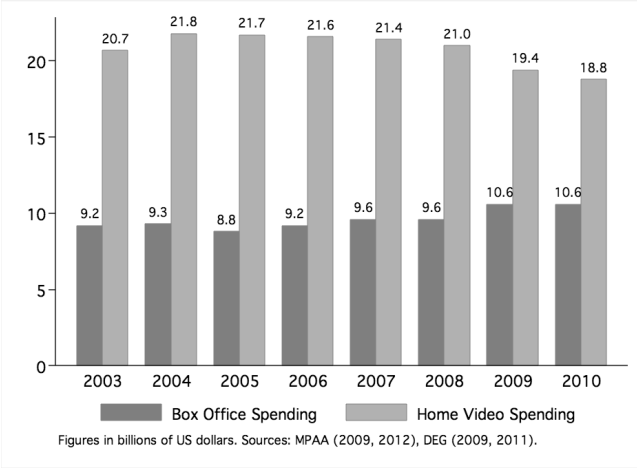

Fig. 1 US box office and home video spending (bn. dollars).

Figure (2) compares consumer spending (sell-through and rentals) on DVDs, Blu-rays and digital distribution. The figure illustrates the importance of DVD revenues within the home video market. Of total DVD spending, majority of revenue is generated through DVD sales; the share of rentals has been around 7 billion dollars or 35 percent of total DVD spending in recent years [32]. Even though the size of the Blu-ray market has grown rapidly during the

last few years, spending on Blu-rays comprised less than 8 percent of total home video spending in 2009. In addition to the Blu-ray market, the digital distribution is becoming increasingly popular: in 2009, electronic sales and video-on-demand accounted for about 11 percent of the home video revenue. Spending on Blu-rays grew by 500 percent between 2007 and 2009 and digital spending nearly doubled during the same time. The growth has not, however, been quite enough offset the DVD sales decline during our study period.

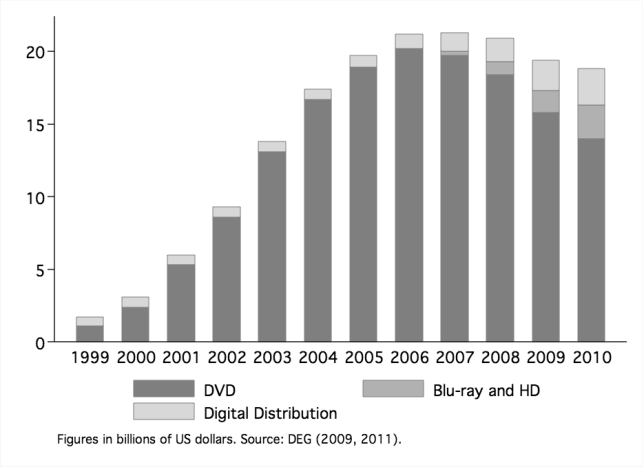

Fig. 2 DVD, Blu-ray and digital spending (bn. dollars).

3 Literature

The empirical literature on file-sharing has concentrated on the question of whether or not file-sharing can explain the substantive drop in record sales during the last decades. The results are mixed, partly due to data limitations. Since data on actual downloads has not been available, many studies use measures of internet use or broadband penetration as a proxy for downloads. The results vary from file-sharing explaining the whole sales decline in the US [29] to explaining only 14 to 23 percent of the decline [48]. The impact of digital piracy on sales has also been studied by using survey data (see [36], [49], [31], [38] and [46]). All studies find a negative relationship between file-sharing and sales. The estimates of the magnitude of the impact, however, vary significantly.

Few studies try to capture the effects of file-sharing by using a measure of song availability on a particular network as a proxy for the number of downloads. Bhattacharjee et al. [6] find that the availability of files on the WinMX network does not hurt the rank survival of the top-selling albums, but reduces the sales of low-ranked albums. McKenzie [30] shows that the availability of a

song on the LimeWire network does not have a negative impact on the single's position in the sales rank. Blackburn [8] uses data on file availability on file-sharing networks and record sales combined with album-level characteristics to estimate the effects of file-sharing on different groups of artists. The results indicate that ex ante popular artists suffer from sales decline due to file-sharing, whereas unknown artists gain from the exposure effects of file-sharing.

Some recent studies use natural experiments to study the causal link between piracy and sales. Danaher et al. [13] estimate the effect of anti-piracy measures in France on iTunes music consumption. The authors use the difference-in-difference method to estimate the effect of the "three strikes" law in song and album consumption, and find that compared to a control group of other European countries, the anti-piracy measures increased song and album downloads in France by approximately 22-25%. In a cross-country natural experiment setting, Danaher and Smith [12] find that shutting down Megaupload, a popular piracy site, had a positive effect on movie studios' digital revenue. The revenues were estimated to be 6-10% higher due to the shutdown.

This study is closely related to that of Oberholzer-Gee and Strumpf's [35], who are the first to use data on the actual number of downloads in a file-sharing network to study the relationship between file-sharing and record sales. Their data covers 17 weeks of downloads in the OpenNap network and, according to the authors, corresponds to 0.01 percent of all downloads at the time of study, last third of 2002. To overcome endogeneity problems, downloads are instrumented with several instruments, the most important of which is the timing of German school kids on vacation. International school holidays provide a positive supply shock of files in the network reducing the costs of downloading without being related to record sales in the USA. By using various specifications, the authors [35] conclude that the effect of file-sharing on record sales is not statistically significant nor economically important. The Oberholzer-Gee and Strumpf's [35] paper has also received criticism in their choice of instruments: see [27] and [28] .

The effects of file-sharing on movie business is a far less studied field. The results from the few empirical studies are mixed. For example, Smith and Telang [45] find that broadband penetration had a *positive* impact on DVD sales over the period 2000-2003. Bounie et al. [11] survey a sample of university students and staff and find that internet piracy had no effect on movie theater attendance but had a negative impact on sales and rentals of movie VHSs and DVDs. De Vany and Walls [16] estimate the effects of online piracy to the box office revenues of a single hit movie and find the losses from internet piracy to amount to 42 million dollars for the particular movie. Bai and Waldfogel [5] study two samples of Chinese college students and estimate that unpaid consumption accounts for 75 per cent of total movie consumption among college students. According to the study, every instance of unpaid consumption displaces 0.14 paid consumption instances. Rob and Waldfogel [39] find that unpaid first consumption reduces paid consumption by 1 unit in a sample of college students. In total, piracy is estimated to reduce paid consumption by 3.5 per cent.

The data used in this study is collected as in Smith and Telang [45], who use data on torrent file downloads on Mininova and on The Pirate Bay to study the relationship between DVD sales, television broadcasts and internet piracy. The authors find that television broadcasts stimulate DVD sales, and that the availability of pirated content does not erode this promotional stimulus. This study differs from [45] in three important aspects. Firstly, Smith and Telang [45] use Amazon.com sales rank data to proxy sales on Amazon.com, whereas the sales data used in this paper covers both physical and online marketplaces. Secondly, the identification strategy in [45] is based on television broadcasts creating an exogenous demand shock to DVD demand, whereas the identification in the present paper hinges on dynamic panel methods. Thirdly, Smith and Telang [45] study the later parts of movies' lifecycle, whereas in this paper, the sales and downloads are studied right after the release of a movie.

4 Data

To study the short-term effect of movie downloads on DVD sales, data on weekly DVD sales and movie torrent downloads in the USA during a 13-week period from March 2 to May 31, 2009 is used. The download data is collected weekly from public torrent indexing site Mininova (mininova.org). The sales data is provided by Nash Information Services.

The focus is on the home video sell-through market instead of theatrical, rental or digital markets for three reasons. Firstly, home video market and especially DVD sell-through was during the study period the most important source of revenue for the movie industry [17]. Secondly, since movie theater attendance is a different experience from watching a movie at home, it can be argued that downloading mostly substitutes home-viewing, not theatre attendance[2]. Finally, the sales of physical DVDs are studied instead of digital distribution or Blu-ray sales for the reason that even though the market share for digital downloads and Blu-ray discs are growing, during the time of the study digital downloads and Blu-rays comprised less than 20 percent of total home video spending.

4.1 Sales Data

The sales data is provided by Nash Information Services, a company behind the website thenumbers.com, an online source of movie business data. The building block for the empirical analysis is the set of movies released on DVD in the USA during the period February 3-May 26, 2009. From those releases, only movies that had theatrical release in the US during 2008 or 2009 and that had not been released before on DVD (henceforth, I call these "new releases") were selected in the sample, leaving out releases and re-releases of older movies.

[2] This view is supported by the fact that the group of people that invests more in home technology also attends movies more often than their low-tech counterparts [32].

The release information was collected from Box Office Mojo. Blu-ray and HD movies as well box sets comprising of several movies were also excluded from the sample. Box sets are excluded since comparable sales data for them is not available. The focus is on new releases since there is a reason to believe that the sales and download patterns for older movies differ from those of new releases. Moreover, focusing on new releases makes it possible to concentrate on the strongest earning period of the DVDs. According to [7], as much as 30 to 50 percent of total revenue of a DVD occurs during the first week after it's release, and another 30 percent within the next three to four weeks.

The total number of newly released titles during February 3-May 26, 2009 is 129. Unfortunately, sales data is available only for a subsample of 50 titles. Movies for which sales data is not available are movies that are less popular in terms of DVD sales. If the movies in the sample are not a good representation of the population of new releases, the generalizability of the results will be compromised. However, descriptive statistics in Table (1) show that the movies in the data show considerable amount of variation in DVD sales, downloads and genre. This suggests that the data set does not include only one type of movies, namely blockbusters.

4.2 File-Sharing Data

To measure downloading activity in the BitTorrent network, a data set on torrent file downloads was collected on the torrent site mininova.org. Torrent sites function as databases and search engines for torrent files, with some operating their own tracker. Mininova is the successor to Suprnova, one of the four original torrent databases, and was during the study period one of the most popular torrent site hosting over one million torrents and having on average 10 million downloads per day[3]. Thus downloads in mininova.org provide a good representation of downloads on the BitTorrent network.

To be perfectly clear on the difference between torrent file downloads and actual movie file downloads, it should be pointed out that data on actual downloads of the *target files* (in this case movie files) in the BitTorrent network is not used; instead data on the downloads of the torrent files associated with the movie files is used. This is done because the monitoring of the exact number of target file downloads over BitTorrent network is next to impossible. However, downloading a movie file requires downloading a torrent file, for which download data is available. Even if there inevitably are differences between the number of torrent file downloads and actual target file downloads, there is no reason to suspect that the difference is large or that it would change across movies or in time[4].

[3] See http://www.mininova.org/statistics and http://torrentfreak.com/top-10-torrent-sites-of-2008-081228/

[4] The differences between torrent file downloads and target file downloads result from the fact that one target file download might require that the torrent file is downloaded multiple times (due to technical problems, for example). Also, downloading a torrent file does not necessarily mean that the user finishes downloading the target file.

The data was collected as follows. A search by movie title was made on mininova.org to find all torrents related to a specific movie in the sample. The search was conducted a day before the DVD release of the title and at the end of each week during the study period. The number of downloads of individual torrent files pointing to a specific movie were added together to establish the total number of torrent file downloads for each movie. Since mininova.org reports the cumulative number of downloads for each torrent daily, the number of weekly torrent downloads for each movie was calculated by substracting the previous week's downloads from current week's downloads.

Since the study focuses on DVD sales in the USA, the number of downloads that originate in North America have to be separated from downloads that take place outside USA. Unfortunately, without knowing the IP-addresses of the downloaders it is impossible to know where the downloaders are located geographically. However, it is possible to get information on the access statistics on mininova.org. According to the web information company Alexa (www.alexa.com) the largest single location of visitors in mininova.org during the study period was North America with 15 per cent of visitors originating in the USA [5]. Measurement studies on the geographical properties of BitTorrent users give more detailed insight in the issue. According to [22]), the two most active contributors to BitTorrent traffic are the EU and the North America, respectively. The share of BitTorrent users located in the EU is over 50 percent, whereas the North America accounts for less than 40 percent of the network users. In the case of movies, Germany is the leading location with North America coming in second. Together Germany and North America account for almost 70 per cent of movie download traffic, with UK, Canada, France, Netherlands and Sweden following clearly farther behind.

Germany is clearly an important source for movie downloads on the BitTorrent network. Luckily the torrent files provide detailed information on the audio language and subtitles of the movies in question. This way it is possible to distinguish the movies that have subtitles or audio tracks other than English, or that have file description in a language other than English. In the case of Germany the separation is especially easy since nearly all of the movies watched in Germany are dubbed in German, and it can assumed that these versions are not downloaded by North American users. There is also a considerable number of French, Dutch, Swedish and Spanish files, which are easy to exlude from the data[6]. The countries that might bias the results for North American downloads upwards are torrents downloaded by other English speaking countries[7]. However, according to[22], these countries together account for approximately 15 percent of download traffic in the category of

[5] See http://www.alexa.com/siteinfo/mininova.org

[6] In unclear cases the comments attached to the torrent file at mininova.org were checked to see in what language people were commenting the torrent to get an idea of the country of origin of the downloaders.

[7] The same is true, of course, for users outside North-America that watch movies in English without subtitles. Their share of all downloaders is, however, negligible.

popular movies, and around 11 per cent of Mininova visitors in general, so their impact on the results is not likely to be signficant.

4.3 Descriptive Statistics

Tables (1) and (2) present summary statistics for sales and downloads by movie genre. Movies in the sample represent a total of 25 different genres[8]. On average, a movie in the sample sold over 120 493 copies and was downloaded 29 307 times in one week. Sales numbers vary from a movie selling 1 684 copies in one week to a movie selling almost three and a half million copies in one week. Downloads vary from zero to 244 926 downloads for a movie in one week.

Since the data is constrained by the fact that sales numbers are not available for some of the less-selling titles, the representativeness of the sample is a potential cause for concern. One way to check if the movies in the data represent only the most popular titles of 2009 is to check what portion of them belong to the top 100 selling movies of 2009. Out of 50 movie titles in the data, 27 rank among the 100 highest selling DVDs of year 2009[9]. With approximately half of the movies falling out of the top 100 list, it can be concluded that the movies in the sample do not represent only the best-selling titles.

Figure 3 depicts a scatterplot of downloads and sales (in logs). There correlation between downloads and sales is moderate: the simple correlation between the two series is 0.61.

To gain additional insight into the popularity of movies on sales charts and on BitTorrent, Table (3) lists the most downloaded movies on BitTorrent in 2009 and the ten best-selling DVD titles for the same year. Five of the ten movies (*Star Trek, Transformers: Revenge of the Fallen, The Hangover, Twilight, Harry Potter and the Half-Blood Prince*) are in the top ten list of both DVD sales and BitTorrent downloads. These are movies that also faired well at the box office: they are among the top ten highest grossing movies in 2009. The most notable difference between popularity on BitTorrent and popularity in the DVD market is the popularity of animations both at the box office and in the DVD market. *Ice Age: Dawn of the Dinosaurs, Monsters vs. Aliens, Madacasgar 2: Escape to Africa* and *Up* made the top ten list for DVD sales but are not equally popular among file-sharers [10]. This suggests that there are some movie-specific factors, such as the genre of the movie or its supply on BitTorrent, which affect the popularity of a movie on the BitTorrent network but wich are not directly related to its success in the DVD market.

[8] Information on the genres was collected from Box Office Mojo, www.boxofficemojo.com.

[9] Top selling DVD data is provided by The Numbers and available at: http://www.the-numbers.com/dvd/charts/annual/2009.php

[10] Of the top ten movies on BitTorrent only two, *RocknRolla* and *State of Play*, fall outside the 100 top selling DVDs in 2009. The success of *RocknRolla* on BitTorrent is at least partly explained by the fact that it was uploaded by the famous uploader *axxo*.

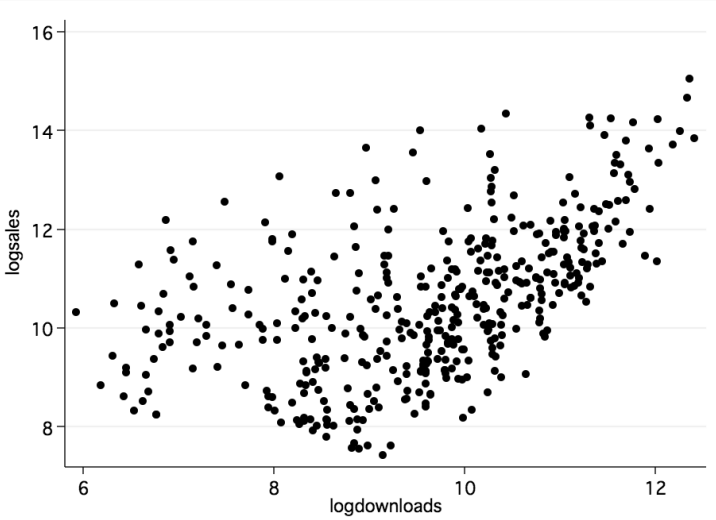

Fig. 3 Scatterplot of downloads and sales (in logs).

To illustrate the sales and download data, Figure (4) depicts sales and downloads for a randomly selected movie in the sample. The graph demonstrates the declining trend in sales: sales are highest at the first week of release (week 2 in the data for this particular movie) and decline rapidly after that. Downloads exhibit a similar declining trend. Typically movies are being shared on BitTorrent before the release of the DVD. For example, file-sharing for this particular movie started 92 days before its DVD release and the movie was downloaded 166 600 times in total before it entered the data[11].

Finally, the data allows to examine whether or not the choice to analyse sales and downloads during the first weeks or months after a DVD is released is reasonable as opposed to following the sales and downloads for a longer period of time. Luckily, information on the total number of DVDs sold in year 2009 is available for 27 titles in the data, which makes it possible to calculate the portion of sales which occurs during the early weeks of the release[12]. On average, over 70 percent of sales of a DVD in the sample occur during the first 2-13 weeks after its release. At the highest, 95 per cent of the total sales of a DVD occured during the 13-week period. A large fraction of sales occurs even over a shorter period of time: on average, 57 per cent of sales accumulate over the first four weeks of release.

[11] As a robustness check, the effect of past downloads on current sales was estimated, and the main conclusions remained unchanged.

[12] The data was obtained from www.thenumbers.com.

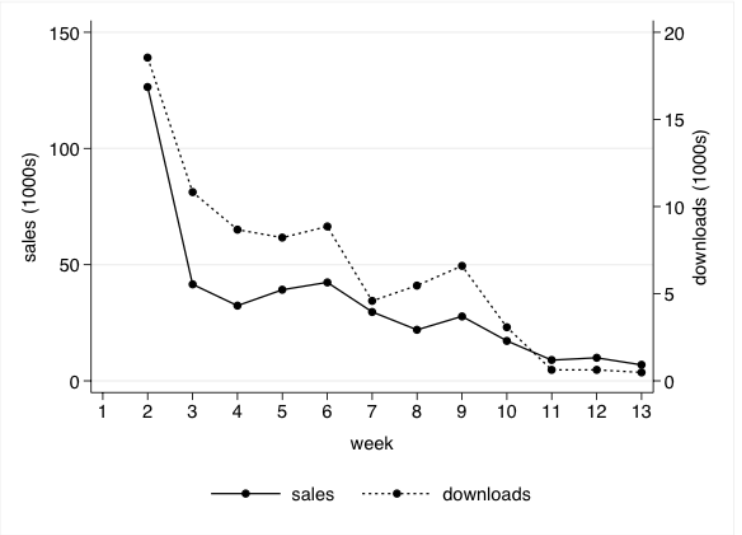

Fig. 4 Downloads and sales for a movie in the sample.

5 Estimation

The short-term effect of BitTorrent file-sharing on the sales of movie DVDs is estimated. The analysis is carried out with panel data consisting of sales and downloads of 50 individual movie titles over a 13-week period. In total, with some missing observations, the total number of observations is 461 movie-weeks. The panel is unbalanced due to different release times of the titles in the data. As a result, the number of observations available for each title varies from two to thirteen weeks.

The main cause for concern in the estimations is endogeneity between sales and downloads. If sales and downloads are driven by an underlying, unobserved popularity or quality of a movie, movies which are more popular to download in a given week are also likely to sell more, and vice versa. As a result of this unobserved heterogeneity, downloads are likely to be correlated with the error term making the OLS estimate on the coefficient on downloads biased upwards and leading to inconsistent estimates in general. The omitted variable bias can be ameliorated to some extent in a panel data by estimating the model with movie-specific fixed effects. The bias can not, however, be corrected by fixed effects estimation if the unobserved heterogeneity varies in time.

As is evident from the data, sales of a movie DVD are highest right after release and decline fairly steadily after that. A flexible polynomial and a lagged sales variable capture the declining trend in sales, and movie fixed effects control for movie-specific factors which do not change over time. Unobserved time-varying popularity (and, possibly, downloads) makes DVD sales deviate from the declining trend. This unobserved heterogeneity, which affects the popularity of a DVD in a given week, can be the result of a publicity campaign

or promotion, for example. Downloads often exhibit similar downward-sloping trend, even though downloading takes place over a longer period of time, starting from (or preceding) the theatrical release of the movie. However, downloads are also affected by the supply side of the market: movie's popularity on the BitTorrent network depend on the availability of that movie on the network, and on the popularity of the uploader. If the time-varying popularity of a movie on the sales charts does not coincide with the time-varying popularity of a movie on the BitTorrent network, the correlation between downloads and the error term is not as strong as expected.

With dynamic panel methods, the effect of downloads on sales can be credibly estimated even when downloads are endogenous. Moreover, dynamic panel estimations allows to account for path dependency on the dependent variable. Sales can thus depend on past weeks' sales, without the dynamic panel bias present in OLS and fixed effects estimation. Since time-invariant movie characteristics are likely to be correlated with the error term, the estimated equation is first-differenced to remove the fixed effect. After first-differencing, the lagged sales variable and downloads remain correlated with the error term. However, lags 2 and deeper of sales and downloads remain orthogonal to the error and are thus valid instruments for the first-differenced sales and downloads, if errors are not autocorrelated. The first critical assumption in the identification strategy is that for sales and downloads, past values are correlated with current, first-differenced, values. The second critical assumption is that the error term is not autocorrelated. If there is autocorrelation in the error, some of the lags used as instruments will be correlated with the error term.

5.1 Dynamic Panel Estimation

The popular Arellano and Bond [2], Arellano and Bover [3] and Blundnell and Bond [9] difference and system GMM estimators, which were also developed by Anderson and Hsiao [1], Hansen [19] and Holtz-Eakin, Newey and Rosen [19], are designed for estimating models with a relatively short time dimension, endogenous regressors, dynamic dependent variable and the presence of fixed effects, heteroscedasticity and autocorrelation within cross-section units [40]. In the estimated model, the sales of a movie DVD are allowed to depend on previous week's sales. The path dependency in sales is explained by the fact that the success of sales in the previous week has an effect through word-of-mouth and because the successful DVDs get more shelf-space and promotion in stores. Since the lagged sales variable captures the effect of *past* downloads on sales, dynamic specification allows a convenient way to estimate a model where downloads influence sales at a later point in time than they actually occur.

The equation to be estimated is:

$$\Delta S_{i,t} = \gamma \Delta S_{i,t-1} + \beta \Delta D_{i,t} + \delta_t \Delta W_t + \Delta v_i + \Delta \varepsilon_{i,t}, \tag{1}$$

where $S_{i,t}$ denotes sales (DVD units sold) of a movie title i in week t, $S_{i,t-1}$ denotes sales (DVD units sold) of a movie title i in week $t-1$, $D_{i,t}$ denotes BitTorrent downloads for movie i in week t, $Week_t$ includes controls for time trends (week dummies or movie-specific polynomial $\sum \delta_s t_i^s$ measuring the number of weeks since the release of the movie), v_i is the movie-specific fixed effect and $\varepsilon_{i,t}$ denotes the error. In estimations with polynomial time trends, a dummy for Easter week is added, since sales are generally higher during the holidays. Since the distributions of sales and downloads are skewed and the variables vary in several orders of magnitude, sales and downloads enter the equation in natural logarithms. The estimated $\hat{\beta}$ is thus interpreted as the file-sharing elasticity of sales.

The estimated equation is first-differenced to remove the fixed effect. The lagged sales term $S_{i,t-1} - S_{t-2}$ in equation (1) is still potentially endogenous since it is correlated with the error term $\varepsilon_{i,t} - \varepsilon_{i,t-1}$. Moreover, if downloads are correlated with the error term, they remain so after first-differencing. However, deeper lags of sales and downloads in levels are correlated with the first-differenced sales and downloads and orthogonal to the error, provided the errors are not autocorrelated. Lags 2 and deeper of sales and downloads are thus available as instruments for the first-differenced $S_{i,t-1}$ and $D_{i,t}$, respectively. The assumption of non-autocorrelated errors is crucial for the identification strategy and is tested using Arellano-Bond test for autocorrelation.

5.2 Results

Table (4) presents results from estimating equation (2) with two-step difference GMM with lags 2 and deeper of sales and downloads (both in levels) used as instruments for the first-differenced $S_{i,t-1}$ and $D_{i,t}$, respectively[13]. Since too many instruments can overfit endogenous regressors and weaken specification tests as [41] discusses, the instruments are collapsed. Instead of each instrumenting variable creating one column for each time period and lag available for that time period, the instruments are collapsed into a single column [40]. To further avoid instrument proliferation, in estimations with week fixed effects, only lags two through three are used[14]. Column (1) in Table (4) presents the results two-step difference GMM with movie-specific polynomial time trends of degree four[15] and a dummy for Easter week. Column (2) presents results for two-step estimations with week dummies. The control variables are stastically significant and of the expected sign: sales are moderately autoregressive

[13] In one-step estimation, initial weight matrix is used to estimate parameters. In two-step estimations, a new weight matrix is calculated based on the paramaters estimated in the one-step stage. This updated weight matrix is then used to re-estimate the parameters. Two-step estimator is shown to be more efficient than one-step estimator, but requires that the standard errors are corrected for downward bias [47].

[14] The estimations were carried out also with orthogonal forward deviations instead of first-differencing to maximize sample size. The results were very similar to those in Table (4).

[15] Higher-order polynomials did not improve the fit of the model.

(though the coefficient is not significant in the specification with polynomial time trend), decline after the release week of the DVD and are significantly higher during Easter week. The coefficient on downloads is small, negative and not statistically significant in both model specifications.

Hansen tests in Table (4) indicate that the instruments are jointly valid in the difference GMM estimations. Sargan test, which is not weakened by the number of instruments, rejects the null of instrument validity in specification with polynomial time trends. However, Sargen test requires homoskedastic errors for consistency, an assumption that is not met in the analysis. Arellano-Bond test for autocorrelation is applied to first-differenced residuals. Evidence of second-order autocorrelation in residuals would indicate that there is first-order autocorrelation in levels and thus some of the lags used as instruments would be correlated with the error. Tests reveal no evidence of autocorrelation in levels.

When week fixed effects are estimated instead of polynomial time trends, the coefficient on lagged sales is within the credible range between the within- and OLS-estimates[16]. In estimations with polynomial time trends, the coefficient on lagged sales is surprisingly low. If the coefficient is biased towards zero, weak instrumentation might be suspected, as discussed in [9]. However, the estimation with week dummies can be considered the preferred specification for other reasons as well. For estimating the coefficient standard errors, the idiosyncratic errors need to be uncorrelated across cross-section units. Also, the Arellano-Bond test for autocorrelation is not valid if errors are correlated across movies. Including time dummies prevents at least contemparenous correlation across movies and makes the assumption of uncorrelated errors more likely to hold.

In the specification with week fixed effects, the coefficient on downloads is negative, small and not statistically different from zero. However, the parameter is not estimated very precisely, and the confidence interval is in the range [-0.21, 0.06]. This gives an upper bound of approximately -0.21 on the negative effect of illegal downloads on sales. The file-sharing elasticity of sales indicates that if the downloads of a movie increased by 100 percent, the sales would decrease by approximately 21 percent.

5.3 Robustness of Results

The problem of weak instruments has recently received a lot of attention also in the context of dynamic GMM estimations [41]. As is the case with instrumental variables estimators generally, a large instrument set can overfit endogenous variables. With difference (and system) GMM estimators, the problem

[16] Since the coefficient on lagged sales term in the within-esimation is biased downwards, the results of estimating a simple fixed effects model give a lower bound on the credible estimate on the lagged sales coefficient (0.325). The simple upward biased OLS coefficients, which give the upper bound on the lagged sales coefficient, are 0.916 and 0.870 in the specification with polynomial time trend and week fixed effects, respectively. Credible estimation for lagged sales coefficient is therefore in the range [0.325, 0.916].

is twofold. Not only can the large number of instruments overfit endogenous variables, it can weaken the Hansen test, making it hard to detect the weak instrument problem. Difference and system GMM estimations with large number of instruments can produce results which are not valid but which appear valid due to the weakened Hansen test[17].

To test the robustness of the results, equation (1) is estimated with different lag-lengths. In difference GMM estimations, the Hansen test for joint instrument validity is not robust to reducing the number of instruments, when the model is estimated with polynomial time trends. With week fixed effects, instrument remain jointly valid with all lag-lengths. In estimations with polynomial time trend, another cause for concern is the low coefficient for the lagged sales variable. The coefficient is unreasonably low compared to the lower bound indicated by the downwards-biased within groups estimate. As Blundnell and Bond [9] point out, if the instruments used in the first-differenced estimation are weak, the difference GMM coefficients are likely to be biased in the direction of within groups. The similarity between difference GMM and within groups coefficient estimates and the non-robustness of the Hansen statistic to the reduction of instrument count suggests that the difference GMM estimations might suffer from weak instruments, when the model is estimated with polynomial time trends instead of week fixed effects. To be on the safe side, the results with week fixed effects should thus be considered more robust.

6 Discussion

The empirical literature on digital piracy and its impact on different industries has been plagued by data availability issues, and the results on the effects of digital piracy have been mixed. This study contributes to the empirical literature on digital piracy by using actual file-sharing data in estimating whether file-sharing displaces DVD sales. The estimated coefficient on downloads is statistically not different from zero, and the dynamic panel estimation results indicate an upper bound of -0.21 on the file-sharing elasticity of sales.

The data enables to describe torrent file-sharing of movies in some detail. There are some differences in the popularity of movies on the sales charts and on BitTorrent. On average, blockbusters which are succesful at the box office, sell more in DVDs and are heavily downloaded on BitTorrent. However, in 2009, the ten best selling DVD titles included four animated movies, none of which made it to the top downloaded movies on BitTorrent. Compared to top-selling movies, the genres of sci-fi, action and drama/thriller were overrepresented on BitTorrent's most popular titles. This might reflect the fact that the people buying DVDs and the people downloading are two distinct groups with different tastes and characteristics. More importantly, supply side issues, which are not necessarily related to the overall popularity of a specific movie, play a crucial role in determining the success of a movie amongst file-sharers.

[17] As Roodman [41] discusses, the perfect Hansen test statistic 1.000 is one indication that the test is weakened due to instrument proliferation

For example, in 2009, the success of the movie*Rock'nRolla* on BitTorrent can be explained at least partially by the fact that it was released by a popular uploader. Torrents uploaded by famous release groups are downloaded heavily, because they are simply more available and probably perceived to be of high quality. Another top movie on BitTorrent in 2009, *X Men Origins: Wolverine*, was famously leaked online as an unfinished workprint before its theatrical debut, gaining a lot of publicity and attracting downloaders.

The emergence of file-sharing and digital piracy has happened at a time when music record sales have declined sharply. For movies, the relationship between sales decline and file-sharing has not been as clear-cut. Though spending on DVD sell-through has declined by approximately 20 percent from its peak level in 2006, Blu-ray and digital spending have grown significantly during the same period. The growth has not, however, been quite enough to offset the DVD sales decline, until very recently. In dollar terms, spending on DVD sell-through declined by approximately 3.8 billion dollars between 2006 and 2009, while spending on Blu-rays and digital distribution increased by a total of 2.6 billion dollars. However, if the increase in box office spending is taken into accout, spending on movies in the North America has remained fairly stable, over 30 billion dollars, since 2006. Moreover, in 2012 overall home entertainment spending increased for the first time since 2007, due to increased demand for Blu-rays and digital purchases [20]. It seems that consumers are shifting their spending from DVDs to Blu-rays and digital distribution and are paying higher prices for cinema tickets. IMAX theatres, 3D-movies and the growing popularity of online services, such as Netflix, have clearly abetted this trend. Thus, the decline in DVD sales might simply be signifying that we have entered a new phase in the life-cycle of DVDs. Competition from other forms of entertainment is also likely to have contributed to declining trend in home video spending. For example, the gaming industry generated approximately 20 billion dollars in revenue in 2009[18].

The focus of this study is short-term and it does not assess the long-term effects of digital piracy nor its overall economic consequences. Even though file-sharing possibly affects prices and the supply of content in the longer term, the results of the study indicate that the immediate sales replacement effect of file-sharing is, perhaps suprisingly, moderate.

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References

1. Anderson, T.W.,Hsiao, C. (1982). Formulation and Estimation of Dynamic Models Using Panel Data. *Journal of Econometrics*, 18, 47-82.

[18] http://www.npd.com/press/releases/press_100114.html

2. Arellano, M., Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies*, 58, 277-297.
3. Arellano, M., Bover, O. (1995). Another Look at the Instrumental-Variable Estimation of Error-Components Models. *Journal of Econometrics*, 68, 29-52.
4. A&M Records v. Napster (2001). Available at: www.law.cornell.edu/copyright/cases/239_F3d_1004.htm. Accessed December 15, 2011.
5. Bai, J. and Waldfogel, J. (2012). Movie Piracy and Sales Displacement in Two Samples of Chinese Consumers. *Information Economics and Policy*, 24(3), 187196.
6. Bhattacharjee, S., Gopal, R.D., Lertwachara, K., Marsden, J. D.,Telang, R. (2007). The Effect of Digital Sharing Technologies on Music Markets: A Survival Analysis of Albums on Ranking Charts. *Management Science*, 53(9), 1359-1374.
7. Bhattacharya, S., Comerford, W. (2006). Win in the Flat World. DVD Supply Chain. The Emerging Challenge for Media Profitability. White Paper, Infosys.
8. Blackburn, D. (2007). The Heterogeneous Effects of Copying: The Case of Recorded Music. Harvard University Working Paper.
9. Blundell, R., Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics*, 87, 11-143.
10. Bond, S. (2002). Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice. The Institute for Fiscal Studies, Department of Economics, UCL. CEMMAP Working Paper No CWP09/02.
11. Bounie, D., Waelbroeck, P., Bourreau, M. (2006). Piracy and Demand for Films: Analysis of Piracy Behavior in French Universities. *Review of Economic Research on Copyright Issues*, 3(2), 15-27.
12. Danaher, B., Smith, M.D. (2013). Gone in 60 seconds: The Impact of the Megaupload Shutdown on Movie Sales. Available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2229349 Accessed April 30, 2013.
13. Danaher, B., Smith, M.D., Telang, R., Chen, S. (2012). The Effect of Graduated Response Anti-Piracy Laws on Music Sales: Evidence from an Event Study in France. Available at SSRN: http://ssrn.com/abstract=1989240 or http://dx.doi.org/10.2139/ssrn.1989240 Accessed April 30, 2013.
14. DEG: Digital Entertainment Group (2009). DEG Year-End Entertainment Report. Available at: http://www.scribd.com/doc/27845653/DEG-2009-Home-Entertainment-Report. Accessed December 15, 2011.
15. DEG: Digital Entertainment Group (2011). Press Release: DEG Year-End Entertainment Report. Available at: http://www.degonline.org/pressreleases/2011/f_Q410.pdf. Accessed April 30, 2013.
16. De Vany, A. S., Walls, D.W. (2007). Estimating the Effects of Movie Piracy on Box Office Revenue. *Review of Industrial Organization*, 30, 291-303.
17. EMA: Entertainment Merchants Association (2009). 2009 Annual Report on the Home Entertainment Industry.
18. Gopal, R. D., Bhattacharjee, S., Sanders, S. (2006). Do Artists Benefit from Online Music Sharing. *Journal of Business*, 79(3), 1503-1533.
19. Hansen, L.P. (1982). Large Sample Properties of Generalized Method of Moment Estimators. *Econometrica*, 50, 1029-1054.
20. Hollywood Reporter (2013). Home Entertainment Spending Rises for the First Time in Five Years. Available at: http://www.hollywoodreporter.com/news/home-entertainment-spending-rises-409796 Accessed April 30, 2013.
21. Holz-Eakin, D., Newey, W., Rosen H.S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica*, 56, 1029-1054.
22. Iosup, A., Garbacki P., Pouwelse J.A., Epema, D.H.J. (2005). Analyzing BitTorrent: Three Lessons from One Peer-Level View. In Proceedings of the 11th AISC Conference.
23. Josefowicz, J. J., Kelley, Jason M., Brewer, S.M. (2008). New Release: An Empirical Analysis of VHS/DVD Rental Success. *Atlanta Economic Journal*, 36, 139-151.

24. Kravets, D. (2008). "File Sharing Lawsuits at a Crossroads, After 5 Years of RIAA Litigation". Available at:
http://www.wired.com/threatlevel/2008/09/proving-file-sh. Accessed December 15, 2011.
25. LEK Consulting (2006). The Cost of Movie Piracy.
Available at:
http://www.archive.org/stream/MpaaPiracyReort/LeksummarympaRevised_djvu.txt.Accessed December 15, 2011.
26. Liebowitz, S. J. (2005). Pitfalls in Measuring the Impact of File-Sharing. CESifo Economic Studies, 51, 439477
27. Liebowitz, S. J. (2007). How Reliable is the Oberholzer-Gee and Strumpf Paper on File-Sharing? Available at SSRN: http://ssrn.com/abstract=1014399 or http://dx.doi.org/10.2139/ssrn.1014399 Accessed March 26, 2012.
28. Liebowitz, S. J. (2010). The Oberholzer-Gee/Strumpf File-Sharing Instrument Fails the Laugh Test (May 1, 2010). Available at SSRN: http://ssrn.com/abstract=1598037 or http://dx.doi.org/10.2139/ssrn.1598037 Accessed March 26, 2012.
29. Liebowitz, S. J. (2008). Testing File-Sharings Impact By Examining Record Sales in Cities. *Management Science*, 54, 852-859.
30. McKenzie, J. (2009). Illegal Music Downloading and Its Impact on Legitimate Sales: Australian Empirical Evidence. *Australian Economic Papers*, 48(4), 296307.
31. Michel, N. J. (2006). The Impact of Digital File Sharing on the Music Industry: An Empirical Analysis. *Topics in Economic Analysis & Policy*, 6(1), 1549-1573.
32. Motion Picture Association of America (2007). MPAA 2007 Theatrical Market Statistics. Available at:
http://www.mpaa.org/2008%20MPAA%20Theatrical%20Market%20Statistics.pdf. Accessed December 15, 2011.
33. Motion Picture Association of America (2009). MPAA 2009 Theatrical Market Statistics. Available at:
http://www.mpaa.org/Resources/091af5d6-faf7-4f58-9a8e-405466c1c5e5.pdf. Accessed December 15, 2011.
34. Motion Picture Association of America (2012). MPAA 2012 Theatrical Market Statistics. Available at:
http://www.mpaa.org/Resources/3037b7a4-58a2-4109-8012-58fca3abdf1b.pdf Accessed April 30, 2013.
35. Oberholzer-Gee, F. Strumpf, K. (2007). The Effect of File Sharing on Record Sales: An Empirical Analysis. *Journal of Political Economy*, 115(1), 142.
36. Peitz, Martin, Waelbroeck, P. (2004). The Effect of Internet Piracy on Music Sales: Cross-Section Analysis. *Review of Economic Research on Copyright Issues*, 1(2), 71-79.
37. Peitz, M., Waelbroeck, P. (2006). Piracy of Digital Products: A Critical Review of the Theoretical Literature. Available at SSRN: http://ssrn.com/abstract=889128 or http://dx.doi.org/10.2139/ssrn.889128 Accessed March 26, 2012.
38. Rob, R., Waldfogel, J. (2006). Piracy on the High C's: Music Downloading, Sales Displacement, and Social Welfare in a Sample of College Students. *Journal of Law and Economics*, 49(1), 29-62.
39. Rob, R., Waldfogel, J. (2007). Piracy on the Silver Screen. *The Journal of Industrial Economics*, 55(3), 379395.
40. Roodman, D. (2009). How to Do xtabond2: An Introduction to "Difference" and "System" GMM in Stata. *Stata Journal*, 9(1), 86136.
41. Roodman, D. (2009). A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics*, 71(1), 135158.
42. Screen Digest (2007). Online Movie Strategies. Competitive Review and Market Outlook. Available at:
http://www.screendigest.com/reports/07onlinemoviestrat/NSMH-76LLT7/sample.pdf. Accessed December 15, 2011.
43. Siwek, S.E. (2006). The True Cost of Motion Picture Piracy to the U.S. Economy. Institute for Policy Innovation, Policy Report No 186.
44. Smith, M. D., Telang, R. (2006). Piracy or Promotion? The Impact of Broadband Internet Penetration on DVD Sales. Working Paper, Carnegie Mellon University, John III Heinz School of Public Policy and Management.

45. Smith, M. D., Telang, R. (2009). Competing with Free. The Impact of Movie Broadcasts on DVD Sales and Internet Piracy. *Management Information Systems Quarterly*, 33(2), 321-338.
46. Waldfogel, J. (2010). Music File Sharing and Sales Displacement in the iTunes Era. *Information Economics and Policy*, 22(4), 306314.
47. Windmeijer, F. (2005). A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators. *Journal of Econometrics*, 126, 25-51.
48. Zentner, A. (2005). File Sharing and International Sales of Copyrighted Music: An Empirical Analysis with a Panel of Countries. *Topics in Economic Analysis & Policy*, 5(1).
49. Zentner, A. (2006). Measuring the Effect of File Sharing on Music Purchases. *Journal of Law & Economics*, 49(1), 63-90.

Table 1 Summary statistics for weekly DVD sales (1000s).

	Titles	**Obs.**	**Mean**	**Stand. Dev.**	**Min**	**Max**
All	50	478	120.49	297.55	1.68	3414.96
Action	3	33	117.03	228.18	4.16	1192.37
Action Fantasy	1	6	126.71	112.84	42.11	334.30
Action Horror	1	3	604.87	569.45	145.16	1241.88
Animation	3	31	247.38	377.78	14.64	1406.18
Comedy	7	67	142.62	327.28	3.03	1702.83
Documentary	1	13	13.61	10.82	3.10	41.87
Drama	10	99	62.15	115.14	2.82	836.62
Drama/Thriller	1	13	30.34	25.23	5.50	94.95
Family	1	5	293.08	287.19	67.16	773.17
Family Adventure	1	8	298.99	509.49	46.93	1546.13
Family Comedy	1	13	259.42	416.90	50.66	1556.58
Fantasy Drama	1	4	511.50	474.34	161.20	1201.38
Foreign/Horror	1	12	8.91	13.01	1.92	48.76
Historical Drama	2	19	21.91	31.85	1.68	134.69
Horror	3	20	66.61	109.77	5.30	473.56
Horror Thriller	1	13	20.24	14.00	4.29	48.57
Musical	1	13	82.53	92.23	6.88	320.05
Music Drama	2	18	66.10	110.22	6.89	470.11
Period Adventure	1	13	122.38	191.09	21.86	728.79
Period Drama	1	7	87.30	75.80	14.95	234.38
Romance	3	28	309.07	755.87	2.75	3414.96
Sci-Fi	1	8	217.69	318.54	40.05	978.24
Sports Drama	1	6	93.39	99.11	21.20	279.15
Thriller	1	13	20.71	23.75	3.23	84.68
War Drama	1	13	9.70	8.38	3.03	31.83

Table 2 Summary statistics for weekly downloads (1000s).

	Titles	**Obs.**	**Mean**	**Stand. Dev.**	**Min**	**Max**
All	50	461	29.31	38.07	0	244.93
Action	3	33	57.21	43.42	0	210.02
Action Fantasy	1	7	33.85	17.19	23.13	70.10
Action Horror	1	2	20.46	8.16	14.69	26.23
Animation	3	27	44.82	31.52	2.92	128.72
Comedy	7	62	35.52	51.76	0.55	244.93
Documentary	1	13	14.24	7.93	4.61	25.11
Drama	10	91	19.43	29.31	0	152.39
Drama/Thriller	1	13	40.91	37.83	2.82	146.33
Family	1	5	8.11	2.61	6.63	12.76
Family Adventure	1	8	42.83	34.37	7.10	101.63
Family Comedy	1	13	26.23	17.78	13.85	81.48
Fantasy Drama	1	4	10.71	2.18	8.68	13.77
Foreign/Horror	1	12	14.44	6.06	6.58	22.60
Historical Drama	2	19	16.77	7.85	5.15	33.24
Horror	3	20	1.99	1.58	0	4.71
Horror Thriller	1	13	13.17	5.66	6.45	24.31
Musical	1	13	24.30	15.91	0	46.88
Music Drama	2	18	20.94	22.49	0.49	66.29
Period Adventure	1	13	39.58	31.71	2.57	108.08
Period Drama	1	7	1.09	0.54	0	1.63
Romance	3	28	53.58	68.28	0.78	233.12
Sci-Fi	1	8	58.61	47.14	0	119.10
Sports Drama	1	6	12.29	13.80	0	29.47
Thriller	1	13	42.80	42.76	3.22	165.30
War Drama	1	13	12.56	6.79	5.16	29.45

Table 3 The most popular movies on BitTorrent and in DVD sales in 2009[a].

Top Movies on BitTorrent	**Downloads (millions)**	**World Box Office (millions of dollars)**
1 Star Trek	10.96	385.50
2 Transformers: Revenge of the Fallen	10.60	836.30
3 RocknRolla	9.43	25.70
4 The Hangover	9.18	467.30
5 Twilight	8.72	392.60
6 District 9	8.28	210.80
7 Harry Potter and the Half-Blood Prince	7.93	934.00
8 State of Play	7.44	87.80
9 X-Men Origins: Wolverine	7.20	373.10
10 Knowing	6.93	183.60

Top Selling DVDs	**Units (millions)**	**World Box Office (millions of dollars)**
1 Twilight	10.24	392.60
2 Transformers: Revenge of the Fallen	9.27	836.30
3 Up	8.48	731.30
4 Madagascar 2: Escape 2 Africa	7.78	603.90
5 Harry Potter and the Half-Bood Prince	6.65	934.00
6 Star Trek	6.07	385.50
7 The Hangover	5.94	467.30
8 Monsters vs. Aliens	4.85	381.50
9 Ice Age: Dawn of the Dinosaurs	4.83	886.70
10 The Proposal	4.74	317.40

[a]Sources: www.torrentfreak.com, www.thenumbers.com and www.theboxofficemojo.com.

Table 4 Dynamic panel estimation results (difference GMM)[a].

	(1)	(2)
Lagged sales	0.205 (0.126)	0.542* (0.065)
Downloads	-0.017 (0.044)	-0.076 (0.068)
Polynomial time trend	YES	NO
Week fixed effects	NO	YES
Easter-week	0.499* (0.102)	1.314* (0.272)
Arellano-Bond Pr>z;		
AR(1)	0.042	0.011
AR(2)	0.790	0.094
Hansen test (p-value)	0.222	0.557
Sargan test (p-value)	0.043	0.675
Number of groups	47	47
Number of instruments	27	15
Observations	360	360

[a]Two-step difference GMM estimation results for equation (1). Dependent variable is log(sales). Standard errors are corrected using finite-sample Windmeijer (2005) correction. The instrument set is collapsed; in estimations with week fixed effects (column 2), lags 2 through 3 are used. Arellano-Bond test for second order autocorrelation is reported in column AR(2), the null hypothesis is that there is no autocorrelation. *) Significant at the 1 percent level.

ESSAY 2

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The Impact of Visual Effects on Movies' Box Office Revenues

Unpublished manuscript, submitted to a journal.

The Impact of Visual Effects on Movies' Box Office Revenues

Emmi Martikainen*

Abstract The impact of visual effects and other movie-specific variables on box office revenues is estimated for 248 movies released in the USA in 2011. A measure of visual effect intensity of a movie is constructed based on movies' end credit information: visual effects are measured by the share of visual effect crew on total crew. The quantile regression estimation results suggest that the impact of visual effects on demand depends on the popularity of the movie at the box office: the effect is significant for movies in and below the median. For the most popular titles, the effect is not statistically different from zero. Also the effect of winning an Oscar depends on the popularity of the movie: the positive effect from winning an Oscar is strongest for the less popular titles.

Keywords Movie demand · Visual effects · Quantile regression
JEL codes L82, Z11

1 Introduction

In 1977, computer generated imagery (CGI) was so expensive that George Lucas could afford only 90 seconds of it in *Star Wars*. By 1995, the technology had advanced to the point where first completely computer generated feature film, *Toy Story*, was completed (Epstein, 2005). Today visual effects, which are mostly digital, are made by specialized companies around the world. For example, the visual effects production in Iron Man 3, the movie which earned the second highest opening weekend box office revenue of all time and has grossed over $1 billion globally, was a coordinated effort between 22 different companies (Marshall, 2013 and Internet Movie Database, IMDb). Critics opposing the heavy use of digital effects claim

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that computer-generated effects are used to make up for poor storytelling, while others see visual effects as an integral part of storytelling and production and state that the technology actually makes possible to tell stories that would have otherwise been impossible to tell (McClean, 2007). Nearly all Hollywood movies have some visual effects: they are used not only in science fiction or fantasy movies, but in comedies, dramas, periodical films etc. Even though visual effects, and especially digital visual effects are now an established part of the film industry, there is little to no empirical work on the impact of visual effects on movie demand. To estimate whether visual effects have an impact on the demand for movies, a variable measuring the visual effect intensity of movies is contructed in this paper. Following the idea in Ji and Waterman (2011), the measure is based on movies' end credit information. The impact of visual effects on demand is then estimated for a sample of newly released movie titles.

Waterman (2007) suggests that technological change can have two effects on demand: cost reducing and quality enhancing. With movies, cost reducing technological change occurs when new technology enables filmmakers to achieve similar outcomes than before with less costs. For example, crowd scenes can be created digitally without the need of actual people working as extras. Quality enhancing effect occurs when new technology allows the creation of more impressive visual effects than before, e.g. monsters, landscapes, architectural scenes, action sequences, or more realistic and impressive animation. Waterman (2007) shows that under specific assumptions, if audience responds positively to the enhanced quality brought about by new technology, producers have an incentive to increase production investment at the cost of product variety. This result is consistent with the casual observation that movie production budgets have *increased* during a time when digital technologies have advanced. However, the question of whether or not audience actually does respond positively to enhanced quality brought about by new technology is an empirical one, and the subject of this paper.

Visual effects can affect demand through at least two different channels. Firstly, genres which make heavy use of visual effects, such as science fiction and fantasy, can become more popular as digital technology progresses. On the other hand, the popularity of individual movies within each genre can depend on the use of visual effects. Ji and Waterman (2011) tackle the first issue and study the popularity of different genres over time, measured by the prevalence of different genres among the highest grossing movies. The authors find that genres which are more technology intensive (action, animation and science fiction) have become more common among the top selling titles. Instead of analyzing trends in the popularity of different genres, the present study incorporates a measure of visual effect intensity of a movie directly in the demand estimation. By controlling for other movie-specific factors which affect movie demand, the possibly quality enhancing effect of new technology can be estimated.

The results suggest that visual effects have a positive impact on demand, but the impact differs across different quantiles of the conditional revenue distribution. For the titles in the lowest quartile of the revenue distribution, visual effects have both statistically and economically significant impact on demand, while the demand for most popular movies at the box office is driven by other factors. Interestingly, also

the impact of winning an Oscar varies depending on the popularity of the movie: the positive quality signal of an Oscar win is strongest for the more obscure movies.

The paper is organized as follows. Empirical literature on movie demand is reviewed in Section 2. Data is described in Section 3, and the estimation strategy in Section 4. Estimation results are presented and discussed in Section 5. Section 6 concludes the paper.

2 Literature

A number of studies estimates the impact of movie-specific factors on the financial success of a movie. Litman (1983) finds that critical reviews, production costs, Christmas release and Oscar nomination and win all have a positive impact on the financial success of a movie. According to Litman (1983), also science fiction movies and movies released by major studios perform better financially. Litman and Kohl (1989) extend the work by Litman (1983) and find a positive relationsip between familiarity of actors, stories and characters, positive reviews and the success of the film. Prag and Casavant (1994) find that marketing costs are positively associated with production costs, Oscar awards and the presence of stars, and that film rating, production costs and the presence of stars impact demand only when marketing costs are excluded. Brewer et al. (2009) study the impact of many movie-specific as well as macroeconomic effects on film success, distinguishing between *ex ante* and *ex post* information available to the public. Wallace et al. (1993) and Albert (1998) study especially the impact of movie stars, and report a positive relationship between star actors and revenues. Nelson and Glotfelty (2012) use a continuous measure of star power based on the number of visits to stars' IMDb pages, and estimate that replacing an average star with a top star would increase revenues significantly.

Sochay (1994) finds that increased competition between movies during the release time has a negative effect on the financial success of a film. Einav (2007) studies the seasonality in the demand for movies and finds that there are both seasonal variation in the demand for movies and in the number and quality of movies released, but the seasonality in demand is much weaker than the seasonality in supply. Nelson et al. (2001) and Deuschert et al. (2005) measure the impact of Oscar nomination and win for films' financial success. Nelson et al. (2001) find that being nominated and winning in the best picture and best actor or actress categories has a positive effect on movie's performance. Deuschert et. al. (2005) find that nomination increases revenues while winning the award has only little positive effect. Elliott and Simmons (2008) study the impact of advertising expenditures on box office revenues, when critical reviews are used as quality signals. According to the authors, advertising has a positive effect on total box office revenue. Ravid (1999) finds that star performers, sequels, visibility, big production budgets and having no restricted rating have a positive impact on revenues, but only family ratings and, to some extent, sequels, are associated with higher return-on-investment.

The results concerning the effect of critical reviews are somewhat mixed. Eliashberg and Shugan (1997) distinguish the role of expert reviewers as influencers of demand and as predictors of demand. The authors find that expert opinions function

merely as predictors of film success, having no causal effect on demand. Basuroy et al. (2003) and Basuroy et al. (2006) have later challenged the view of Eliashberg and Shugan (1997). Gemser and Leenders (2007) study the Dutch film market and find that arthouse movies and mainstream movies respond differently to critical reviews. The authors demonstrate that critical reviews influence the demand for arthouse movies. Even though critical reviews can be associated with the success of mainstream movies, they do not influence the demand as they do in the case of arthouse movies. Reinstein and Snyder (2005) analyse the impact of expert reviews on the demand for movies using information on the timing of reviews to avoid the spurious correlation between reviews and movie revenues. The authors find that positive reviews have especially large influence on dramas and movies that did not have a wide release. Hennig-Thurau et al. (2012) separate empirically the perceptions of consumers and reviewers by using an auxiliary regression, and find that the isolated expert opinions affect the long-term box office revenues but not the short-term revenues. Moreover, the relationship between expert reviews and movies' success is nonlinear.

In a number of papers, De Vany and Walls (1996, 1999, 2004) study the distribution of box office revenues. De Vany and Walls (1996) study how box office revenues are determined dynamically, and how information discovery and transmission shape the revenue process. Based on a sample of over 2000 movies, De Vany and Walls (1999) show that revenues follow the Levy stable process and are asymptotically Pareto distributed. According to the authors movies are extremely risky products whose outcomes should be modeled as probability distributions. The use of risk and survival analysis, and the modeling of quantiles and extreme outcomes are thus best suited for modeling revenues and profits in the motion picture industry. De Vany and Walls (1999) also study the impact of movie genre, MPAA rating, budget, the number of opening screens and the presence of stars on box office revenue and profits. The authors find that the presence of star actors is associated with a favourable shift in the probability mass of box office revenues and profits, but due to the nature of the revenue distribution, there is still extreme uncertainty present in the revenue distribution even in the presence of stars. Contrasting the results in De Vany and Walls (2004) which state that revenues should be estimated with a non-Gaussian stable distribution with infinite variance, Derrick et al. (2013) find that the first week's revenue as well as revenues in later weeks can in fact be estimated with OLS and assuming finite variance of the error term.

The work originating in De Vany and Walls (1996) emphazises the role of information transmission or information cascades in the success of movies. Increasing returns to information in movies means that growth in box office revenues is autocorrelated. Autocorrelation in revenues implies that movies which grew in the previous period are more likely to grow in the present period than movies whose growth has taken place further in the past. The top ranked movies earn a disproportionately large share of total revenue, and this effect is attributable to information transmission, that is, to word-of-mouth effects. Building on the work by de Vany and Walls (1996), Walls (1997) finds that there are increasing returns to information created by word-of-mouth effects in the Hong Kong movie market. Hand (2001) confirms the finding

of increasing returns to information for the United Kingdom, and McKenzie (2009) for the Australian movie market.

De Vany and Walls (1997) model the competition between films as a rank tournament. Walls (2005) uses the stable distribution regression model to confirm some earlier results on the box office success of movies. Walls (2009) uses nonparametric methods to analyse the relationship between movie profits, budgets, the number of opening screens, movie stars and other movie attributes. Walls (2009) finds that the expected profitability and mean profitability are positive for sequels, while the expected profitability of including a star actor is positive while mean profitability is negitive. There are positive marginal returns to budget and opening screens, but the effect varies depending on the level of these variables.

Majority of the studies focus on the US market. However, Bagella and Becchetti (1999) study movies produced in Italy, and find that demand is influenced by the po-pularity of the director, actors and the interaction of the two. Collins et al. (2002) study movies in the UK, and find that star power and review scores are positively correlated with movie revenues. In a number of papers, McKenzie studies the Australian movie market (see, for example McKenzie, 2008; McKenzie, 2009). McKenzie McKenzie and Walls (2013) find that Australian films earn less at the box office than foreign films. Moreover, the authors report that government subsidies have no effect on the financial success of a film.

Recent articles use more detailed measures of film attributes to estimate the demand for movies. Fowdur et al. (2009) measure "emotional product attributes" of movies by constructing a text-based measure of emotional characteristics of movies. The authors find that the demand is higher for movies with greater emotional complexity and the demand for movies that elicit negative emotions is related to overall macroeconomic conditions.

The measure of technology intensity on movies in this paper is similar to that of Ji and Waterman (2011). Ji and Waterman (2011) study trends in movie content, and suggest that genres which benefit most from technological advances have become more prevalent over time, because production investments have shifted towards those movie types. In contrast to Ji and Waterman (2011), who study time trends in movie content, this study estimates directly the impact of visual effect intensity of a movie on box office revenues. The present study is thus the first to incorporate a measure of digital visual effect intensity of a movie in a demand estimation.

3 Data

The data set used in this study is a sample based on movies that had theatrical release in 2011 in the USA. According to the Motion Picture Association of America (MPAA), 609 movies had theatrical release in 2011 and earned some box office revenue in that year (MPAA, 2012). The availability of production budget data restricts the sample to 248 movies in total. The availability of budget data might not be random across movies: more obscure movies, that is, movies with very low production budget and low box office revenues, are more likely to lack budget data than blockbusters. However, budgets in the sample range between $17 000 and $250 million,

while box office revenues range between less than $2 000 and over $381 million. The movies in the sample thus exhibit considerable variation in terms of production costs and popularity at the box office.

The dependent variable in the estimations is the total US box office revenue earned during the movie's theatrical run. Movie-specific independent variables are based on the findings in the empirical literature on movie demand, and include movie genre, MPAA rating, production budget, a measure of star power, Metascore rating measuring the critical response to a movie, the number of Oscar wins in a major category[1], an indicator variable for whether or not the movie is a sequel, an indicator variable for whether the movie is available in 3D, and an indicator variable for whether or not the movie was released during the same week as one of the top 10 blocbusters of the year. All movie-specific data are collected from Box Office Mojo (boxofficemojo.com) and Internet Movie Database (IMDb, imdb.com).

Movie genres and MPAA ratings are assigned based on IMDd labeling. There are in total 11 genre dummies (Action, Adventure, Animation, Biography, Comedy, Crime/Thriller, Documentary, Drama, Family, Horror, Sci-fi/Fantasy). The omitted and most common genre in the estimations is Drama. A dummy variable was created for the MPAA rating R (Restricted). The other MPAA ratings categories include NR (Not Rated), PG (Parental Guidance Suggested), PG13 (Parents Strongly Cautioned) and G (General Audiences). The measure of star power for actors and directors was constructed using IMDb's Starmeter for the year 2010. A dummy variable was created indicating whether a movie had an actor or a director in the top 50 in the Starmeter ranking in the year preceding the release. Starmeter is based on the number of visits to actors' and directors' webpages, and captures the general interest in a an actor or a director during a specific time period (see Nelson and Glotfelty, 2012). Star power was measured at the end of 2010 to avoid the reversed causality between star power and box office revenues: stars can attract audiences to a movie, but a popular movie can also cause actors and actresses to gain star power. By using a variable which measures star power *before* the theatrical release, we are able to interpret the possible causality running from the presence of star performers to box office revenues.

Critical reviews are included as a proxy for the unobserved quality of a movie, and are measured by a variable *Metascore*. Metascore is reported by metacritic.com, and it reports a weighted average of movie's critical response, with some influential critics and publications given more weight (see metacritic.com). The variable ranges between 0 and 100 and takes both online and print reviews into account. Since expert reviews are likely to be correlated with the unobserved quality of the movie, the correlation between reviews and box office revenues might be spurious. The movies are sometimes rated after their theatrical opening, so critical reviews do not necessarily have purely influential role in the estimations. The variable *Metascore* is thus included to control for the unobserved quality of the movie, and the relationship between critical reviews and demand is not necessarily interpreted as ciritical reviews

[1] The major categories are: original screenplay, adapted screenplay, directing, best picture, actor in a leading role, actress in a leading role, actor in a supporting role and actress in a supporting role.

having a causal effect on demand (see Reinstein and Snyder, 2005; Eliashberg and Shugan, 2007).

Descriptive statistics for the variables in the data are presented in Table 1. Box office revenues range from less than $ 2 000 USD to over $ 381 million. The average production budget is approximately $34 million, with the lowest budget in the sample being $17 000 and the highest $250 million. Revenues and budget are heavily skewed to the right. For example, for box office revenues, the median is 13.48, while the mean is 38.94. For the production budget, the median (20.00) is also lower than the mean (34.00). Almost 39% of the movies are rated R. Approximately 12% of movies in the sample were competing against a top 10 blockbuster of the year, that is, they were released within the same week as one of the blockbusters. The average critical response to the movies in the sample is 54 out of 100, with the lowest movie earning a score of 9 and the best movie earning a score of 89. Six different movies in the sample were awarded an Oscar in a major category.

3.1 Visual Effects Data

Visual effects in movies refers to imagery produced outside live action shoots, most often during post production. Computer generated imagery (CGI) is the application of computer graphics to visual effects, and has become increasingly prevalent during recent years. In contrast, special effects, which can be divided into in-camera optical and on-set mechanical effects, refer to practical effects made on set (ShowWatcher, 2012). Special effects include examples like car chases, explosions and use of mechanized props and makeup, while visual effects refer most often to digitally created imagery and computer animation (ShowWatcher, 2012).

To study whether movie audiences respond positively to visual effects in movies, a measure of movie's visual effect intensity is constructed. The measure is based on movies' end credit information, and is calculated as the ratio of movie's visual effects crew to movie's total crew. The data is collected from IMDb (imdb.com). Creating visual effects is a labor intensive process, and in some cases the visual effect crew can even surpass the live action crew. The percentage of crew dedicated to producing visual effects is a straightforward way to approximate the otherwise hard to measure visual effect intensiveness, or technology intensiveness of a movie.

Table 2 presents the percentage of visual effects crew by movie genre. Most movies in the sample belong to the categories drama (76) or comedy (55). In the total sample, visual effects crew makes up on average 14% of total crew, and the figure ranges between zero and 76%. Movies belonging to the genre Sci-fi/Fantasy, Animation and Family use most visual effects, as measured by the size of the relative visual effects crew. For Sci-fi/Fantasy, the share of visual crew relative to total crew is 42%, and the value ranges between 9% and 76%. Movies of this genre also have bigger production budgets and they collect more box office revenues, on average.

Figure 1 depicts the scatterplot of box office revenues (in USD millions) and the technology intensiveness of the movies in the sample, along with a regression line and the 95% confidence interval. A large proportion of the movies seems to be concentrated on the lower end of the distribution in terms of both visual effects and

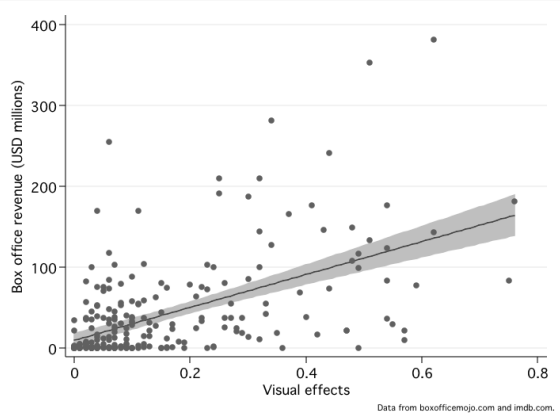

Fig. 1 Scatterplot of box office revenues and visual effects.

box office revenue, highlighting the fact that the distributions are heavily skewed to the right.

4 Estimation Strategy

The box office revenue distribution is highly skewed and the mean is shown to be dominated by rare well-performing movies in the far right tale of the distribution (De Vany and Walls, 1996). As De Vany and Walls (1996) point out, analysing mean outcomes is not fruitful in the case of movie revenues. To estimate credibly the effect of visual effects on movie demand, the estimations are carried out using a quantile regression method. Quantile regression, introduced by Koenker and Bassett (1978), is more robust to outliers in the dependent variable and heavy tales than ordinary least squares (see, for example, Koenker and Hallock, 2001). With quantile regression, the conditional median and other quantiles is estimated instead of estimating the conditional mean of revenues. Instead of allowing the covariates merely to shift the location of the conditional distribution of the dependent variable, the conditional revenue distribution can be fully characterized with quantile regression.

The estimated equation is:

$$ln(R_i) = \alpha + \beta\, VISUALS_i + \gamma' X_i + \varepsilon_i \tag{1}$$

where $ln(R_i)$ is the log of total US box office revenue for movie i, $VISUALS_i$ is a measure of visual effect intensity of movie i, and X_i is a matrix of other movie-specific variables including the movie genre, production budget, measure of star power, Metascore rating measuring critical response to the movie, and indicator variables equaling one if the movie has an actor or director in the top 50 in the Starmeter ranking, if the movie is rated R, if the movie received an Oscar for a major category,

if the movie is a sequel, if the movie is available in 3D and if the movie was released during the same week as a top ten box office hit movie. Parameters to be estimated are α, β and the parameter vector γ. The stochastic error term is ε.

Based on the empirical literature on the determinants of box office success, the coefficients for budget and star power are expected to be positive. Production budget increases production values, and is likely to be positively correlated with advertising expenses. The presence of star performers is also likely to inflate the production budget making it hard to disentangle the effect of stars, budget and advertising on demand. However, the main focus is on estimating the effect of visual effects on demand, and separating the effects of budget, stars and advertising on demand is not the main focus of this study. Sequels and movies that are part of a franchise have a built-in audience and generally perform better at the box office. Critical reviews function as a proxy for the overall unobserved "quality" of a movie, so positive reviews are expected to be positively related to demand. Blockbuster movies are likely to crowd out demand in movie theaters. Thus, the variable indicating if a movie is released within a week of the release of a blockbuster is expected to be negative. Since the restricted rating R narrows down the potential audience of a movie, rating R is expected to have a negative effect on demand. Movies released in 3D can generate either higher or lower revenues than 2D movies, depending on audiences' tastes.

5 Results

The results from estimating equation (1) with quantile regression are presented in Table 3. Coefficients from OLS estimations and quantile estimations for the median are reported for comparison. For both quantile and OLS regression, visual effects have a positive impact on demand, and the coefficients between quantile regression and OLS are almost identical. Production budget has a significant and positive impact on demand, but the coefficient is essentially zero. This result can be due to the fact that production budget, advertising and star power are likely to be highly correlated. Indeed, dropping production budget from the estimations increases the magnitude and significance of the estimated coefficients for almost all other explanatory variables.

In the quantile regression, movies belonging to the genres Comedy and Family have higher demand than the omitted category Drama. Winning an Oscar award and having a star performer in the cast also increases demand. Sequels or movies in 3D do not have an advantage at the box office. According to the OLS estimations, belonging to the genre Documentary has a negative effect on box office revenue. Restricted rating decreases demand, and Oscar awards and star power have the expected positive effects on box office revenues.

The estimated coefficients for visual effects for different quantiles are reported in Table 4. The estimated coefficients and 95% confidence intervals are depicted in Figure 2. Genre dummies are omitted since they do not bring any new information compared to the results in Table 3: the dummies for Comedy and Family are consistently positive and significant, and the dummy for Documentary is negative and significant. The impact of visual effects, when estimated for the different quartiles, is positive and significant for the movies belonging to the lowest quartile of box office

revenues, and movies belonging to the median. The positive effect from visual effects is strongest for the movies belonging to the lowest quartile. Interestingly, winning an Oscar has a strongest impact on lower quartiles of the revenue distribution, indicating that most obscure titles benefit most from the prestige and advertisement related to winning an Oscar.

Table 5 reports the results for testing for the equality of coefficients across differents quartiles. For visual effects and Oscar awards, the null hypotheses of equal coefficients across the 25th and 75th quartiles are rejected. For all other explanatory variables, the coefficients are equal across quartiles.

To test whether the results are robust against different measures of technology intensiveness, the estimations were carried out by constructing a more broad variable measuring the technology intensiveness of the movies in the sample. The alternative technology variable includes the total ratio of the visual effects crew, special effects crew and animation crew to total crew. The results are qualitatively similar, although when a more broad measure of technology intensiveness is used, the estimated coefficient on technology intensiveness is smaller, but positive and statistically significant for the lower quartiles of the conditional revenue distribution.

6 Discussion

Despite the trend towards increasing use of visual effects in movies, thus far there have been no demand estimations quantifying the impact of visual effects on movie demand. In this article, the intensity of visual effects of movies is measured as the percentage of the visual effects crew of the total crew of a movie. The impact of visual effects on box office revenues is then estimated for a sample of newly released movies. The estimations are carried out using quantile regression, which allows the impact of visual effects and other explanatory variables to differ across different conditional quantiles of the revenue distribution.

The results suggest that visual effects have a positive effect on demand, but the effect depends on the popularity of the movie at the box office. In the lowest quartile of the box office revenue distribution, visual effects have strongest positive impact on demand. On the other hand, for the most popular titles, technology intensiveness of a movie does not seem to have a strong effect on demand. For the most popular movies, the presence of stars, Oscar award, the genre of the movie, rating and the production budget explain the performance at the box office rather than visual effects. Interestingly, winning an Oscar has the strongest impact on demand for the more obscure titles. This is a result that can be expected, since movies are experience goods whose value is impossible to know before consuming them. Oscar awards function as quality signals and the more obscure a movie is, the less there are other quality signals available.

Movie genres which are technology intensive in the sense that they make heavy use of visual effects have become increasingly popular during recent years (Ji and Waterman, 2011). Production investments have thus shifted towards these types of movies. More technology intensive movies have bigger production budgets, suggesting that the technology has not been cost reducing as much as it has been, to some

extent, quality enhancing. Movie audiences seem to respond positively to the visual effects in movies, but for the most popular movies, other factors are more important in determining demand.

References

1. Albert, S. (1998). Movie Stars and the Distribution of Financially Succesful Films in the Motion Picture Industry. *Journal of Cultural Economics*, Vol. 22(4), pp. 249–270.
2. Bagella, M. & L. Becchetti (1999). The Determinants of Motion Picture Box Office Performance: Evidence from Movies Produced in Italy. *Journal of Cultural Economics*, Vol. 23(4), pp. 237–256.
3. Collins, A. & C. Hand (2002). What Makes a Blockbuster? Economic Analysis of Film Success in the United Kingdom. *Managerial and Decision Economics*, Vol. 23(6), pp. 343–354.
4. Derrick, F. W., Williams, N.A. & C.E. Scott (2013). A Two-Stage Proxy Variable Approach to Estimating Movie Box Office Receipts. *Journal of Cultural Economics*. DOI 10.1007/s10824-012-9198-y.
5. Deuchert, E., Adjamah, K. & F. Pauly (2005). For Oscar Glory or Oscar Money? *Journal of Cultural Economics*, Vol. 29(3), pp. 159–176.
6. De Vany, A. S. & D. W. Walls (1994). An Empirical Study of the Determinants of Revenues and Marketing Expenditures in the Motion Picture Industry. *Journal of Cultural Economics*, Vol. (18), pp. 217–235.
7. De Vany, A. S. and Walls, D.W. (1996). Bose-Einstein Dynamics and Adaptive Contracting in the Motion Picture Industry. *The Economic Journal*, Vol. 439(106), pp. 1493-1514.
8. De Vany, A. S. and Walls, D.W. (1997). The Market for Motion Pictures: Rank, Revenue and Survival. *Economic Inquiry*, Vol. 35(4), pp. 783–797.
9. De Vany, A. S. and Walls, D.W. (1999). Uncertainty in the Movie Industry: Does Star Power Reduce the Terror of the Box Office? *Journal of Cultural Economics*, Vol. 23(4), pp. 285–318.
10. De Vany, A. S. & D. W. Walls (2004). Motion Picture Profit, the Stable Paretian Hypotheses, and the Curse of the Superstar. *Journal of Economic Dynamics and Control*, Vol. 28(6), pp. 1035-1057.
11. Einav (2007). Seasonality in the U.S. Motion Picture Industry. *RAND Journal of Economics*, Vol. 38(1), pp. 127–145.
12. Eliashberg, J. & Shugan, S. (1997). Film Critics: Influencers or Predictors? *Journal of Marketing*, Vol. 61(2), pp. 68–78.
13. Elliott, C. & R. Simmons (2008). Determinants of UK Box Office Success: The Impact of Quality Signals. *Review of Industrial Organization*, Vol. 33(2), pp. 93–111.
14. Epstein, E. J. (2005). The Schizoid Split in Movies. Will Digital Effects Ruin Hollywood? *Slate Magazine*. Retrieved 6 June, 2013. Available at: http://www.slate.com/articles/arts/the_hollywood_economist/2005/12/the_schizoid_split_in_movies.html
15. Gemser, G., Van Oostrum, M. & M. Leenders (2007). The Impact of Film Reviews on the Box Office Performance of Art House versus Mainstream Motion Pictures. *Journal of Cultural Economics*, Vol. 31, pp. 43–63.
16. Hand, C. (2001). Increasing Returns to Information: Further Evidence from the UK Film Market.*Applied Economics Letters*, Vol. 8(6), 419-421.
17. Hennig-Thurau, T., Marchand, A. & B. Hiller (2012). The Relationship Between Reviewer Judgments and Motion Picture Success: Re-analysis and Extension. *Journal of Cultural Economics*, Vol. 36(3), 249-283.
18. Litman, B. & L. Kohl (1989). Predicting Financial Success of Motion Pictures: the 80's Experience. *Journal of Media Economics*, Vol. 2, pp. 35–50.
19. Marshall, R. (2013). Breaking Down the High-Tech Global Jigsaw Puzzle of Iron Man 3. Digital Trends. Available at: http://www.digitaltrends.com/gaming/marvels-vp-of-visual-effects-talks-iron-man-3-tech/
20. McClean, S. T. (2007). Digital Storytelling: The Narrative Power of Visual Effects in Film. MIT Press, Massachusettes Institute of Technology.
21. McKenzie, J. (2008). Bayesian Information Transmission and Stable Distributions: Motion Picture Revenues at the Australian Box Office. *The Economic Record*, Vol. 84(266), pp. 338–353.
22. McKenzie, J. (2009). Revealed Word-of-Mouth Demand and Adaptive Supply: Survival of Motion Pictures at the Australian box office. *Journal of Cultural Economics*, Vol. 33(4), pp. 279–299.

23. McKenzie, J. & D.W. Walls (2013). Australian Films at the Australian Box Office: Performance, Distribution and Subsidies. *Journal of Cultural Economics*, Vol. 37(2), pp. 247–269.
24. Neelamegham, R. & P. Chintagunta (1999). A Bayesian Model to Forecast New Product Performance in Domestic and International Markets. *Journal of Business*, Vol. 72, pp. 463–492.
25. Nelson, R. A., Donihue, M.R., Waldman, D.M. & C. Wheaton (2001). What's an Oscar Worth? *Economic Inquiry*, Vol. 39(1).
26. Nelson, R. A. & R. Glotfelty (2012). Movie Stars and Box Office Revenues: an Empirical Analysis. *Journal of Cultural Economics*, Vol. 2(66), pp. 141–166.
27. Ravid, A. (1999). Information, Blockbusters and Stars: A Study of The Film Industry. *Journal of Business*, Vol. 72, pp. 463–492.
28. Reinstein, D. A. & C.M. Snyder (2005). The Influence of Expert Reviews on Consumer Demand for Experience Goods: A Case Study of Movie Critics. *The Journal of Industrial Economics*, Vol. 53(1), pp. 27–51.
29. Sochay, S. (1994). Predicting the Performance of Motion Pictures. *Journal of Media Economics*, Vol. 7(4), pp. 1–20.
30. Wallace, T., Seigerman, A. & M. Holbrook (1993). The Role of Actors and Actresses in the Success of Films: How Much is a Movie Star Worth?. *Journal of Cultural Economics*, Vol. 17(1), pp. 1–27.
31. Walls, D. W. (2004). Motion Picture Profit, the Stable Paretian Hypotheses, and the Curse of the Superstar. *Journal of Economic Dynamics and Control*, Vol. 28(6), pp. 1035–1057.
32. Walls, D. S. (2005). Modeling Movie Success When 'Nobody Knows Anything'. Conditional Stable-Distribution Analysis of Film Returns. *Journal of Cultural Economics*, Vol. 29(3), pp. 177–190.
33. Walls, D. S. (2009). Screen Wars, Star Wars, and Sequels. *Empirical Economics*, Vol. 37(2), pp. 447–461.
34. Waterman, D. (2007). The Effects of Technological Change on the Quality and Variety of Information Products. *Economics of Innovation and New Technology*, Vol. 16(8), pp. 587–594.

Table 1 Selected summary statistics for the movies in the sample.

	Mean	St. Dev.	Min.	Max.	N
Box office revenue	38.94	60.44	0.00	381.01	248
Budget	34.21	43.38	0.02	250.00	248
Metascore	54.41	16.73	9	89	248
Oscar Award	0.02	0.15	0	1	248
Rating R	0.39	0.49	0	1	248
Starmeter top 50	0.20	0.40	0	1	248
Competition	0.12	0.33	0	1	248
Visual crew %	0.15	0.16	0	0.76	248

Table 2 Selected summary statistics by genre.

Genre	N	Box office	Budget	Visual crew %
Action	18	39.30	44.44	0.18
Adventure	14	48.15	61.56	0.22
Animation	12	103.19	93.67	0.39
Biography	8	8.91	15.58	0.07
Comedy	55	35.75	26.88	0.07
Crime/Thriller	13	24.42	26.30	0.10
Documentary	10	8.61	3.99	0.08
Drama	76	16.52	14.22	0.07
Family	7	68.49	56.57	0.23
Horror	14	22.75	17.56	0.19
Sci-fi/Fantasy	21	121.08	94.76	0.42
All	248	38.94	34.21	0.14

Table 3 Quantile regression and OLS estimation results for equation (1)[a].

	QR	OLS
Visual effects	3.438**	3.416**
	(1.679)	(1.543)
Budget	0.000***	0.000***
	(0.000)	(0.000)
Crime/Thriller	1.326	0.960
	(0.879)	(0.687)
Adventure	-0.142	-0.267
	(1.002)	(0.708)
Horror	0.988	0.514
	(1.480)	(0.715)
Comedy	1.754**	1.288***
	(0.717)	(0.427)
Documentary	-1.761	-1.900**
	(1.350)	(0.786)
Animation	-0.777	-0.061
	(1.394)	(0.875)
Biography	-0.585	-0.286
	(0.868)	(0.848)
Sci-fi/Fantasy	0.305	0.311
	(0.904)	(0.734)
Action	-0.201	0.381
	(0.916)	(0.631)
Family	2.231**	1.786*
	(1.015)	(0.952)
Competition	-0.749	-0.743
	(0.692)	(0.459)
Oscar award	2.626***	2.721***
	(0.682)	(0.976)
Rating R	-0.502	-0.683**
	(0.444)	(0.338)
Sequel	0.830	0.894
	(0.551)	(0.558)
3D	0.359	0.338
	(0.671)	(0.579)
Star power	1.480***	1.437***
	(0.446)	(0.390)
Metascore	0.001	0.013
	(0.012)	(0.009)
Constant	13.86***	12.82***
	(0.920)	(0.630)
N	248	248
Pseudo R^2	0.34	-
Adjusted R^2	-	0.45

[a]Quantile regression for the median and OLS regression estimation results for equation (1). Dependent variable is log(box office revenue). In quantile regression, standard errors are bootstrapped with 1000 replications. *) Significant at the 10% level, **) Significant at the 5% level, ***) Significant at the 1% level.

Table 4 Quantile regression estimation results for equation (1)[a].

	(1)	(2)	(3)
Quantile	0.25	0.50	0.75
Visual effects	7.209***	3.438*	1.604
	(2.484)	(1.677)	(1.278)
Budget	0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Competition	-0.994	-0.749	-0.860
	(0.981)	(0.692)	(0.584)
Oscar award	4.103***	2.626***	1.597**
	(0.887)	(0.682)	(0.635)
Rating R	-1.049	-0.502	-0.585*
	(0.655)	(0.444)	(0.321)
Sequel	1.298	0.830	0.455
	(1.031)	(0.551)	(0.325)
3D	-0.581	0.359	-0.045
	(1.161)	(0.671)	(0.494)
Star power	1.910**	1.480**	1.175***
	(0.786)	(0.446)	(0.344)
Metascore	0.024	0.001	0.006
	(0.020)	(0.012)	(0.009)
Constant	10.42***	13.86***	15.16***
	(1.407)	(0.920)	(0.746)
Pseudo R^2	0.35	0.34	0.27
N	248	248	248

[a]Quantile regression estimation results for different quartiles for equation (1). Dependent variable is log(box office revenue). Standard errors are bootstrapped with 1000 replications. *) Significant at the 10% level, **) Significant at the 5% level, ***) Significant at the 1% level.

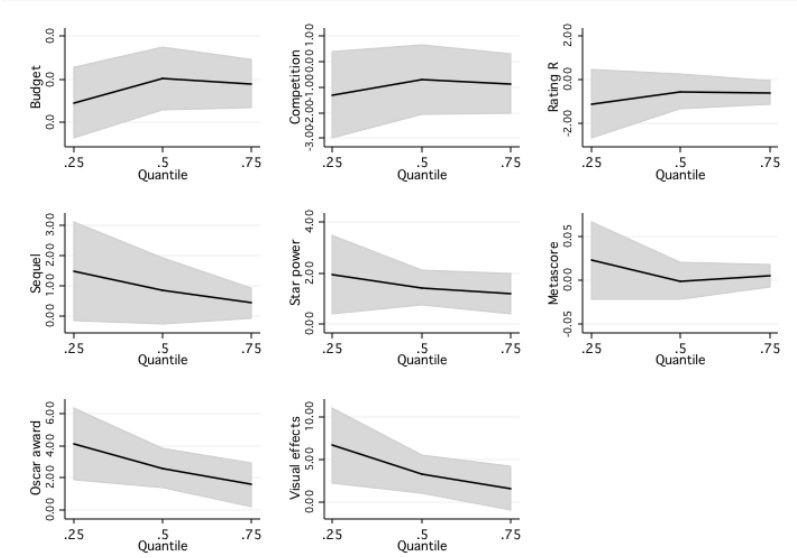

Fig. 2 Estimated coefficients and the 95% confidence intervals by quartile.

Table 5 Test for the equality of the quantile regression coefficients across quartiles[a].

	0.25 = 0.50	0.25 = 0.75
Visual effects	0.082	0.023
Budget	0.300	0.480
Competition	0.779	0.893
Oscar award	0.109	0.018
Rating R	0.350	0.496
Sequel	0.590	0.381
3D	0.351	0.647
Star power	0.501	0.311
Metascore	0.195	0.359

[a]F-test for the equality of coefficients across quartiles. Prob. > F is reported. Null hypotheses is that the coefficients are equal.

ESSAY 3

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The Demand for Live Performing Arts: Evidence from Opera
Unpublished manuscript.

The Demand for Live Performing Arts: Evidence from Opera

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Abstract Using detailed data for 2001-2009 from the sales system of the Finnish National Opera, we estimate the determinants of demand for opera tickets. We find that operas in their premiere season are more popular than reprises. Demand is higher for non-classical operas, Finnish operas and for performances with a famous opera singer. Critical reviews and the overall popularity of the opera influence demand. There is also evidence of seasonal effects. By excluding temporarily discounted tickets and controlling for star performers, specially priced performances, and different seating areas, we are able to credibly estimate the price elasticity of demand. The demand for opera tickets is negative and close to unity, but the elasticity differs between reprises and operas in their premiere season.

Keywords demand estimation · opera · performing arts
JEL Classification Z11, L32, L82

1 Introduction

While majority of the empirical studies on live performing arts focus on the demand for theatre, only few focus on the demand for opera. Determinants of demand for opera have not been studied using recent data and rigorous empirical methods. Even though progress has been made and some stylized facts for the performing arts as a whole exist, there are some findings in the empirical literature that have been hard to understand. For example, the empirical evidence concerning price elasticity of demand is mixed. The estimates vary, and some studies report even positive price elasticity indicating that performing arts is a Veblen good. However, the lack of good data and identification problems suggest that the positive elasticity results are more of a sign of endogeneity or omitted variable problems than evidence for actual positive elasticity.

We use detailed data on prices and quantities of tickets sold in the Finnish National Opera to estimate the determinants of demand for opera tickets. Our data set is rich enough to allow us to estimate the effect of several performance-specific characteristics on demand. In addition, unlike in majority of the studies, our ticket sales data is sufficiently disaggregated to avoid the problems brought about by aggregation and construction of average price measures in estimating price elasticity. In particular, we are able to control for performance and play characteristics that influence pricing and are likely to influence demand as well. Our data also allows us to separate between full-priced and different types of campaign tickets. This is important since low-pricing strategy is likely associated with anticipated demand. The number of tickets sold is limited by the capacity of the opera house, so that the actual demand is not observed for the performances that are sold out. We circumvent this problem by estimating a demand model using censored regression method, which yields unbiased results even in the presence of censoring.

We find that the demand is higher for performances in their premiere season, for non-classical operas and for performances with a famous opera singer. Demand increases for consecutive performances, possibly suggesting positive word-of-mouth effects. Demand is higher on weekends than on weekdays and there are demand differences between months. Different operas seem to compete against each other: the total number of opera performances during a month has a negative effect on the demand for individual plays. Critical reviews, both positive and negative, influence demand. Increase in the price of substitutes has a positive impact on demand. The previous literature regarding elasticities is mixed and sensitive to the level of aggregation in the data. Using more disaggregated data typically yields higher price elasticities and carefully controlling for performance characteristics is essential (Seaman, 2006). Our overall price elasticity estimate is negative and close to unity. However, elasticity depends largely on the type of performance: demand is elastic (-2.6) for reprises and inelastic (-0.2) for operas in their premiere season.

The remaining of the paper is structured as follows. Empirical literature on performing arts demand is reviewed in section 2. In section 3, the data is described, and some background information concerning the Finnish National Opera is presented. The estimation method is discussed in section 4 and the results are presented and discussed in section 5. Section 6 concludes.

2 Empirical Literature on the Demand for Performing Arts

The empirical literature on performing arts demand is thoroughly reviewed in Seaman (2006). Like Corning and Lvy (2002) point out, demand studies typically take one of two approaches: survey studies which try to characterize socio-economical characteristics of performing arts patrons, and econometric studies which focus on quantifying determinants of demand. This study falls into the latter category. More specifically, our study belongs to the strand of

literature which incorporates detailed measures of performance characteristics or quality in the demand estimation.

A number of articles concentrate on estimating price and income elasticities for different performing art forms using aggregated time-series, cross-sectional or survey data on attendance, and calculated average ticket prices. The level of aggregation is often at the company-season level, but sometimes data is aggregated across different companies and years, or even across different performing art forms. Average ticket price is typically constructed from total attendance and revenue data.

One of the earliest studies is Moore (1966), who finds that income has a positive effect on total expenditures per evening, including spending on higher quality tickets and complementary goods, while demand is inelastic with respect to price and income. The author also discusses the effect of total number of shows, the expansion of the motion picture industry, endogeneity problems of the estimations and the leisure-price substitution effect of income, which is omitted from the model. Other demand studies which do not incorporate output characteristics or quality in the estimated model are Gapinski (1984) and Gapinski (1986), who reports some evidence of substitution between different performing arts. Focusing on the results for opera subscriber tickets, Felton (1989) reports that the impact of price, number of plays, and the popularity ratings of the opera vary between individual opera companies, income has no effect on demand and unemployment rate has a negative effect on demand. In a later study, Felton (1992) finds that price and income elasticities differ across individual opera, ballet and orchestra companies and across different budget categories. Greckel and Felton (1987) find that popularity of a conductor is a significant determinant of demand for a symphony orchestra, while results concerning price and income elasticities are mixed. Jenkins and Austen-Smith (1987) find a small positive effect of less esoteric (more low-brow) programming on theatre demand while Dobson and West (1989) find that the type of play or day of the week has no effect on the demand for theatre. In their learning-by-consuming model on theatre demand, Levy-Garboua and Montmarquette (1996) report that demand is price elastic and the quality of the outing as well as substitution effects from other entertainment matter.

Throsby (1990), and in a previous study Throsby (1983), studies a number of quality characteristics, such as type or genre of play and reputation of author, on the demand for theatre. In addition, the author constructs quality measures indicating the standard of production, acting and design using press reviews of the play, thus making the important distinction between objective and subjective quality measures. According to the results audience prefers classic and well-known plays, but the effect of subjective quality measures varies across theatres. The price elasticity coefficients range from positive to negative between theatres, and are not always significant. Throsby (1990) concludes that quality characteristics seem to be more important determinants of demand than price. Abbe-Decarreux (1994) studies similar quality variables for theatre than Throsby (1990), and finds that most of the quality variables are significant. By studying ticket demand across different price categories, the

author finds the demand for regularly priced tickets to be inelastic, and the demand for low-priced tickets to be elastic.

Krebs and Pommerehne (1995) construct a popularity variable for productions based on the relative number of times the piece has been performed assuming that low-brow productions get a longer run than high-brow plays. According to the authors, past demand has a large impact on current demand, but the quality variables are not statistically significant. Luksetich and Lange (1995) estimate the relationship between total expenditure per symphony performance and demand, and find the effect to be not significant. Withers (1980) estimates demand for the aggregated performing arts controlling for leisure-price effects. The results indicate a moderate negative own-price and positive substitution-price elasticity, and income elasticity close to unity, or larger, depending on model specification. Withers (1980) finding, that the positive income effect is at least partially offset by the negative leisure-price effect, has been later elaborated in Zieba (2009) (see also discussion in Gapinski, 1986 and Ekelund and Ritenour, 1999).

Zieba (2009) also estimates the effect of substitutes and several objective quality indicators on demand for German public theatres. Price is inelastic for German theatres, and the demand is positively related to the price of symphony concerts, relative number of guest performances and spending on costumes and dcor, while artistic wages have no effect on demand. OHagan and Zieba (2010) complement the estimations in Zieba (2009). In addition to estimating the effect of quality variables as in Zieba (2009), the authors estimate the effect of innovativeness of a theatre, size of the production cast, number of different genres, theatre capacity, the number of competing theatres and market size, on demand. The authors find that own-price elasticity is negative but small in absolute value. Guest performances, artistic wages and cast size have positive and significant effect on demand across different time periods and different model specifications.

The study by Corning and Levy (2002) is notable in the sense that the authors use performance-level data across three different theatre venues, instead of using aggregated data. The authors study seasonal effects and differences in tastes across different venues concentrating on the demand for full-price single tickets. Corning and Levy (2002) find that the price and income elasticities of demand differ across venues. Demand is higher during weekends than on weekdays, and for night shows compared to matinees, but there is no significant variation in demand between months. Consumers differ in their tastes regarding genre and quality signals, including critical reviews, across different theatre venues.

Werck and Heyndels (2007) incorporate a number of objective output characteristics in estimating demand for Dutch theatres. Using theatre-year level aggregated panel data, the authors find that demand is higher for productions with large cast size, Dutch-speaking playwright, and for revivals of old productions. Demand is price inelastic, but income elastic. Akdede and King (2006) focus on the differences between more and less developed cities in theatre demand in Turkey. The authors find that demand is more price elastic

in less developed cities, while in developed cities, plays with a known author and plays with music, comedy or dance have higher demand. Toma and Meads (2007) report a positive relationship between demand for symphony orchestras and some age cohorts and find that the presence of competing symphony orchestras in close proximity decreases demand. The total number of season performances has a positive effect on attendance, but the effect is decreasing in the number of performances. Quality as measured by relative expenditure on artistic personnel has a positive effect on demand.

In addition to econometric studies using revealed preference data, a number of studies use stated preference data to study performing arts demand. Willis and Snowball (2009) use choice experiments in estimating the effect of several attributes on theatre demand in South Africa. Utility increases for productions with professional or semi-professional cast, and for productions with a famous director. Consumers prefer plays with a South African context, and comedies over musicals, but the variance in tastes is significant among the population. Grisola and Willis (2011) study the effect of theatre production characteristics, and information on theatre productions, on demand in a discrete choice framework. The authors find evidence of heterogeneity in preferences for different theatre characteristics. Especially word-of-mouth and critical reviews have a strong effect on demand and willingness-to-pay, but the effect, especially for word-of-mouth, is heterogeneous among theatregoers. In a later study, Grisolia and Willis (2012) use a latent class model to confirm the results for heterogeneity in audience tastes.

Previous studies higlight the sensitivity of the results to the level of aggregation in the data, and the importance of incorporating output characteristics, such as type and quality of play, in the demand estimation. In contrast to the majority of the literature, we use data on prices and quantities and other product characteristics at the level of individual opera productions and performances. The present study thus contributes to the existing literature by estimating the effect of several quality characteristics on opera demand using performance level data, and employing an estimation method which is robust to the capacity constraints of the opera house.

3 Data

Our data comes from the sales information system of the Finnish National Opera (FNO). The FNO is the only professional opera house in Finland, and thus is the main supplier of opera performances in the country. The main auditorium, on which most of the opera performances are given, has a capacity of around 1,350 seats. Some 12,000 tickets a month were sold to opera performances in our data.

Most previous studies of opera or other performing arts demand use aggregated data, for example number of tickets sold in a theater or theaters during a given time period and average prices on that period. We are able to make an improvement in that respect, since we have access to detailed sales data

in the sales information system of the Finnish National Opera. Sales reports from the system include the exact number of tickets sold and sales revenue for each individual performance by area of seating and price category. The data covers all performances between September 2001 and May 2009. Descriptive statistics of the data are presented in Table 1.

The data allows us to control for factors which are correlated with prices and demand and would lead to biased elasticity estimates if ignored. The potential sources of endogeneity which we control for are the different types of seating areas, discount campaigns to promote sales, separately priced performances for which demand is expected to be higher, and performances with famous performers.

3.1 Ticket sales and price information

The main auditorium of the opera house is divided into six seating areas that differ in price and quality of view. For each of these areas, full-price tickets and several types of discount-price tickets are sold. The information on the list prices of tickets is obtained from the season brochures of the opera and combined with the sales data. Given the structure of the data, there is no need to use average prices of different seating areas or different discount categories in estimating price elasticity. We are able to make a distinction between full-price tickets, tickets with permanent discounts available to every performance and distinct, and often targeted, temporary discounts used to promote sales of a particular performance. Being able to make this distinction is crucial in estimating price elasticities.

There are multiple sources of price variation in our data. Some of this variation comes from higher pricing of performances that feature famous opera singers. The price of some plays is set higher, a notable example being Wagner's Ring tetralogy. The main price variation used to identify price elasticity comes from three general changes in pricing during the period of interest: In 2002, all list prices were increased (by 4 to 13%, depending on seating category and play type). In 2003, there was a major increase in the list prices of tickets to premiere season plays and stalls tickets to reprise plays (8 to 56%). In 2006, the prices of cheaper seating categories in premiere season operas were lowered (5 to 22%). Minor variation in prices is due to list price roundings following adoption of euro in 2002 (-3 to +1%). Finally, since we measure prices in real terms (list price is divided by CPI) there is also price variation due to general consumer price inflation.

3.2 Explanatory variables

In addition to the detailed information on quantities and prices described above, our data includes a rich set of explanatory variables, parts of which have been matched to sales data from other data sources. Changes in the prices of

substitutes is measured by the logarithm of the weighted average of the CPI components "museums" and "recreational events". Since type of performance is expected to have a significant influence on demand, we have classified operas in the categories of classical (Beethoven and Mozart, premiered before 1916), modern (world premiere after the 2nd World War) and other, and to Finnish and foreign operas. We also have information on whether a performance is a premiere, whether the opera is on its premiere season and whether the performance features a famous opera singer. We are able to identify three famous, frequently employed star performers whose presence in a performance has also led to a higher price. In addition, we construct a dummy to indicate the presence of other famous singers. Data also includes the date of the performance, so that we know the day of the week, month and year of performance. Since we observe every performance of a given opera, we also know the number of times the piece has been performed before. Our data also allows us to measure the total supply of opera performances in the FNO during a given month. Since performances partly compete for the same attendees, more supply is likely to lead to a lower demand for each individual performance. To measure the quality of the production, we construct a variable indicating the critical response (positive, negative or neutral) of the opera. The variable is based on critical reviews published in the largest national newspaper, Helsingin Sanomat. We also measure the overall popularity of different pieces by adding a variable, which measures how many times the piece was performed worldwide during the five seasons from 2007/2008 to 2011/2012[1]. A special dummy is created for Wagner's ring, which was priced higher than other performances.

Unlike some of the earlier studies, we do not attempt to identify income elasticities in our analyses. This is because there is very little variation in aggregate disposable income per capita and its components apart from a linear trend in our sample period.

3.3 The Finnish National Opera

The Finnish National Opera (FNO), founded in 1911, is the only professional opera house in Finland with over 500 permanent employees. As the only professional opera house, it has no direct competitors. There are approximately 15-20 opera productions a year, of which 4-5 are premieres. Together with ballet productions, the total number of individual performances a year is approximately 300. A total of 250 000-300 000 people per year visit FNO. Over 70% of FNOs total costs are financed by the state, by Ministry of Education and Culture, and approximately 10% by subsidies from the city of Helsinki and adjacent municipalities Vaasa, Espoo and Kauniainen. State funds are lottery funds administered by Ministry of Education and Culture. Ticket sales, sponsor revenues and other revenues cover around 20% of total costs with ticket sales accounting approximately 80% of own revenue. Finnish National Opera

[1] The data is from www.operabase.com

is governed by the Foundation of Finnish National Opera, who is responsible e.g. for the use of funds and the appointment of directors. The Foundation also makes the decisions concerning the repertoire and the overall strategy of the institution. Ministry of Education and Culture and the FNO agree to some guidelines concerning the financing of the opera on a 4-5 year basis. Even though the FNO receives public subsidies, it is responsible for maintaining a balanced budget, and has to make pricing, repertoire and other financial and strategic decisions accordingly[2].

4 Estimation method

Estimation of demand parameters for performing arts is complicated by capacity constraints. Since the demand which exceeds the number of tickets available is not observed, the dependent variable in the demand model is right-censored. In other words, we only observe the true demand for performances for which the demand did not exceed the capacity of the seating area. Since the dependent variable is not observed over its entire range, conventional regression methods yield biased results and lead to incorrect interpretations on the effect of each independent variable on demand. To correct for the bias brought about by capacity constraints, we estimate demand using censored regression (Tobit), which allows the dependent variable to be censored. Moreover, the censored regression method allows the capacity constraint to vary for each observation. This is important, since the number of tickets available differs between seating areas, and because different number of free tickets are given in advance for each performance.

To examine the effect of price and various performance-specific factors on the number of tickets sold, we estimate the following log-linear demand equation using censored regression with robust standard errors:

$$ln(y_{ik}) = \alpha + \beta ln(p_{ik}) + \gamma\prime x_i + \epsilon_i \quad (1)$$

where y_{ik} is the number of tickets sold to seating area k for performance i, p_{ik} is the real ticket price (price divided by the consumer price index) and x_i is a vector of performance characteristics. Performance-specific characteristics include time dummies (day of the week and month), the number of times the piece has been performed before and dummies indicating whether the performance has a famous opera singer, whether the piece is classical or modern, and whether the opera is Finnish. We also construct a variable measuring the total number of performances in a given month to study whether the supply of performances crowds out the demand for an individual performance. To control for substitution between competing cultural products, the prices of substitutes are included. Dummy variables for positive and negative reviews are included (the omitted category being neutral reviews), and a variable measuring the number of times the piece has been performed before worldwide. Parameters

[2] Information from FNO's Annual Reports and FNO's website.

to be estimated are α, β and parameter vector γ. The stochastic error term is ϵ. The parameter β can be interpreted as the price elasticity of demand i.e. the relative change in ticket demand caused by 1 percent increase in ticket price. Due to the censored regression method, the simple elasticity should be interpreted as the elasticity concerning latent ticket sales. That is, the elasticity is the demand response of a price change in the case of no capacity constraints.

There are two potential sources of bias in the estimation of price elasticity β. Firstly, unobserved performance characteristics that are correlated with both price and demand are likely to bias elasticity estimates upward. This is because prices can be expected to be set higher for performances which are anticipated to sell more. However, we observe the actual ticket price of each performance which can then be compared to the predetermined list price. For most cases, we observe the reason for differential pricing. Mostly this kind of price variation is due to famous star performers. In our estimations, we control for all sources of price variation that can be associated with anticipated demand variation. We include a separate dummy for those (10) performances for which we do not know the reason for differential pricing. This means that all performance characteristics that are correlated with the price are controlled for. We are therefore able to make an improvement compared to studies in which performance-specific characteristics cannot be appropriately taken into account in the estimations.

Another source of bias in estimating price elasticities is related to discount prices. In our data, the prices of full-price tickets and tickets with permanent discounts (such as a student discount or senior discount) do not depend on demand. This is because these prices are permanent in nature and thus cannot be used as a device to promote sales in the short-run. Therefore, prices of tickets in these categories can be considered exogenously determined. In contrast, prices of temporarily available discount-tickets should be considered endogenous since lower prices are used to boost sales in cases of low demand. The presence of temporarily available discount tickets presumably leads to a positive bias in the estimated price elasticity if the average price of tickets sold is used as the price variable. We correct for this problem by excluding the temporarily discounted tickets from our estimations and estimating the demand for full-price tickets and tickets with a permanent discount only. Exclusion of temporary-discount tickets is based on information from the Finnish National Opera's sales department, according to which every discount category can be classified as permanent or temporary. As a result of our variable definitions, the estimated price elasticities reflect the effects of list price changes on demand for tickets sold at these prices.

Laamanen (2013) estimates the demand for opera tickets using censored quantile regression (censored least absolute deviations, CLAD), which is less sensitive to distributional assumptions concerning the error term than Tobit. The results in Laamanen (2013) offer thus the unbiased benchmark to which the results obtained using censored regression can be compared. The results in Laamanen (2013) are qualitatively similar to those presented in this study.

The price elasticity estimates are, however, somewhat larger in absolute terms than in the present study.

5 Results

The results from estimating equation (1) are presented in Table 2. Experimenting with different subsets of the data revealed that especially the price elasticity estimate differs significantly between operas in their premiere season and reprise operas. Thus, we present the results from estimating equation (1) separately for these two groups in Table 3.

For the whole sample, the coefficient for the price elasticity coefficient is negative and close to unity. The results change, however, when the model is estimated separately for reprises and operas in their premiere season. The effect of price on demand is small and negative for operas in their premiere season, whereas demand for reprises is highly elastic. The full-sample results in Table 2 show that operas in their premiere season have a higher demand than reprises and the demand is even higher for premiere-night performances. The following performance of a piece has a 3% higher demand than the previous, suggesting positive word-of-mouth effects. Demand is higher on weekends than on other days and there are demand differences between months. The demand is lower for operas classified as classical or modern, and higher for Finnish operas. All star performers have positive and statistically significant effects on demand. The elasticity with respect to the prices of substitutes is positive and significant. Critical reviews and the overall worldwide popularity of the opera have significant effects on demand.

The results differ slightly when estimated separately for premiere season operas and reprises (Table 3). For reprises, the demand is higher for Finnish than non-Finnish operas. The effect of star performers is especially pronounced for reprises. The results also highlight the importance of controlling for special performances: the demand for Wagner's Ring is significantly higher than for other pieces. Total number of performances during the month crowds out the demand for reprises, but does not have an effect on operas in their premiere season. The prices of substitutes have stronger impact on the demand for reprises than on operas in their premiere season.

Interestingly, critical reviews have a more pronounced effect on operas in their premiere season than on reprises. This is understandable, since operas in their premiere season have unknown quality, and thus expert reviews have an important role in influencing demand. Also, reviews are more readily available for operas in their premiere season than for reprises.

6 Conclusions

We estimate the determinants of demand for opera tickets using ticket sales data from the sales system of the Finnish National Opera. Ticket price has

a negative effect on demand but the effect depends on the type of opera: the demand is price elastic for reprises (-2.6) but inelastic for operas in their premiere season (-0.2). The results demonstrate that taking into account active pricing strategies is crucial. For example, the presence of a star performer increases the demand for a performance, and the anticipated increase in demand leads to higher ticket pricing. Our data allows us to control for factors which influence both pricing and demand, and to use only the general changes in prices that occured during our study period to identify the price elasticities. The estimation results confirm that correcting for the bias is important: without correcting for endogeneity, the price elasticity estimate is positive and statistically significant. We also take into account the fact that temprorary discount prices may have been used to boost demand of some performances. It is shown that discount pricing is another potential source of upward bias in price elasticity of demand for opera.

We are able to identify various factors other than price that influence demand for opera performances. Demand is found to be higher for operas in their premiere season than for reprises, and even higher for premiere night performances. The demand for classical pieces is lower than for other types of operas. The results show evidence of seasonal effects: demand varies significantly between months and days of the week. Star performers have positive and significant effects in stimulating demand, and the effects are especially important for reprises. The demand increases from a performance to the next, which suggests that there are positive word-of-mouth effects. Operas in their premiere season are not negatively affected by the total supply of performances in the same month, but there is evidence of total supply of performances crowding out of the demand for reprises. Expert reviews and the overall popularity of the opera have a significant impact on demand, and the reviews are especially important for operas in their premiere season.

The results highlight the differences between the demand for operas in their premiere season and for reprises. Overall, operas in their premiere season seem to be less affected by pricing than reprises. The experience good nature of live performing arts is confirmed by the empirical results: quality signals are important, and they are especially important for performances whose quality is less known.

References

1. Abbe-Decarroux, F. (1994). The Perception of Quality and the Demand for Services: Empirical Application to the Performing Arts. Journal of Economic Behavior & Organization, 23(1), 99-107.
2. Akdede, S.H. & King, J. (2006). Demand for and Productivity Analysis of Turkish public theater. Journal of Cultural Economics, 20, 219-231.
3. Corning, J. & Levy, A. (2002). Demand for Live Theater with Market Segmentation and Seasonality. Journal of Cultural Economics, 26(3), 217-235.
4. Dobson, J. & West, A. (1989). Performing Art Subsidies and Future Generations. In: H. H. Chartrand et. al. eds."Cultural Economics '88: A Canadian Perspective", pp. 11-28.
5. Felton, M. V. (1989). Major Influences on the Demand for Opera Tickets. Journal of Cultural Economics, 13(1), 53-64.
6. Greckel, F. & Felton, M. V. (1987). Price and Income Elasticities of Demand: A Case Study of Louisville. In: N. K. Grant et al., eds., "Economic Efficiency and the Performing Arts", Association for Cultural Economics, pp. 62-73.
7. Jenkins, S. P. & Austen-Smith, D. (1987). Interdependent Decision-Making in Nonprofit Industries: A Simultaneous Equation Analysis of English Provincial Theatres. International Journal of Industrial Organization, 5(2), 149-174.
8. Laamanen, J-P. (2013). Estimating Demand for Opera Using Sales System Data: The Case of Finnish National Opera. Forthcoming in the Journal of Cultural Economics. Available at: http://link.springer.com/article/10.1007%2Fs10824-012-9190-6#page-1
9. Levy-Garboua, L. & Montmarquette, C. (2002). The Demand for The Arts. Cirano Scientific Series Working Paper.
10. Seaman, B. A. (2006). Empirical Studies of Demand for the Performing Arts. In: Ginsbur, V. and Throsby, C. D. (Eds.), "Handbook of the Economics of Arts and Culture (ch. 14)", Elsevier, North-Holland, 415-472.
11. Throsby, C. D. (1983). Perception of Quality in Demand for the Theatre. In: Shanahan, J.L. (Ed.), "Markets for the Arts", University of Akron Press, Akron, Ohio.
12. Throsby, C. D. (1990). Perception of Quality in Demand for the Theatre. Journal of Cultural Economics, 14(1), 65-82.
13. Urrutiaguer, D. (2002). Quality Judgments and Demand for French Public Theatre. Journal of Cultural Economics, 26(3), 185-202.
14. Werck, K. & Heyndels, B. (2007). Programmatic choices and the demand for theatre: the case of Flemish theatres. Journal of Cultural Economics, 31(1), 25-41.

Table 1 Descriptive statistics. 4914 observations (performance - seating area combinations).

	mean	st. dev.	min	max
Number of tickets sold	152.9	178.4	2	804
Seating area 1	495.0	206.8	63	804
Seating area 2	117.5	32.89	12	166
Seating area 3	118.6	29.08	7	195
Seating area 4	49.77	13.87	5	66
Seating area 5	88.79	25.95	2	106
Seating area 6	47.75	15.96	6	61
Real ticket price (euro, in 2000 prices)	39.67	19.08	12.00	106.0
Seating area 1	56.31	8.358	43.89	90.40
Seating area 2	64.46	10.19	53.17	106.0
Seating area 3	45.93	7.792	37.73	76.11
Seating area 4	33.64	6.105	27.44	66.60
Seating area 5	23.51	5.033	18.86	43.76
Seating area 6	14.13	2.674	12.00	32.35
Real substitute price index (2000 = 100)	99.66	4.258	89.80	107.4
No. of performances during the month	12.85	3.222	2	19
Premiere	.0354	.1848	0	1
Premiere season	.3760	.4844	0	1
Times performed	4.967	3.190	1	19
Classical	0.140	.3474	0	1
Modern	0.112	.3158	0	1
Domestic play	0.112	.3158	0	1
Wagner's Ring	0.019	.1384	0	1
Star actor 1	0.019	.1384	0	1
Star actor 2	0.028	.1652	0	1
Star actor 3	0.078	.2684	0	1
Other star actor	0.004	.0697	0	1
Positive press review	0.539	.4984	0	1
Negative press review	0.124	.3302	0	1
Times performed worldwide (07/08 - 11/12)	229.0	206.6	0	629
Tuesday	0.140	.3474	0	1
Wednesday	0.174	.3796	0	1
Thursday	0.183	.3868	0	1
Friday	0.192	.3946	0	1
Saturday	0.197	.3983	0	1
Sunday	0.006	.0779	0	1
September	0.097	.2969	0	1
October	0.115	.3202	0	1
November	0.098	.2985	0	1
December	0.112	.3158	0	1
January	0.137	.3449	0	1
February	0.097	.2969	0	1
March	0.097	.2969	0	1
April	0.094	.2918	0	1
May	0.100	.3001	0	1
June	0.004	.0697	0	1

Table 2 Determinants of opera demand. Censored regression.[a]

Log real ticket price	-0.816***	(0.087)
Prices of substitutes	0.674***	(0.193)
Total number of performances in a month	-0.020***	(0.003)
Premiere	0.179***	(0.047)
Premiere season	0.664***	(0.025)
Classic play	-0.274***	(0.024)
Modern play	-0.291***	(0.069)
Domestic play	0.300***	(0.066)
Wagner's Ring	1.178***	(0.076)
Star actor 1	1.520***	(0.145)
Star actor 2	0.520***	(0.053)
Star actor 3	0.371***	(0.028)
Other star actor	0.648***	(0.185)
Positive review	0.062***	(0.016)
Negative review	-0.111***	(0.024)
Times performed worldwide	0.001***	(0.000)
No. of times performed	0.034***	(0.003)
Tuesday	0.052*	(0.029)
Wednesday	0.126***	(0.028)
Thursday	0.087***	(0.028)
Friday	0.325***	(0.028)
Saturday	0.506***	(0.028)
Sunday	0.181*	(0.097)
September	0.247***	(0.045)
October	0.492***	(0.047)
November	0.598***	(0.047)
December	0.479***	(0.047)
January	0.449***	(0.048)
February	0.386***	(0.047)
March	0.470***	(0.050)
April	0.498***	(0.049)
May	0.368***	(0.049)
June	0.532***	(0.079)
Number of observations	4914	
Number of right-censored observations	1795	

[a]Dependent variable: log tickets sold. Seating category dummies, dummies for periods of senior and student discounts and a dummy for special pricing for an unknown reason included. Robust standard errors in parentheses. (*) denotes significance at 10% level, (**) at 5% level and (***) at 1% level.

Table 3 Determinants of opera demand. Censored regression.[a]

	Premiere season		Other	
Log real ticket price	-0.197**	(0.087)	-2.558***	(0.276)
Prices of substitutes	0.528*	(0.305)	0.945***	0.247
Total no. of performances in a month	0.003	(0.004)	-0.021***	(0.003)
Premiere	0.108***	(0.039)	—	
Classic play	-0.280***	(0.037)	-0.326***	(0.027)
Modern play	0.161***	(0.056)	-0.481***	(0.105)
Domestic play	-0.004	(0.045)	0.328***	(0.109)
Wagner's Ring	—		1.826***	(0.144)
Star actor 1	0.777***	(0.118)	2.646***	(0.255)
Star actor 2	0.289***	(0.043)	1.331***	(0.176)
Star actor 3	0.262***	0.044	0.451***	(0.040)
Other star actor	—		1.086***	(0.196)
Positive review	0.110***	(0.029)	0.035*	(0.020)
Negative review	-0.165***	(0.029)	-0.033	(0.033)
Log times performed worldwide	0.001***	(0.000)	0.001***	(0.000)
No. of times performed	0.031***	(0.003)	0.039***	(0.004)
Tuesday	0.035	(0.030)	0.069*	(0.040)
Wednesday	0.020	(0.032)	0.175***	(0.039)
Thursday	0.034	(0.028)	0.106***	(0.041)
Friday	0.153***	(0.032)	0.405***	(0.038)
Saturday	0.239***	(0.031)	0.603***	(0.040)
Sunday	0.013	(0.094)	0.164	(0.153)
September	-1.456***	(0.107)	0.249***	(0.049)
October	-1.362***	(0.107)	0.588***	(0.050)
November	-1.106***	(0.105)	0.662***	(0.050)
December	-1.150***	(0.102)	0.498***	(0.052)
January	-1.342***	(0.106)	0.496***	(0.054)
February	-1.210***	(0.097)	0.399***	(0.052)
March	-1.149***	(0.098)	0.387***	(0.060)
April	-1.363***	(0.104)	0.602***	(0.051)
May	-1.435***	(0.113)	0.452***	(0.052)
June	—	(0.113)	0.597***	(0.086)
July	—		—	
Number of observations	1848		3066	
Number of right-censored observations	1000		795	

[a]Dependent variable: log tickets sold. Seating category dummies, dummies for periods of senior and student discounts and a dummy for special pricing for an unknown reason included. Robust standard errors in parentheses. (*) denotes significance at 10% level, (**) at 5% level and (***) at 1% level.

ESSAY 4

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Convergence of European Retail Payments

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Convergence of European Retail Payments

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Abstract

Convergence in the European retail payments market is estimated during the period 1995-2011 for the most used retail payment instruments: cash, debit card, credit card, direct debit, credit transfer, cheque and e-money. Two methods for estimating convergence are used: sigma convergence and beta convergence. There is some evidence of convergence for all payment instruments, except for cheques and e-money. The results suggest that the cross-country dispersion of the use of payment instruments has declined over time in Europe, and the pace of convergence has picked up since the introduction of the single currency. There is also evidence for beta convergence for card payments, direct debits and credit transfers. The results indicate that integration in European retail payments has progressed and, in con-trast to some other segments of the financial markets, integration has not deteriorated during the financial crisis.

Keywords: Retail payments, Convergence, Financial integration
JEL codes: F36, G20

1. Introduction

Financial integration is important for both the smooth operation and the efficiency of the payment system; promoting financial integration is also one element of the Eurosystem's mission[1]. Measuring and monitoring the state of integration in the financial market is, therefore, of great interest to central bankers. To assess developments in the integration of the financial markets, the ECB has constructed several quantitative indicators (ECB, 2009). During the recent economic crisis, integration has given way to more urgent matters and there is, in fact, some evidence that integration in the financial markets started to deteriorate during the period of economic turmoil (ECB, 2009; ECB, 2012). In comparison to other segments of the financial markets, integration in the retail payments market has been more difficult to quantify, and the effects of recent developments, including the creation of the Single Euro Payments Area (SEPA) or the economic crisis, have been hard to evaluate with existing measures of integration.

In this paper, we estimate the convergence of cross-country payment habits. We interpret convergence as an indicator of integration in the retail payments market, and are especially interested in the substitution of traditional payment instruments by electronic payment technologies.

[1] See: "The Mission of the Eurosystem" on the ECB's website: http://www.ecb.int/ecb/orga/escb/html/mission_eurosys.en.html

Integration of the retail payments market is likely to affect competition, prices and the payment infrastructure. More specifically, integration aids the cross-border diffusion of new and more efficient payment technologies and practices. For payment providers, implementing new payment technologies is easier in a harmonised and integrated market. For consumers, the acceptance and availability of new payment instruments, and greater awareness of these instruments, increase the use of new payment technology. In an integrated market, payment behaviours are thus expected to converge towards the use of more sophisticated and efficient payment instruments.

The degree of integration in the European capital and financial markets varies between market segments. The money, bond and equity markets have reached a high level of integration, following the introduction of the single currency in 1999, while integration in other market segments, such as retail banking, has been more modest (ECB, 2010). Unlike large value payments, the procedures, instruments and services offered to customers in the field of retail payments have not yet been harmonised. This shortcoming is being addressed in the context of the Single Euro Payments Area (SEPA) project, which aims to achieve a fully integrated retail payments market and promote the integration of the retail banking market in general. Within SEPA, no distinction is made between national and cross-border payments; all euro payments are treated as domestic payments. However, even the successful introduction of SEPA does not guarantee the convergence of actual payment behaviour. Payment habits are slow to change, and payment market and pricing structures differ across Europe (see e.g. Heikkinen, 2007; Jonker and Kosse, 2008).

The efficiency and performance of the retail payments system is an economically significant question; according to a study by Schmiedel et al. (2012), the social costs of retail payments amount to approximately 1% of the GDP of the European Union (EU). The convergence of retail payments has many implications for the overall performance of the economy. The financial integration of the retail payments market facilitates the cross-border movement of people, goods and capital, and thus promotes the integration of the European single market. The convergence of payment behaviours can have an important role in the diffusion of new payment technologies and thus economic performance; there is empirical evidence that the electronification of the retail payments system promotes economic growth (Hasan et al., 2012a) and banking performance (Hasan et al., 2012b). The convergence of cross-country habits is important because payment instruments are network goods; the benefit of using a payment instrument depends on the number of other people using it[2]: for example, the benefit of having a payment card depends on how many retailers accept it, which in turn depends on how many people use the card. A well-known feature of network goods is that the market needs to reach a minimum size to achieve a sustainable equilibrium. If cross-country payment habits converge towards the use of non-cash payment instruments, the overall European market reaches the point at which there is enough critical mass for the market to become viable and grow further. SEPA is likely to accelerate this development by increasing network compatibility and economies of scale (Bolt and Schmiedel, 2011).

In the present study, convergence in European payment behaviours is measured using data on payments made in cash and using non-cash payment instruments. The aim of this study is to answer two questions: first, did the retail payments market become more integrated during the period 1995-2011, as evidenced by the convergence of payment behaviours? Second, has integration been stronger in the period after the introduction of euro than in that before? The answers to these two questions provide important information concerning the level and evolution

[2]For a review of the literature on network externalities and two-sided markets, see, for example, Rochet and Tirole (2006).

of integration in the European retail payments market. In this study, some preliminary evidence is also provided on the way in which integration has evolved since the creation of SEPA and during the economic crisis.

The methods used to estimate convergence in different segments of the financial markets were originally developed in the literature on empirical growth. The study employs two such methods, namely sigma and beta convergence. Earlier studies have relied on broad measures describing the financial market infrastructure (Schmiedel and Schoenenberger, 2005), the concentration of the national retail payment infrastructure or the number of credit transfers processed in SEPA format (ECB, 2010), for example. In this paper, actual data on the volume and the value of transactions made in cash, by credit card, debit card, direct debit, credit transfer, cheque and e-money in the 27 EU countries during the period 1995-2011 are used to measure convergence and integration, rather than broad measures on retail payment infrastructure.

The study finds evidence that some degree of convergence for different payment instruments took place during our study period. The only exceptions are for cheques and e-money, for which there is no unambiguous evidence of either sigma or beta convergence. Evidence of convergence is most prevalent when it is measured as a decrease in the cross-country dispersion of the use of payment instruments over time. This sigma convergence was most evident during the last twelve years of our study period. Moreover, the speed of convergence has increased since the introduction of the single currency for most of the payment instruments studied. Evidence of beta convergence is found for the volume of debit card and credit card transactions, and for the value of the remote payment instruments, that is, for direct debits and credit transfers.

The remainder of this paper is structured as follows: in Section 2, the relevant empirical literature is reviewed; in Section 3, the sample data and summary statistics are described; and in Section 4, the concept of measuring convergence is introduced. In Section 5, the empirical results on the convergence of European retail payment behaviours are presented; the final section concludes.

2. Literature Review

This study is related to two strands of empirical literature: that on payment instrument demand and that on the integration of the financial markets[3]. The methods used to measure sigma and beta convergence are derived from neoclassical growth theory and were thus originally developed and applied in the economic growth literature. Important contributions include those from Barro and Sala-i-Martin (1992), Sala-i-Martin (1996) and Mankiw et al. (1992). The concept and methods of convergence have since been applied to various contexts and the literature is extensive.

Adam et al. (2002) classify, review and apply existing indicators for capital market integration to measure integration in the European financial markets. The indicators are classified into four groups: indicators using interest-rate differentials to measure convergence in the interbank, government bond, mortgage and short term corporate loan markets; indicators using the correlation with stock market returns to measure stock market integration; indicators based on

[3]A number of studies, which are not reviewed here, use survey methods to study consumers choice between different payment instruments (see, for example, Stix, 2004). Furthermore, articles which concentrate on the determinants of cash demand, or focus on individual countries, or articles which study financial market integration without applying sigma or beta convergence methods, are excluded.

the decisions of households and firms; and indicators based on cross-country institutional differences. This paper follows and extends the approach by Adam et al. (2002) by applying the sigma and beta convergence methods to the retail payments market.

Hartmann et al. (2003) measure the integration in the financial structures in the euro area by applying the sigma convergence method to countries' asset and liability components, namely currency and deposits, loans, and debt securities. By graphing the evolution of the standard deviations, the authors find that, with the exception of the bond market, countries have more heterogeneous financial structures. Pagano and von Thadden (2004) find convergence in bond yields under the European Monetary Union, and attribute remaining yield differentials to fundamental country-specific default risks. Similarly to Hartmann et al. (2003), Pagano and von Thadden (2004) do not estimate sigma convergence, but rather rely on visual inspection.

Baele et al. (2004) extend the price- and quantity-based measures in Adam et al. (2002) by constructing a definition of an integrated financial market and introducing news-based measures of integration. In addition to building a methodological framework for financial market integration, Baele et al. (2004) are interested in the effects of local news versus global news on interest rates, and study integration in the government and corporate bond, credit, equity and money markets. Similarly to Adam et al. (2002), Baele et al. (2004) do not extend the measures of integration to the retail payments market. Korkeamaki (2009) studies the effect of introducing the euro on the relationship between interest rates and stock market returns, and estimates the convergence of interest rate sensitivity across EU countries. The results imply that the interest rate risk has decreased in the period since the introduction of the euro; companies have been able to protect themselves against risks more efficiently in a more complete and integrated European financial market. Moreover, the author finds evidence of sigma convergence for interest rate sensitivity across European countries.

A number of studies estimate the demand for different payment instruments. Humphrey et al. (1996) estimate a model of payment instrument demand in a cross-country panel data setting. The authors study five instruments: cash, paper giro, electronic giro, credit cards and debit cards. The price of a transaction, which the authors calculate based on several sources and definitions, is not an important determinant of demand. The significance of other variables, such as the availability of point-of-sale terminals, automated teller machines (ATMs) and institutional variables depends on whether lagged use of these payment instruments and country-specific dummies are included in the regression. When lagged use and country dummies are dropped, the availability of point-of-sale terminals increases the demand for debit cards, but decreases the demand for all other instruments. The number of ATM terminals is positively related to the growth in debit card and credit card use, and income is positively associated with non-cash payments. Violent crime increases the use of non-paper-based instruments and the concentration of the banking sector increases the use of debit cards. The authors also find some evidence of substitution between different payment instruments.

Guariglia and Loke (2004) estimate the demand for non-cash payment instruments for a panel of European countries using the generalised method of moments (GMM) estimator. The results emphasise the role of past habits in determining current payment behaviour, and the importance of distinguishing between the volume and the value of transactions. Humphrey et al. (2000) forecast the evolution of the use of cheques and electronic payments in the United States, while Snellman et al. (2001) study the substitution of cash by non-cash payments in Europe and develop a forecast for the use of cash.

Measures of integration for the retail payments market have been constructed in several financial integration reports produced by the ECB (see, for example, ECB, 2010). However, conver-

gence in the retail payments market appears to have only been studied in Deungoue (2008), who uses retail payment data mostly covering the period before the introduction of the euro (1990-2002). In contrast, the payment data in the present study is more recent and allows the full effect of the adoption of the euro on the integration process to be estimated. The effect of introducing the euro on the sigma convergence process has not been estimated using retail payment data before. By estimating the speed of convergence before and after the introduction of the euro, the effect of euro introduction on the speed of convergence can be estimated. Moreover, the dataset used in this study allows us to make a distinction between the transactions made by debit card and credit card, and to study the convergence for e-money. Visually inspecting the data is an important first step but, as the estimation results indicate, visual inspection does not always provide enough information to analyse underlying data patterns or to quantify significant relationships between variables. Based on the results of this paper, some tentative conclusions can also be drawn regarding the way in which integration in retail payments market has developed during the recent economic crisis and since the introduction of SEPA.

3. Data and Summary Statistics

The present study uses annual data on the volume and the value of retail payment transactions for the current 27 EU countries for the period 1995-2011. The payment instruments studied are cash, debit card, credit card, direct debit, credit transfer, cheque and e-money. Mobile money is not included, since data on mobile money transactions are not available. Moreover, while mobile money is increasingly popular in some of the developing countries, it remains a marginal means of payment in Europe (see Hyytinen and Takalo, 2009; and Leinonen, 2010, for a discussion on the trends and future of the mobile money market). Payment data is provided by the ECB Statistical Data Warehouse. Macroeconomic variables are collected from the World Bank and Eurostat databases.

Data on cash transactions is not generally available. This study uses the method commonly employed in the literature to approximate the value of transactional cash demand (see, for example, Snellman et al., 2001; Sisak, 2011; and Schmiedel et al., 2012). Following Humphrey (2004) and Sisak (2011), the starting point is the notion that cash is mostly used in consumer point-of-sale transactions. To approximate the value of point-of-sale consumption, spending on education, financial services, health and housing is subtracted from the total private consumption. This is done because spending on education, financial services, health and housing forms the part of household consumption which does not take place at point-of-sale locations. The residual value (private consumption minus spending on education, financial services, health and housing) is then used as an approximation of the total value of consumption that takes place at point-of-sale locations. Point-of-sale purchases are then reasonably assumed to be made mainly in cash and by card. The value of transactions made by debit card and credit card is then subtracted from the total value of point-of-sale consumption. The resulting value is an approximation of the value of payments made in cash[4]. The number of transactions made in cash is obtained by dividing the value of payments made in cash by the average value of a cash transaction. The average value of cash transaction is taken from the study by Schmiedel et al. (2012); the value varies between countries but not between years.

[4]Since separate data on debit and credit card transactions is not available for France, the value of all cards, as reported in the ECB Statistical Data Warehouse, has been used when calculating the value and the volume of cash transactions for France.

Tables 1-6 present summary statistics for the retail payment instruments and other variables used in the estimations. Summary statistics are presented for selected sub-periods and for the total study period 1995-2011. On average, credit transfers and cash are the most popular payment methods in terms of value and volume of transactions, respectively. Figure 1 depicts the evolution of the total number of transactions in the 27 EU countries for the years 2000-2011[5]. The number of cheque transactions has been declining steadily, and was less than 5 billion in 2011. The number of debit and credit card transactions has been increasing and totalled approximately 28 billion in 2011. Debit cards are clearly a more popular payment medium than credit cards: over 80% of the combined debit and credit card transactions were made by debit card. The number of transactions made by credit transfer and direct debit has increased over the period studied. The number of cash transactions is measured on the right-hand scale and reaches over 155 billion. The downward trend in the number of cash transactions in the late 2000s should be interpreted with caution; since the measure of cash transactions is based on private consumption, it is very sensitive to the overall economic development. Cash transactions are thus more likely to reflect the impact of the financial crisis on the economy than other instruments.

The real value of transactions is depicted in Figures 2-3, in separate axis for scaling reasons[6]. The value of debit card transactions increases, while the value of credit card transactions decreases slightly during the period coinciding with the financial crisis. According to the estimations, cash transactions reaches EUR 3.5 trillion, and tends to decrease after the year 2000. The value for e-money payments increases significantly between 2007 and 2008 but e-money, in relation to other payment instruments, remains a marginal means of payment. E-money institutions such as Amazon and PayPal have their European headquarters in Luxembourg, and the high volume and value of e-money transactions originating in Luxembourg is of a different magnitude compared with other countries in our sample. The robustness of the results by excluding Luxembourg in the e-money estimations are discussed in Section 5. The total value of cheque transactions remains high, at almost EUR 5 trillion in 2011. However, the diminishing role of cheques is clearly demonstrated in Figure 3: the value of transactions made by cheque halves during the ten-year period studied. Credit transfers and direct debits are the most important payment instruments in value terms: the value for credit transfers alone was close to EUR 200 trillion in 2011.

4. Estimating the Convergence of Retail Payments

To study the convergence of retail payments and the evolution of different payment instruments used in different countries, two approaches are adopted: sigma convergence and conditional beta convergence. To avoid dynamic panel bias, the conditional beta convergence is estimated using the difference GMM estimation method. The two methods give different perspectives on convergence: sigma convergence measures how the cross-country dispersion in the

[5]Total reported numbers are an estimate, since there are some randomly missing observations, which have been replaced by our approximations in Figure 1. Total numbers for 2000-2011 are presented because the data are more complete starting from 2000. France does not report data on debit card and credit card transactions separately, so France is excluded in the total calculations for the 27 EU countries for debit and credit cards. Calculations presented in Figure 1 are, however, very close to ECB estimates (see http://www.ecb.europa.eu/press/pr/date/2012/html/pr120910.en.html).

[6]There is a jump in the series in 2006 for credit transfers and direct debits owing to changes in data reporting methodology which took place in Germany at that time. The robustness of the results was checked by excluding Germany in the estimations; the conclusions were unaffected.

distribution of transactions evolves over time, while beta convergence measures how countries move within the distribution and is used to investigate whether countries which start from a lower volume or value of transactions for a particular payment instrument catch up with countries which start from a higher volume or value of transactions (Sala-i-Martin, 1996).

4.1. Sigma Convergence

In the presence of sigma convergence, the dispersion of payment instrument use across countries decreases over time (Sala-i-Martin, 1996). More specifically, sigma convergence implies that the standard deviation of the distribution of the volume and the value of transactions for different payment instruments decreases, making the observations increasingly centred on the mean over time. Figures 4 and 5 plot the evolution of the standard deviation of the volume and the value of different payment instrument transactions per capita across the 27 EU countries. For most of the payment instruments, the standard deviation of the volume of transactions peaks immediately after the introduction of the euro in 1999. After 2000, the standard deviation seems to decrease or remain stable for all instruments, except for cheques and e-money. The standard deviation of direct debits starts to increase slightly after 2006; however, for the most recent years, there is a decreasing trend. For the value of transactions, cheques have a very high and volatile standard deviation throughout the period studied.

To test empirically whether the standard deviation has a decreasing time trend, the following model is estimated:

$$S_t = \alpha_0 D_{PRE} + \beta_0 (D_{PRE} * trend) + \alpha_1 D_{POST} + \beta_1 (D_{POST} * trend) + \epsilon_t \quad (1)$$

where S_t is the standard deviation of the volume or the value of transactions (in logs and per capita terms) for a particular payment instrument across the 27 EU countries in year t, D_{PRE} is a dummy variable equalling one for the years before the introduction of the single currency in 1999[7], D_{POST} is a dummy equalling one for the years after 1999, D_{PRE}*$trend$ and D_{POST}*$trend$ are the time trends for the before-euro and after-euro introduction periods respectively, and ϵ_t is the error term. Equation (1) is estimated separately for the volume and the value of all payment instruments in our data. The parameters to be estimated are intercepts α_0 and α_1 and the slope coefficients for the time trend before-euro and after-euro introduction, β_0 and β_1. The estimation allows us to directly compare the speed of convergence before and after the introduction of the single currency, by comparing the estimated slope coefficients β_0 and β_1. Since SEPA was introduced in 2008 and the time period after 2008 is too short to estimate time trend effects, equation (1) does not include variables indicating the introduction of SEPA.

4.2. Beta Convergence

Beta convergence takes place if countries that have a low initial volume or value of payment instrument use grow faster in the subsequent period than countries with a higher initial level of use of that payment instrument. The former are then seen as catching up with the more evolved latter. Thus, in the presence of beta convergence, the volume or value of payment instrument use in the preceding period is inversely related to the current growth rate of that payment instrument use. Beta convergence can be unconditional or conditional. Conditional convergence takes place

[7]Equation (1) was estimated with the euro dummy equalling one for the years after 2002, when the euro notes and coins entered circulation, but this did not qualitatively change the results.

if there is a negative relationship between previous period's level of transactions and the current period growth rate of transactions, when other factors affecting the growth in transactions are controlled for. Conditional beta convergence is thus estimated by regressing the growth rate of the interest variable on the lagged level of the variable, and on a set of control variables. The control variables include, for example, macroeconomic, technological and institutional variables. A negative and statistically significant coefficient on the lagged level variable is seen as evidence of beta convergence (Barro and Sala-i-Martin, 1992; Sala-i-Martin, 1996).

The following dynamic panel data model is estimated:

$$\Delta y_{it} = \alpha + \beta y_{t-1} + \gamma X_{it} + v_i + \epsilon_{it} \quad (2)$$

In equation (2), Δy_{it} is the growth rate of the volume or the value of transactions for a payment instrument in country i, α is a constant,y_{it-1} is the one-year lagged level of payment instrument use in country i, X_{it} is a set of time-varying control variables for country i, v_i is a country-specific fixed effect and ϵ_{it} is the error term.

Equation (2) is estimated separately for the volume and the value of transactions made in cash, by debit card, credit card, direct debit, credit transfer, cheque and in e-money. In the presence of beta convergence, the coefficient on the lagged level of payment instrument use (β) is negative and statistically significant. The bigger the β (in absolute terms), the faster the economy is converging. The control variables in equation (2) are based on the determinants of demand for retail payment instruments in the empirical literature (see, for example, Guariglia et al., 2004; Humphrey et al., 1996; and Snellman et al., 2001). To avoid variable and instrument proliferation, cross-substitution between different payment instruments is not controlled for in the estimations.

Equation (2) is estimated by using the difference GMM method developed by Arellano and Bond (1991) and further elaborated by Arellano and Bover (1995), and Blundell and Bond (1998). The dynamic panel methods, originating from Arellano and Bond (1991), Anderson and Hsiao (1982), Hansen (1982) and Holtz-Eakin et al. (1988), are used to estimate models with a relatively short time dimension, dynamic dependent variable, endogenous regressors, and which show evidence of heteroskedasticity and autocorrelation within cross-section units (Roodman, 2006 and Bond, 2002).

The control variables in X_{it} depend on the payment instrument studied. Since the use of cash is expected to be related to the opportunity cost of holding cash and the ease of acquiring cash, the deposit rate and the number of ATMs in a country are included as explanatory variables. However, the number of ATMs can have a negative effect on cash use, if the former is positively related to customers awareness and acceptance of payment cards, or if the same cards are used to withdraw cash and make payments (Humphrey et al., 1996). The volume of card payments depends on the technology and infrastructure available. For credit and debit cards, the number of electronic funds transfer at point-of-sale (EFTPOS) terminals and the number of ATMs in a country are included as explanatory variables. The use of cheques or e-money is not constrained by the availability of payment technology variables (ATMs or EFTPOS terminals), so no controls for technology are added in the estimations of cheque or e-money demand. Additionally, the real interest rate (lending rate) is expected to have a negative effect on credit card use. For all payment instruments, GDP is included to control for changes in macroeconomic conditions. All value variables are in logs and in real per capita terms. Volume variables are in logs and per capita terms. Finally, equation (2) is estimated with year dummies [8].

[8]The effects of euro adoption and the creation of SEPA were also tested by including euro and SEPA dummies and

5. Empirical Results

Sigma convergence results from estimating the volume of transactions for the period 1995-2011 using equation (1) are presented in Table 7 [9]. In the period after the euro was introduced, the standard deviation of cash use has a negative time trend. However, the coefficient is small, indicating that the speed of convergence is very slow. Countries diverge in terms of their debit card use before the introduction of the euro, but converge in the after-euro introduction period. The same is true for credit transfers. For credit cards, there is convergence both in the before-euro and after-euro introduction periods. The introduction of the euro has no effect on the speed of convergence: based on the F-test, the speed of convergence is equal before and after the introduction of the euro. For direct debits, the standard deviation has decreased in the after-euro introduction period; however, there is no difference in the speed of convergence between the before-euro and after-euro introduction periods. Countries seem to diverge in terms of the volume of cheque and e-money transactions, but the divergence is slower after the introduction of euro.

The estimation results for the value of transactions in the 27 EU countries for 1995-2011 are presented in Table 8. For cash, there is evidence of convergence in the before-euro introduction period. The slope coefficient in the period after the introduction of the euro is negative and statistically significant, but small, indicating that the speed of convergence is slow and has little economic significance. For debit and credit cards, the standard deviation has a positive time trend before the introduction of the euro; however, after, their use converges. The use of direct debits diverges in the before-euro period but, after the introduction of the euro, neither convergence nor divergence is found. Countries converge in terms of credit transfers in the period after the introduction of the euro. Cheque and e-money transactions diverge, but this slows down after the introduction of the single currency. Overall, the introduction of the euro has had a positive effect on the convergence process for all payment instruments.

Tables 9 and 10 present the results of estimating the sigma convergence equation for the sub-period 2000-2011, for which there are fewer missing observations on transactions across countries. The results for the volume of transactions in Table 9 reveal that there is sigma convergence for all payment instruments, except for cheques and e-money. For the value of transactions, countries are converging in terms of all payment instruments except for e-money, as is evident from Table 10. The results indicate that the convergence process has been faster and more comprehensive during the most recent years in the data.

The conditional beta convergence results from estimating equation (2) with the difference GMM method are presented in Tables 11 and 12. Cash shows no convergence for the number or the value of transactions. The sign of the coefficient on the deposit rate is consistently negative, and statistically significant for the value of transactions. The coefficient on GDP is positive and significant for the value of transactions, which is to be expected since cash transactions and consumption correlate owing to the method used to approximate cash transactions. The number

interactions in the estimated equation. The interaction terms turned out not to be statistically or economically significant and so were omitted from the model.

[9] Our estimations of sigma convergence measure convergence within the 27 EU countries, without detailing the effects of individual countries or groups of countries, such as euro area or non-euro area countries, on the convergence process. Comparing, for example, the speed of convergence between euro area and non-euro area countries would require a relevant benchmark to which the groups of countries would be expected to converge. In estimating, for example, interest rate convergence, such a benchmark usually arises naturally, but for retail payments a meaningful benchmark is less easy to find.

of ATMs has no significant effect on the volume or the value of cash use. For cheques and e-money, no evidence of convergence is found.

Debit cards converge in terms of volume, but not in terms of value. The number of EFTPOS terminals has a positive effect on the volume of transactions, but for the value of transactions, the effect is not statistically different from zero. The results for the volume and the value of credit card transactions are comparable to the results for debit cards. For the volume of transactions, the estimated beta is negative, statistically significant and of the same magnitude as the beta coefficient for debit cards. For the value of transactions, there is no evidence of convergence. Similarly to debit cards, the other control variables for credit cards are not statistically significant.

Direct debits converge in terms of the volume and the value of transactions, while credit transfers converge only in terms of the value of transactions. For the volume of the remote payment instruments, the significance of the beta coefficient seems to be sensitive to the number of lags used as instruments, and to the control variables included, and the results should thus be interpreted with caution. However, the results concerning the value of transactions seem to be resistant to changes in the instrument count.

The number of EFTPOS terminals has a positive effect on the value of credit transfers. Even though the number of EFTPOS terminals is not directly related to the use of credit transfers, the number of terminals is likely to correlate with the overall technological readiness of a country (Columba, 2009). The relationship between EFTPOS terminals and the use of remote payment instruments is thus likely to reflect the underlying effect of the omitted technology variable on non-cash payment instrument use.

Finally, to check the robustness of the results, estimations for sigma and beta convergence for e-money are carried out excluding Luxembourg. In Luxembourg, the volume and the value of transactions increased substantially after 2007, owing to PayPal and other e-money institutions headquartered in the country. The sigma convergence results remain unchanged: countries diverge in terms of their e-money use, even when Luxembourg is excluded, but more slowly.

Based on the Arellano-Bond tests for autocorrelation, there is no evidence of second-order autocorrelation in the first-differenced errors, which suggests that the errors in levels are not serially correlated. The Sargan test, which is not robust to heteroskedasticity or serial correlation, suggests problems of instrument validity in the estimations concerning the value of cheques; the Sargan test statistic is relatively close to zero for the value of cheques [10]. However, according to the Hansen test statistic, which is robust to heteroskedasticity and serial correlation, the null hypothesis that the instruments are jointly valid is not rejected in any of the estimations. The Hansen test statistic is known to weaken when the instrument count increases. However, the number of instruments is kept moderate in all our estimations to avoid the problems caused by instrument proliferation. The instrument count is restricted in two ways: by restricting the number of lags used as instruments and by collapsing the instrument set, as suggested by Roodman (2006; 2008)[11]. Only lags two to three for the endogenous regressors are included, and the effect of adding or removing lags on the significance and magnitude of the estimated coefficients is tested.

[10] For the volume of credit card transactions, the Sargan test statistic is relatively close to zero; however, if lags two to four are used as instruments, the Sargan test statistic is 0.156. The significance and magnitude of beta are unaffected.

[11] There is no general rule regarding what is a good number of instruments in system and difference GMM estimations. One rule of thumb often used in the literature is that the number of instruments should not exceed the number of cross-sectional units. Since there are 27 cross-sections in our case, the choice of instrument count can be considered to be moderate.

To summarise the beta convergence results, there is evidence of convergence for the volume of transactions made by debit card and credit card, and the results are resistant to different instrument counts and to changes in the model specification. The results concerning the volume of direct debits and of credit transfers are sensitive to the number of lags used as instruments, and to the set of control variables in the difference GMM estimations. In contrast, when transactions are measured in terms of value, there is evidence of convergence for the remote payment instruments.

6. Conclusions

Financial integration in the financial markets in Europe has progressed since the creation of the monetary union. However, the level of integration depends on the market segment and seems to be sensitive to the overall trends in economic development (ECB, 2012). In order to promote integration, policy-makers need tools and indicators to measure the level and progress of integration. For retail payments, the development of these indicators has been less straightforward than for other market segments. In this paper, methods which had been applied previously to measure integration in other segments of the financial markets have been applied to quantify integration in the retail payments market.

The convergence of payment behaviours across the 27 EU countries for the period 1995-2011 has been estimated. Two methods of estimating convergence have been employed: sigma convergence and beta convergence. There is strong evidence of sigma convergence, and the speed of convergence has accelerated for most of the payment instruments studied since the introduction of the single currency. The evidence concerning beta convergence is more varied. The estimation results for beta convergence suggest that countries have been catching up in terms of the volume of card payments, and the value of remote payment instruments.

Based on the findings in this paper, it can be argued that payment behaviours in the 27 EU countries have become more similar since the introduction of the single currency. However, the speed of sigma convergence for cash has been very slow. Moreover, cheques and e-money are exceptions, as countries diverge in their use of these two payment instruments. One possible reason for this lack of convergence could be that there is a negative overall trend in the volume and the value of transactions made by cheque. The divergence result reflects the fact that consumers are making fewer transactions by cheque in most of the 27 EU countries, while in the remaining EU countries, cheques are still relatively popular. For e-money, the overall number and value of transactions is increasing. This payment instrument is, however, still in its early stages of development and the total volume and value of transactions is relatively low. Countries differ in terms of the way in which they adopt payment innovations, and the dispersion in the use of e-money across countries is likely to reflect these different adoption patterns.

The recent financial crisis discouraged integration in many segments of the financial markets, especially in money, bond and equity markets. There is also evidence that in banking, cross-border activity declined during the period of financial turmoil (ECB, 2012). Even though payment behaviours are not likely to be affected by the same factors that led to disintegration in other financial market segments, namely mistrust and increasing differences in country-specific risks, it is nonetheless interesting to note that the convergence in retail payment behaviours has continued regardless of the Europe-wide crisis. However, it is hard to disentangle the effects of SEPA and those of the economic crisis on the convergence process, and the present study offers only some preliminary conclusions. Since economic theory and empirical findings support the fact that integration promotes competitiveness, efficiency and growth, the process of integration

should be considered beneficial, even at times of extreme economic uncertainty. Regardless of our positive findings regarding financial integration, it should be noted that payment behaviours are slow to change, and the differences in payment habits across Europe remain significant. The single market for European retail payments has not yet fully materialised and neither have its benefits. This paper may serve as a useful tool for policy-makers and market stakeholders when predicting the future trajectories of the European retail payments market.

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REFERENCES

[1] Adam, K., Japelli, T., Menichini, A., Padula, M. and Pagano, M., 2002. Analyse, Compare and Apply Alternative Indicators and Monitoring Methodologies to Measure the Evolution of Capital Market Integration in the Euro Area. Centre for Studies in Economics and Finance (CSEF). University of Salerno.
[2] Anderson, T.W. and Hsiao, C., 1982. Formulation and Estimation of Dynamic Models Using Panel Data. Journal of Econometrics 18, 47-82.
[3] Arellano, M. and Bond, S., 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. Review of Economic Studies 58(2), 277-297.
[4] Arellano, M. and Bover, O., 1995. Another Look at the Instrumental Variable Estimation of Error Components Models. Journal of Econometrics 68(1), 29-51.
[5] Baele, L., Ferrando A., Hrdahl, P., Krylova, E. and Monnet, C., 2004. Measuring Financial Integration in the Euro Area. Occasional Paper Series No 14, ECB, Frankfurt am Main.
[6] Barro, R.J. and Sala-i-Martin, X., 1992. Convergence. Journal of Political Economy 100(2), 223-251.
[7] Blundell, R. and Bond, S., 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. Journal of Econometrics 87(1), 115-143.
[8] Bolt, W. and Schmiedel, H., 2011. Pricing of Payment Cards, Competition and Efficiency: A Possible Guide for SEPA. Annals of Finance.
[9] Bond, S., 2002. Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice. Working Paper No 9, Cemmap.
[10] Columba, F., 2009. Narrow Money and Transaction Technology: New Disaggregated Evidence. Journal of Economics and Business 61(4), 312-325.
[11] Deungoue, S., 2008. Will We Pay in the Same Way? The European Journal of Finance 14(1), 49-67.
[12] ECB, 2009. Financial Integration in Europe, ECB, Frankfurt am Main, April.
[13] ECB, 2010. Financial Integration in Europe, ECB, Frankfurt am Main, April.
[14] ECB, 2012. Financial Integration in Europe, ECB, Frankfurt am Main, April.
[15] Guariglia, A. and Loke, Y.J., 2004. What Determines the Value and Volume of Non-Cash Transactions? Evidence from a Panel of European and North American Countries. Applied Economics 36(4), 291-303.
[16] Hansen, L., 1982. Large Sample Properties of Generalized Method of Moments Estimators. Econometrica 50(4), 1029-1054.
[17] Hartmann, P., Maddaloni, A. and Manganelli, S., 2003. The Euro Area Financial System: Structure, Integration and Policy Initiatives. Working Paper Series No 230, ECB, Frankfurt am Main.
[18] Hasan, I., De Renzis, T. and Schmiedel, H., 2012a. Retail Payments and Economic Growth. Research Discussion Papers No 19, Suomen Pankki Bank of Finland.
[19] Hasan, I., Schmiedel, H. and Song, L., 2012b. Returns to Retail Banking and Payments. Journal of Financial Services Research 41(3), 163-195.
[20] Heikkinen, P., 2007. Statistical Trends and Cross-Country Comparisons of Payment Developments. Payment Habits 2010+ Seminar, Suomen Pankki Bank of Finland.
[21] Holtz-Eakin, D., Newey, W. and Rosen, H.S., 1988. Estimating Vector Autoregressions with Panel Data. Econometrica 56(6), 1371-1395.
[22] Humphrey, D., Kaloudis, A., Owre, G., 2004. The Future of Cash: Falling Legal Use and Implications for Government Policy. Journal of International Financial Markets, Institutions and Money 14(3), 221-233.
[23] Humphrey, D.B., Pulley L. B. and Vesala, J. M., 1996. Cash, Paper, and Electronic Payments: A Cross-Country Analysis. Journal of Money, Credit and Banking 28(4), 914-939.
[24] Humphrey, D.B., Pulley, L.B. and Vesala, J.M., 2000. The Checks in the Mail: Why the United States Lags in the

Adoption of Cost-Saving Electronic Payments?, Journal of Financial Services Research 17(1), 17-39.
[25] Hyytinen, A. and Takalo, T., 2009. Who Owns Mobile Money? The Lydian Payments Journal, November.
[26] Jonker, N. and Kosse, A., 2008. Towards a European Payments Market: Survey Results on Cross-Border Payment Behaviour of Dutch Consumers, Occasional Studies 6(1), De Nederlandsche Bank.
[27] Korkeamaki, T., 2009. The Effects of the Euro on Interest Rate Sensitivity. Working Paper Series, Suomen Pankki: Bank of Finland.
[28] Leinonen, H., 2010. Future Payments mobile, social or sociomobile?. SPEED 4(4), 9-15.
[29] Mankiw, G., Romer, D. and Weil, D.N., 1992. A Contribution to the Empirics of Economic Growth. The Quarterly Journal of Economics 107(2), 407-437.
[30] Nickell, S., 1981. Biases in Dynamic Models with Fixed Effects. Econometrica 49(6), 1417-1426.
[31] Pagano, M. and von Thadden, E-L., 2004. The European Bond Markets under EMU. Discussion Paper No 4779, Centre for Economic Policy Research.
[32] Rochet, J-C. and Tirole, J., 2006. Two-Sided Markets: A Progress Report. RAND Journal of Economics 37(3), 645-667.
[33] Roodman, D., 2006. How to Do xtabond2: An Introduction to Difference and System GMM in Stata. Working Papers No 103, Center for Global Development.
[34] Roodman, D., 2008. A Note on the Theme of Too Many Instruments. Working Papers No 125, Center for Global Development.
[35] Sala-i-Martin, X., 1996. The Classical Approach to Convergence Analysis. The Economic Journal 106(437), 1019-1036.
[36] Schmiedel, H., Kostova G. and Ruttenberg, W., 2012. The Social And Private Costs of Retail Payment Instruments: A European Perspective. Occasional Paper Series No 137, ECB, Frankfurt am Main.
[37] Schmiedel, H. and Schnenberger, A., 2005. Integration of Securities Market Infrastructure in the Euro Area, Occasional Paper Series No 33, ECB, Frankfurt am Main.
[38] Sisak, B., 2011. What Drives Cash Demand? Transactional and Residual Cash Demand in Selected Countries. Magyar Nemzeti Bank Working Papers No 10.
[39] Snellman, J., Vesala, J.M. and Humphrey, D., 2001. Substitution of Noncash Payment Instruments for Cash in Europe. Journal of Financial Services Research 19 (2/3), 131-145.
[40] Snellman, H. and Virn, M., 2006. ATM Networks and Cash Usage. Research Discussion Papers No 21, Suomen Pankki: Bank of Finland.
[41] Stix, H., 2004. How Do Debit Cards Affect Cash Demand? Survey Data Evidence. Empirica 31(2), 93-115.

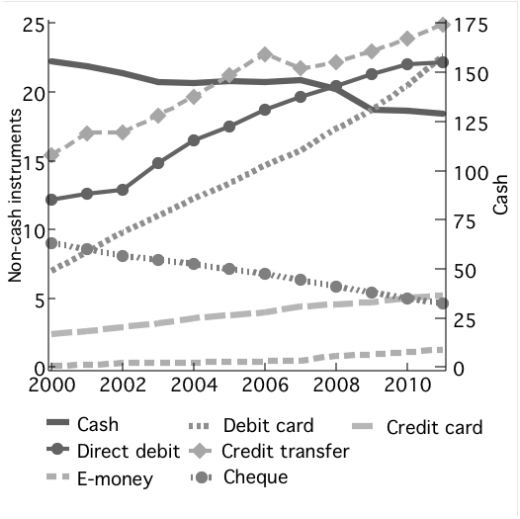

Figure 1: Total number of transactions for the 27 EU countries, in billions.

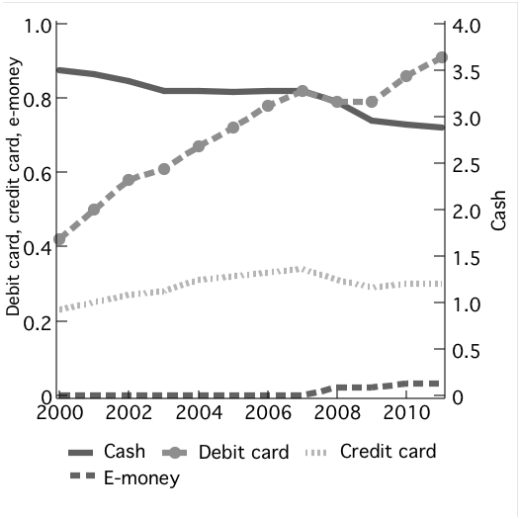

Figure 2: Real value of transactions for the 27 EU countries, EUR trillion.

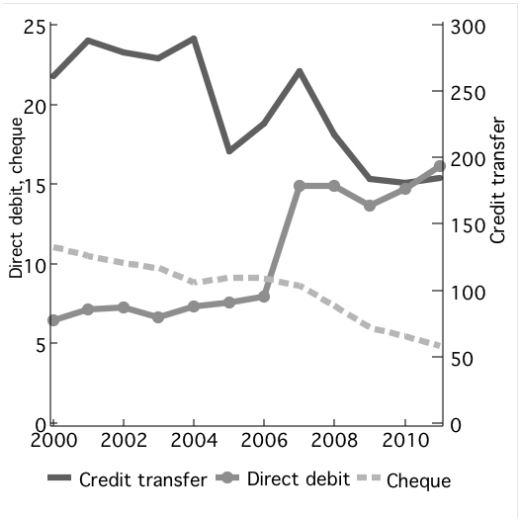

Figure 3: Real value of transactions for the 27 EU countries, EUR trillion.

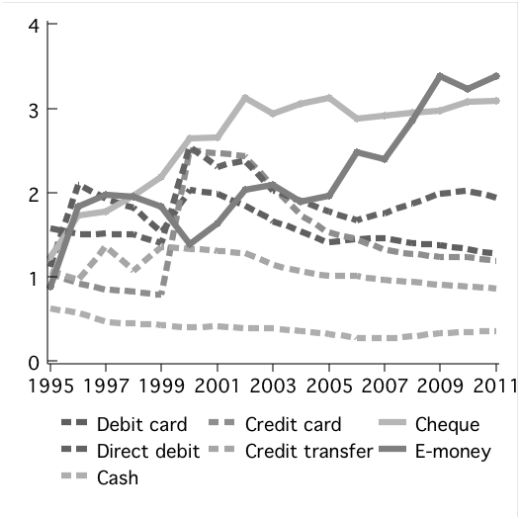

Figure 4: Standard deviation for different payment instruments, volume of transactions.

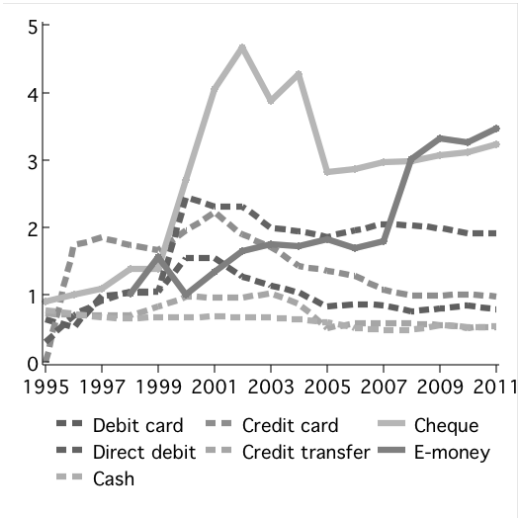

Figure 5: Standard deviation for different payment instruments, value of transactions.

Table 1: Summary statistics for debit card transactions in the 27 EU countries[a].

Debit cards											
	Volume of transactions					Value of transactions					
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum	
1995-2000	103	351.00	565.00	0.30	2620.00	93	23.70	36.10	0.05	154.00	
2001-2006	153	453.00	791.00	0.86	4650.00	156	24.70	49.00	0.06	292.00	
2007-2011	130	729.00	1250.00	5.21	7610.00	130	32.10	61.20	0.24	335.00	
1995-2011	386	519.00	938.00	0.30	7610.00	379	27.00	50.90	0.05	335.00	

[a]Summary statistics for the volume and value of debit card transactions. Volume of transactions in millions. Value of transactions in EUR billion. Data from ECB Statistical Data Warehouse.

Table 2: Summary statistics for credit card transactions in the 27 EU countries[a].

Credit cards										
	Volume of transactions					Value of transactions				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	80	143.00	303.00	0.04	1360.00	72	12.10	29.40	0.00	135.00
2001-2006	150	134.00	349.00	0.09	1870.00	144	12.20	32.00	0.00	167.00
2007-2011	130	184.00	410.00	2.70	1930.00	129	11.40	26.20	0.10	153.00
1995-2011	360	154.00	363.00	0.04	1930.00	345	11.90	29.30	0.00	167.00

[a]Summary statistics for the volume and value of credit card transactions. Volume of transactions in millions. Value of transactions in EUR billion. Data from ECB Statistical Data Warehouse.

Table 3: Summary statistics for direct debit transactions in the 27 EU countries[a].

Direct debits										
	Volume of transactions					Value of transactions				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	111	586.00	1220.00	0.02	5880.00	105	359.00	1020.00	0.00	7490.00
2001-2006	156	595.00	1280.00	0.05	7360.00	153	284.00	746.00	0.00	4190.00
2007-2011	132	796.00	1740.00	0.19	8700.00	132	559.00	2020.00	0.12	12100.00
1995-2011	399	659.00	1440.00	0.02	8700.00	390	398.00	1370.00	0.00	12100.00

[a]Summary statistics for the volume and value of direct debit transactions. Volume of transactions in millions. Value of transactions in EUR billion. Data from ECB Statistical Data Warehouse.

Table 4: Summary statistics for credit transfers in the 27 EU countries[a].

Credit transfers	Volume of transactions					Value of transactions				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	105	863.00	1450.00	1.10	7390.00	103	8780.00	21500.00	4.55	121000.00
2001-2006	157	730.00	1290.00	1.86	7260.00	154	10100.00	28400.00	2.88	130000.00
2007-2011	132	864.00	1280.00	4.36	6090.00	132	7800.00	19600.00	17.80	141000.00
1995-2011	394	810.00	1330.00	1.10	7390.00	389	8980.00	23900.00	2.88	141000.00

[a]Summary statistics for the volume and value of credit transfers. Volume of transactions in millions. Value of transactions in EUR billion. Data from ECB Statistical Data Warehouse.

Table 5: Summary statistics for cash (estimated) in the 27 EU countries[a].

Cash										
	Volume of transactions					Value of transactions				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	151	5770.00	7930.00	101.00	34200.00	151	123.00	174.00	1.74	757.00
2001-2006	161	5510.00	7920.00	116.00	26800.00	161	124.00	194.00	2.53	752.00
2007-2011	124	5220.00	7600.00	90.60	26000.00	124	118.00	186.00	2.09	730.00
1995-2011	436	5510.00	7820.00	90.60	34200.00	436	122.00	184.00	1.74	757.00

[a]Summary statistics for the volume and value of cash transactions (estimated based on private consumption). Volume of transactions in millions. Value of transactions in EUR billion. Data from ECB Statistical Data Warehouse.

Table 6: Summary statistics for the variables used in the beta convergence estimations[a].

	N	Mean	Stand. dev.	Minimum	Maximum
ATMs per 1000 inhabitants	423	0.59	0.32	0.01	1.66
Deposit rate	377	5.64	7.72	0.01	74.68
EFTPOS terminals per 1000 inhabitants	415	11.71	7.60	0.00	37.68
Interest rate	332	4.54	7.89	-71.21	97.47
Real private consumption per capita	441	10954.52	5926.42	1360.63	27125.96
Real GDP per capita	453	19661.61	13402.51	1895.71	70563.15

[a]Summary statistics for the variables used in the beta convergence estimations (1995-2011). Data from ECB Statistical Data Warehouse, World Bank and Eurostat.

Table 7: Sigma convergence estimation results for the period 1995-2011 for the volume of transactions[a].

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend before euro introduction	-0.064*** (0.003)	0.192*** (0.017)	-0.072* (0.035)	-0.022 (0.022)	0.040*** (0.007)	0.223*** (0.015)	0.335*** (0.021)
Time trend after euro introduction	-0.009*** (0.000)	-0.051** (0.003)	-0.078*** (0.006)	-0.016*** (0.004)	-0.045*** (0.001)	0.044*** (0.003)	0.160*** (0.003)
Before euro -dummy	0.687*** (0.008)	1.261*** (0.045)	1.089*** (0.095)	1.580*** (0.060)	1.017*** (0.018)	1.119*** (0.041)	0.823*** (0.058)
After euro-dummy	0.451*** (0.006)	2.125*** (0.032)	2.484*** (0.067)	2.147*** (0.042)	1.580*** (0.013)	2.404*** (0.029)	0.587*** (0.041)
N	459	459	459	459	459	459	459
Adjusted R^2	0.99	0.99	0.93	0.98	0.99	0.99	0.99
F-test, H_0: $\beta_0=\beta_1$	0.00	0.00	0.88	0.79	0.00	0.00	0.00

[a]The ordinary least squares estimation results for equation (1) for the period 1995-2011. The dependent variable is the standard deviation of the log volume of per capita transactions. Standard errors are in parentheses. *) Significant at the 5% level; **) Significant at the 1% level; ***) Significant at the 0.1% level. Time trend before-euro introduction is estimated as $\beta 0$ in equation (1); Time trend after-euro introduction is estimated as $\beta 1$; Before-euro dummy is the estimated before-euro introduction intercept $\alpha 0$ and After-euro dummy is the estimated after-euro introduction intercept $\alpha 1$. The F-test tests the hypothesis that the slope of the time trend is the same before and after the introduction of the euro. The null hypothesis is that the slopes are equal. The *p*-value of the F-test is reported.

Table 8: Sigma convergence estimation results for the period 1995-2011 for the value of transactions[a].

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend before euro introduction	-0.040*** (0.003)	0.144*** (0.012)	0.467*** (0.022)	0.215*** (0.021)	-0.009 (0.007)	0.135* (0.053)	0.376*** (0.015)
Time trend after euro introduction	-0.017*** (0.000)	-0.050*** (0.002)	-0.086*** (0.004)	0.002 (0.003)	-0.039*** (0.001)	0.004 (0.009)	0.167*** (0.005)
Before euro -dummy	0.798*** (0.008)	0.952*** (0.032)	0.615*** (0.059)	0.726*** (0.059)	1.254*** (0.020)	1.241*** (0.146)	-
After euro-dummy	0.773*** (0.006)	2.061*** (0.022)	2.814*** (0.041)	2.328*** (0.041)	1.679*** (0.014)	3.402*** (0.103)	0.625*** (0.052)
N	459	459	459	459	459	459	378
Adjusted R^2	0.99	0.99	0.98	0.99	0.99	0.96	0.98
F-test, H_0: $\beta_0=\beta_1$	0.00	0.00	0.00	0.00	0.00	0.16	0.00

[a]The ordinary least squares estimation results for equation (1) for the period 1995-2011. The dependent variable is the standard deviation of the log value of per capita transactions. Standard errors are in parentheses. *) Significant at the 5% level; **) Significant at the 1% level; ***) Significant at the 0.1% level. Time trend before-euro introduction is estimated as $\beta 0$ in equation (1); Time trend after-euro introduction is estimated as $\beta 1$; Before-euro dummy is the estimated before-euro introduction intercept $\alpha 0$ and After-euro dummy is the estimated after-euro introduction intercept $\alpha 1$. The F-test tests the hypothesis that the slope of the time trend is the same before and after the introduction of the euro. The null hypothesis is that the slopes are equal. The *p*-value of the F-test is reported.

Table 9: Sigma convergence estimation results for the period 2000-2011 for the volume of transactions[a].

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend	-0.008***	-0.067***	-0.137***	-0.046***	-0.045***	0.024***	0.181***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.002)	(0.003)
Constant	0.436***	2.331***	3.279***	2.549***	1.578***	2.672***	0.317***
	(0.007)	(0.018)	(0.032)	(0.039)	(0.008)	(0.026)	(0.038)
N	324	324	324	324	324	324	324
Adjusted R^2	0.34	0.86	0.89	0.39	0.93	0.28	0.91

[a]The ordinary least squares estimation results for equation (1) for the period 2000-2011. The dependent variable is the standard deviation of the log volume of per capita transactions. Standard errors are in parentheses. *) Significant at the 5% level; **) Significant at the 1% level; ***) Significant at the 0.1% level.

Table 10: Sigma convergence estimation results for the period 2000-2011 for the value of transactions[a].

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend	-0.018***	-0.063***	-0.100***	-0.034***	-0.045***	-0.068***	0.191***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.008)	(0.005)
Constant	0.785***	2.231***	3.004***	2.814***	1.768***	4.367***	0.306***
	(0.008)	(0.022)	(0.024)	(0.021)	(0.017)	(0.096)	(0.056)
N	324	324	324	324	324	324	324
Adjusted R^2	0.70	0.79	0.88	0.55	0.76	0.18	0.84

[a]The ordinary least squares estimation results for equation (1) for the period 2000-2011. The dependent variable is the standard deviation of the log value of per capita transactions. Standard errors are in parentheses. *) Significant at the 5% level; **) Significant at the 1% level; ***) Significant at the 0.1% level.

Table 11: Difference GMM estimation results for conditional beta convergence[a].

	ΔCash		ΔDebit card		ΔCredit card		ΔDirect debit	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
β	-0.325	-0.425	**-0.633****	-0.533	**-0.513*****	-0.101	**-0.657***	-0.818***
	(0.280)	(0.238)	(0.188)	(0.684)	(0.129)	(0.459)	(0.294)	(0.214)
Deposit rate	-0.052*	-0.047*	—	—	—	—	—	—
	(0.019)	(0.019)						
Interest rate	—	—	—	—	-0.082***	0.040	—	
					(0.039)	(0.070)		
EFTPOS	—	—	0.801**	0.658	1.187***	0.273	0.347	0.418
			(0.245)	(0.605)	(0.136)	(0.341)	(0.456)	(0.448)
ATMs	-0.047	-0.042	-0.196	0.022	-0.472	0.106	—	—
	(0.034)	(0.027)	(0.175)	(0.628)	(0.248)	(0.451)		
GDP	0.486	0.535*	0.256	0.600	0.414	0.672	-0.164	0.571
	(0.274)	(0.261)	(0.376)	(1.336)	(0.657)	(2.230)	(0.712)	(0.689)
Hansen p	0.154	0.309	0.776	0.072	0.187	0.888	0.152	0.175
Sargan p	0.586	0.701	0.718	0.179	0.054	0.911	0.078	0.283
AR(2)	0.125	0.147	0.069	0.619	0.595	0.599	0.105	0.407
N	274	264	327	320	171	163	331	324
Instruments	19	19	20	20	21	21	20	19

[a]The two-step difference GMM estimation results for equation (2). The dependent variable is the growth rate of transactions for payment instrument *i*. Year dummies are included (the results have been omitted for space reasons). Windmeijer-corrected standard errors are in parentheses. The null hypothesis for the Hansen and the Sargan overidentification tests is that instruments are jointly valid. AR(2) is the *p*-value of the Arellano-Bond test for second-order autocorrelation for first-differenced residuals; the null hypothesis is no autocorrelation. All continuous variables are in per capita terms and in logs. Value variables are in logs, in per capita terms and have been adjusted for inflation. *) Significant at the 5% level; ** Significant at the 1% level; ***) Significant at the 0.1% level. Lags two to three for the endogenous variables are included as instruments or, where specification tests suggest problems, lags two to four.

Table 12: Difference GMM estimation results for conditional beta convergence, continued[a].

	ΔCredit transfer		ΔCheque		ΔE-money	
	Volume	Value	Volume	Value	Volume	Value
β	-0.605	**-1.118*** **	-0.622	-1.213	0.079	-0.624
	(0.764)	(0.402)	(0.761)	(1.846)	(0.392)	(1.183)
EFTPOS	0.496	0.569**	—	—	—	—
	(0.306)	(0.200)				
GDP	-0.508	0.294	0.871	0.993	-2.864	-4.250
	(0.520)	(0.760)	(1.194)	(2.984)	(2.383)	(5.657)
Hansen p	0.238	0.615	0.580	0.119	0.614	0.490
Sargan p	0.175	0.556	0.573	0.003	0.716	0.642
AR(2)	0.501	0.956	0.555	0.319	0.873	0.515
N	325	323	328	305	134	122
Instruments	20	20	19	19	15	15

[a]The two-step difference GMM estimation results for equation (2). The dependent variable is the growth rate of transactions for payment instrument i. Year dummies are included (the results have been omitted for space reasons). Windmeijer-corrected standard errors are in parentheses. The null hypothesis for the Hansen and the Sargan overidentification tests is that instruments are jointly valid. AR(2) is the p-value of the Arellano-Bond test for second-order autocorrelation for first-differenced residuals; the null hypothesis is no autocorrelation. All continuous variables are in per capita terms and in logs. Value variables are in logs, in per capita terms and have been adjusted for inflation. *) Significant at the 5% level; ** Significant at the 1% level; ***) Significant at the 0.1% level. Lags two to three for the endogenous variables are included as instruments or, where specification tests suggest problems, lags two to four.

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