

Appendix A. Curriculum vitae for Leslie M. Marx

A.1. Summary of experience

Leslie M. Marx is the Robert A. Bandeen Professor of Economics at the Fuqua School of Business at Duke University. She served as Chief Economist of the Federal Communications Commission from August 2005 through August 2006. She is an expert in auctions, vertical contracting, antitrust liability, and cartels.

Dr. Marx has published extensively in peer-reviewed journals and elsewhere on topics related to industrial organization, applied game theory, auctions, procurements, and collusion. Her published work includes papers on collusive mechanisms, incentives in procurement contracting, slotting allowances, and exclusive dealing.

A.2. Areas of expertise

- Antitrust damages
- Antitrust liability
- Auctions
- Collusion
- Game theory
- Industrial organization
- Procurements

A.3. Testimony

Sworn testimony over the last five years:

- Expert report and testimony in arbitration involving two large telecommunications companies: 2016.
- *In re Urethane Antitrust Litigation*, No. 08-cv-05169 (D.N.J.). Expert report, deposition, and trial

testimony: 2013–2016.

- *In re Anderson News, L.L.C. v. Am. Media, Inc.*, No. 09-cv-2227 PAC (S.D.N.Y.). Expert report and deposition: 2014.
- *In re Petition of Pandora Media, Inc.*, No. 12-cv-8035 (S.D.N.Y. filed 2013). Expert reports and declaration and deposition and trial testimony: 2013–2014.
- *In re Urethane Antitrust Litig.*, MDL No. 04-1616 (D. Kan. filed 2004). Rule 26 Disclosure and deposition testimony, 2013. [Daubert Hearing, 2016]
- *In re TFT-LCD (Flat Panel) Antitrust Litig.*, MDL No. 07-1827 (N.D. Cal. Filed 2007). Expert reports and deposition testimony: 2011–2014.
- *In re Elec. Carbon Prod. Antitrust Litig.*, No. 05-6042 (D.N.J. filed 2006). Expert report: 2009.

A.4. Education

- PhD, Economics, Northwestern University
- MA, Economics, Northwestern University
- BS, Mathematics, Duke University

A.5. Editorial boards

- *American Economic Journal: Microeconomics*, Editorial Board, 2007 to present
- *International Journal of Game Theory*, 2009 to present
- Referee: *American Economic Review*, *Econometrica*, *Games and Economic Behavior*, *International Journal of Industrial Organization*, *Journal of Economic Theory*, *RAND Journal of Economics*, *Review of Economic Studies*, *Review of Industrial Organization*
- *Journal of Economic Literature*, Editorial Board, 2010–2012

- *Games and Economic Behavior*, Advisory Editor, 2010–2012
- *International Economic Review*, Associate Editor, 2002–2005

A.6. Publications

A.6.a. Research papers in academic journals

- “Club Good Intermediaries.” With Simon Loertscher, Forthcoming in *International Journal of Industrial Organization*.
- “A Long Way Coming: Designing Centralized Markets with Privately Informed Buyers and Sellers.” With Simon Loertscher and Tom Wilkening. *Journal of Economic Literature* 53, no. 4 (2015): 857–97.
- “Antitrust Leniency with Multi-Market Colluders.” With Claudio Mezzetti and Robert C. Marshall. *American Economic Journal: Microeconomics* 7, no. 3 (2015): 205–40.
- “Buyer Resistance for Cartel versus Merger.” With Vikram Kumar, Robert C. Marshall, and Lily Samkharadze. *International Journal of Industrial Organization* 39 (2015): 71–80.
- “Effects of Antitrust Leniency on Concealment Effort by Colluding Firms.” With Claudio Mezzetti. *Journal of Antitrust Enforcement* 2, no. 2, (2014): 305–32.
 - Winner of Best Economics Article—2015 Antitrust Writing Awards.
- “An Oligopoly Model for Analyzing and Evaluating (Re)-Assignments of Spectrum Licenses.” With Simon Loertscher. *Review of Industrial Organization* 45, no. 3 (2014): 245–73.
- “Plus Factors and Agreement in Antitrust Law.” With William E. Kovacic, Robert C. Marshall, and Halbert L. White. *Michigan Law Review* 110, no. 3 (2011): 393–436.
 - Winner of the 10th Annual Jerry S. Cohen Memorial Fund Writing Award for the best antitrust piece during the prior year.

- “Bidder Collusion at First-Price Auctions.” With Giuseppe Lopomo and Peng Sun. *Review of Economic Design* 15, no. 3 (2011): 177–211.
- “Carbon Allowance Auction Design: An Assessment of Options for the U.S.” With Giuseppe Lopomo, David McAdams, and Brian Murray. *Review of Environmental Economics and Policy* 5, no. 1 (2011): 25–43.
- “Coordinated Effects in the 2010 *Horizontal Merger Guidelines*.” With Wayne-Roy Gayle, Robert C. Marshall, and Jean-Francois Richard. *Review of Industrial Organization* 39, no. 1 (2011): 39–56.
- “The Economics of Contingent Re-Auctions.” With Sandro Brusco and Giuseppe Lopomo. *American Economic Journal: Microeconomics* 3, no. 2 (2011): 165–93.
- “Break-Up Fees and Bargaining Power in Sequential Contracting.” With Greg Shaffer. *International Journal of Industrial Organization* 28, no. 5 (2010): 451–63.
- “Slotting Allowances and Scarce Shelf Space.” With Greg Shaffer. *Journal of Economics & Management Strategy* 19, no. 3 (2010): 575–603.
- “Cartels as Two-Stage Mechanisms: Implications for the Analysis of Dominant-Firm Conduct.” With Randall D. Heeb, William E. Kovacic, and Robert C. Marshall. *Chicago Journal of International Law* 10, no. 1 (2009): 213–31.
- “Individual Accountability in Teams.” With Francesco Squintani. *Journal of Economic Behavior & Organization* 72, no. 1 (2009): 260–73.
- “Quantitative Analysis of Coordinated Effects.” With William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg. *Antitrust Law Journal* 76, no. 2 (2009): 397–430.
- “The ‘Google Effect’ in the FCC’s 700 MHz Auction.” With Sandro Brusco and Giuseppe Lopomo. *Information Economics and Policy* 21, no. 2 (2009): 101–14.

- “The Vulnerability of Auctions to Bidder Collusion.” With Robert C. Marshall. *Quarterly Journal of Economics* 124, no. 2 (2009): 883–910.
- “Cartel Price Announcements: The Vitamins Industry.” With Robert C. Marshall and Matthew E. Raiff. *International Journal of Industrial Organization* 26, no. 3 (2008): 762–802.
- Awarded the 2009 Paul Geroski Best Article Prize for one of the best two articles published in the *International Journal of Industrial Organization* in 2008.
- “Bidder Collusion.” With Robert C. Marshall. *Journal of Economic Theory* 133, no. 1 (2007): 374–402.
- “Exploring Relations Between Decision Analysis and Game Theory.” With Jules van Binsbergen. *Decision Analysis* 4, no. 1 (2007): 32–40.
- “Rent Shifting and the Order of Negotiations.” With Greg Shaffer. *International Journal of Industrial Organization* 25, no. 5 (2007): 1109–25.
- “Upfront Payments and Exclusion in Downstream Markets.” With Greg Shaffer. *RAND Journal of Economics* 38, no. 3 (2007): 823–43.
- “Economics at the Federal Communications Commission.” *Review of Industrial Organization* 29, no. 4 (2006): 349–68.
- “Inefficiency of Collusion at English Auctions.” With Giuseppe Lopomo and Robert C. Marshall. *B.E. Journal of Theoretical Economics* 5, no. 1 (2005).
- “Opportunism and Menus of Two-Part Tariffs.” With Greg Shaffer. *International Journal of Industrial Organization* 22, no. 10 (2004): 1399–414.
- “Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity: Comment.” With Greg Shaffer. *American Economic Review* 94, no. 3 (2004): 796–801.

- “The Joint Determination of Leverage and Maturity.” With Michael J. Barclay and Clifford W. Smith, Jr. *Journal of Corporate Finance* 9, no. 2 (2003): 149–67.
 - Winner, Outstanding Paper in Corporate Finance, 1997 Southern Finance Association Meetings.
- “Adverse Specialization.” With Glenn M. MacDonald. *Journal of Political Economy* 109, no. 4 (2001): 864–99.
- “Insurer Ownership Structure and Executive Compensation as Complements.” With David Mayers and Clifford W. Smith, Jr. *Journal of Risk and Insurance* 68, no. 3 (2001): 449–63.
 - Winner, Outstanding Paper in Financial Services, 1998 Southern Finance Association Meetings.
- “Dynamic Voluntary Contribution to a Public Project.” With Steven A. Matthews. *Review of Economic Studies* 67, no. 2 (2000): 327–58.
- “Adaptive Learning and Iterated Weak Dominance.” *Games and Economic Behavior* 26, no. 2 (1999): 253–78.
- “Odd-Eighth Avoidance as a Defense Against SOES Bandits.” With Eugene Kandel. *Journal of Financial Economics* 51, no. 1 (1999): 85–102.
- “Payments for Order Flow on NASDAQ.” With Eugene Kandel. *Journal of Finance* 54, no. 1 (1999): 35–66.
- “Predatory Accommodation: Below-Cost Pricing Without Exclusion in Intermediate Goods Markets.” With Greg Shaffer. *RAND Journal of Economics* 30, no. 1 (1999): 22–43.
- “Process Variation as a Determinant of Bank Performance: Evidence from the Retail Banking Study.” With Frances Frei, Ravi Kalakota, and Andrew Leone. *Management Science* 45, no. 9 (1999): 1210–20.

- “Efficient Venture Capital Financing Combining Debt and Equity.” *Review of Economic Design* 3, no. 4 (1998): 371–87.
 - Winner, Koç University Prize for the Best Paper of the Year in *Review of Economic Design*.
- “The Effects of Transaction Costs on Stock Prices and Trading Volume.” With Michael J. Barclay and Eugene Kandel. *Journal of Financial Intermediation* 7, no. 2 (1998): 130–50.
- “Cost Effective Use of Muscle Relaxants: A Decision Analysis.” With Jeffrey S. Rubenstein, Wendy Colin, Darryl Jackson, Craig Lockwood, and Janice Molloy. *Pediatrics* 100, no. 3 (1997): 451–52.
- “NASDAQ Market Structure and Spread Patterns.” With Eugene Kandel. *Journal of Financial Economics* 45, no. 1 (1997): 35–60.
- “Order Independence for Iterated Weak Dominance.” With Jeroen M. Swinkels. *Games and Economic Behavior* 18, no. 2 (1997): 219–45.

A.6.b. Research papers published in books and conference volumes

- “Leniency, Profiling and Reverse Profiling: Strategic Challenges for Competition Authorities.” With Claudio Mezzetti. In *Anti-Cartel Enforcement in a Contemporary Age: The Leniency Religion*, edited by C. Beaton-Wells and C. Tran, McLean, VA: Hart Publishing, 2015.
- “Tacit Collusion in Oligopoly.” With Edward Green and Robert C. Marshall. In *Oxford Handbook on International Antitrust Economics*, vol. 2, edited by Roger D. Blair and D. Daniel Sokol, 464–97. Oxford, UK: Oxford University Press, 2015.
- “Section 1 Compliance from an Economic Perspective.” With Robert C. Marshall. *William E. Kovacic: An Antitrust Tribute Liber Amicorum*, vol. 2, edited by Nicolas Charbit and Elisa Ramundo, 293–302. New York: Institute of Competition Law, 2014.
- “What Next? Cartel Strategy After Getting Caught.” With Robert C. Marshall and Claudio

Mezzetti), forthcoming in *Competition Law and Economics: Beyond Monopoly Regulation*, East-West Center and Korea Development Institute Monograph Series, Edward Elgar.

- “Economics and the Efficient Allocation of Spectrum Licenses.” With Simon Loertscher. In *Mechanisms and Games for Dynamic Spectrum Access*, edited by Tansu Alpcan, Holger Boche, Michael L. Honig, and H. Vincent Poor. Cambridge, UK: Cambridge University Press, 2014.
- “Tacit Collusion in Oligopoly.” With Edward Green and Robert C. Marshall. In *Oxford Handbook of International Antitrust Economics*, edited by Roger D. Blair and D. Daniel Sokol. Oxford, UK: Oxford University Press, forthcoming.
- “The Economics of Auctions and Bidder Collusion.” With Robert C. Marshall and Michael J. Meurer. In *Game Theory and Business Applications*, 2nd ed., edited by Kalyan Chatterjee and William F. Samuelson, 339–70. New York: Kluwer Academic Publishers, 2014.
- “Coordinated Effects in Merger Review: Quantifying the Payoffs from Collusion.” With William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg. In *Annual Proceedings of the Fordham Competition Law Institute: International Antitrust Law & Policy*, edited by Barry E. Hawk, 271–85. Huntington, NY: Juris Publishing, Inc., 2007.
- “Lessons for Competition Policy from the Vitamins Cartel.” With William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff. In *The Political Economy of Antitrust*, vol. 282, edited by Vivek Ghosal and Johan Stennek, 149–76. New York: Elsevier, 2007.
- “Bidding Rings and the Design of Anti-Collusion Measures for Auctions and Procurements.” With William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff. In *Handbook of Procurement*, edited by Nicola Dimitri, Gustavo Piga, and Giancarlo Spagnolo, 381–411. Cambridge, UK: Cambridge University Press, 2006.

A.6.c. Books

- *The Economics of Collusion: Cartels and Bidding Rings*. With Robert C. Marshall. Cambridge, MA: MIT Press, 2012.

A.7. Honors and awards

- Outstanding paper awards as listed above
- Outstanding Antitrust Litigation Achievement in Economics Finalist, American Antitrust Institute, October 2016
- Outstanding Antitrust Litigation Achievement in Economics Finalist, American Antitrust Institute, October 2014
- Game Theory Society, Council Member, 2013 to present
- FCC Woman Leader, Minority Media and Telecommunications Council, April 2013
- Top 100 Women in Antitrust, *Global Competition Review*, March 2013
- Business School Professor of the Week, *Financial Times*, July 2012
- Alfred P. Sloan Doctoral Dissertation Fellowship, 1993–1994
- Teaching Honor Roll, Simon School of Business, University of Rochester, 1999, 2001
- National Science Foundation Graduate Fellowship, 1989–1992
- Mary Love Collins Memorial Scholarship, 1989–1990
- Julia Dale Memorial Award in Mathematics, 1989
- Marie James Postgraduate Scholarship, 1989
- Phi Eta Sigma Graduate Scholarship, 1989
- Valedictorian, Duke University, 1989
- Alice M. Baldwin Scholarship, 1988–1989

- Faculty Scholar Award, Duke University, 1988–1989
- Phi Chi Theta Foundation Scholarship, 1988–1989
- Phi Eta Sigma Senior Award, 1988–1989
- Golden Key National Honor Society Scholarship, 1987–1988
- National Merit Scholarship, 1985
- Phi Beta Kappa Scholarship, 1985

Appendix B. Shapley value analysis

- (170) In this section, I provide the details of inputs to the Shapley value analysis and details of the calculations of the baseline and alternative Shapley value.

B.1. Inputs to the Shapley value analysis

- (171) This section provides details to the estimates of upstream non-content costs and downstream profits used as inputs for the Shapley value analysis.

B.1.a. Upstream

- (172) Warner Music Group's FY 2015 total global music publisher revenue is \$482 million; artist and repertoire costs are \$272 million; total selling, general, and administrative expenses are \$70 million; depreciation and amortization costs are \$69 million.¹⁵⁴ Therefore, its global music publishing non-content cost (\$70 million + \$69million = \$139 million) is 28.8% of its global revenue.
- (173) Warner's US music publishing revenue is \$191 million.¹⁵⁵ I use its US music publishing revenue and the ratio between its global music publishing non-content cost and revenue to estimate its US music publishing non-content cost: 28.8% * \$191 million, which is \$55 million.
- (174) According to Warner's 10-K, its 2014 music publishing market share is 13%.¹⁵⁶ I use Warner's publishing market share and publishing non-content cost to estimate the total cost of musical work copyright holders: \$55 million / 13%, which is \$424 million.^{157,158}
- (175) Similarly, I use Warner's data to estimate sound recording copyright holders' non-content cost. Its FY 2015 global recorded music revenue is \$2.501 billion; artist and repertoire costs are \$725 million;

¹⁵⁴ Warner Music Group, Annual Report (Form 10-K) (Dec. 10, 2015), at 37, 52-53. "The principal costs associated with our Music Publishing operations are as follows:

- Artist and repertoire costs—the costs associated with (i) paying royalties to songwriters, co-publishers and other copyright holders in connection with income generated from the exploitation of their copyrighted works and (ii) signing and developing songwriters; and
- General and administrative expenses—the costs associated with general overhead and other administrative expenses."

¹⁵⁵ Warner Music Group, Annual Report (Form 10-K) (Dec. 10, 2015), at 40.

¹⁵⁶ *Id.* at 12.

¹⁵⁷ For clarity, I display a few digits for revenue and costs, but the underlying calculations are done using all information available. Therefore, although 55/0.13 is approximately 423, the unrounded cost is actually a bit more than \$55 million, which gives the ratio as approximately 424.

¹⁵⁸ I assume non-content cost is proportional to revenue for simplification.

product costs are \$531 million; total selling, general and administrative expenses are \$902 million; and depreciation and amortization costs are \$228 million.¹⁵⁹ Therefore, its global sound recording non-content cost is \$902 million + \$228 million = \$1.130 billion, which is 45.2% of its global recorded music revenue.¹⁶⁰

- (176) Warner’s US recorded music revenue is \$980 million.¹⁶¹ I use its US recorded music revenue and the ratio between its global recorded music non-content cost and revenue to estimate its US recorded music non-content cost: \$980 million * 45.2% = \$443 million.¹⁶²
- (177) Warner’s 10-K says its 2014 worldwide recorded music sale share is 17%.¹⁶³ This suggests that US sound recording copyright holders’ non-content cost is \$443 million / 17% = \$2.605 billion.
- (178) Therefore, upstream total non-content cost is \$424 million + \$2.605 billion = \$3.028 billion.
- (179) Figure 30 summarizes my estimates for upstream non-content costs:

Figure 30: Shapley value upstream non-content cost estimates

Musical work copyright holders’ total non-content costs (C_1)	Sound recording copyright holders’ total non-content costs (C_2)	Total upstream non-content costs (C_U)
\$424 million	\$2.605 billion	\$3.028 billion

Source: See text.

B.1.b. Downstream

- (180) According to RIAA’s “2015 Year-End Industry Shipment and Revenue Statistics,” the 2015 revenue for “Paid Subscription” and “On-Demand Streaming (Ad-Supported)” are \$1.219 billion and \$385

¹⁵⁹ Warner Music Group, Annual Report (Form 10-K) (Dec. 10, 2015), at 40, 50.

¹⁶⁰ *Id.* 36. “The principal costs associated with our Recorded Music operations are as follows:

- *Artist and repertoire costs*—the costs associated with (i) paying royalties to artists, producers, songwriters, other copyright holders and trade unions; (ii) signing and developing artists; and (iii) creating master recordings in the studio;
- *Product costs*—the costs to manufacture, package and distribute products to wholesale and retail distribution outlets, the royalty costs associated with distributing products of independent labels to wholesale and retail distribution outlets, as well as the costs related to our artist services business;
- *Selling and marketing expenses*—the costs associated with the promotion and marketing of artists and recorded music products, including costs to produce music videos for promotional purposes and artist tour support; and
- *General and administrative expenses*—the costs associated with general overhead and other administrative expenses.”

¹⁶¹ *Id.* at 40.

¹⁶² *Id.* at 40.

¹⁶³ *Id.* at 12.

million, respectively.^{164, 165} The sum of these two numbers, \$1.604 billion, can be used as an estimate of total interactive streaming revenue.

(181)

[REDACTED]

(182) According to RIAA, the estimated US recorded music industry's retail revenue is \$7.016 billion. However, this number is calculated using "[e]stimated payments in dollars to performers and copyright holders for digital radio services under statutory licenses" to approximate the revenue of digital radio services under statutory licenses ("like Pandora, SiriusXM, and other Internet radio"), so it underestimates these services' revenue.¹⁶⁷

(183) Pandora's 2015 total revenue is \$1.164 billion.¹⁶⁸ Using its US and non-US listener numbers, I estimate that its US revenue is approximately \$1.134 billion.¹⁶⁹ Using Pandora's market share of Internet radio, I estimate the revenue of all Internet radio as \$1.619 billion.¹⁷⁰

(184) SiriusXM's 2015 total revenue is \$4.570 billion.¹⁷¹ Music revenue is likely approximately half of its total revenue, which yields 2015 music revenue of approximately \$2.285 billion.¹⁷²

¹⁶⁴ Joshua P. Friedlander, "News and Notes on 2015 RIAA Shipment and Revenue Statistics," Recording Industry Association of America, accessed Sep. 15, 2016, <http://www.riaa.com/wp-content/uploads/2016/03/RIAA-2015-Year-End-shipments-memo.pdf>.

¹⁶⁵ *Id.* at 2. The definition of "Paid Subscription" is given by footnote 3 of the RIAA document "2015 Year-End Industry Shipment and Revenue Statistics": "Streaming, tethered, and other paid subscription services not operating under statutory licenses." The definition of "On-Demand Streaming (Ad-Supported)" is given by footnote 4 of the same document: "Ad-supported audio and music video services not operating under statutory licenses." In addition, the RIAA document "News and Notes on 2015 RIAA Shipment and Revenue Statistics" describes the streaming categories as follows: "The streaming category includes revenues from subscription services (such as paid versions of Spotify, TIDAL and Apple Music, among others), streaming radio service revenues that are distributed by SoundExchange (like Pandora, SiriusXM, and other Internet radio), and other non-subscription on-demand streaming services (such as YouTube, Vevo, and ad-supported Spotify)."

¹⁶⁷ Joshua P. Friedlander, "News and Notes on 2015 RIAA Shipment and Revenue Statistics," Recording Industry Association of America, accessed Sep. 15, 2016, <http://www.riaa.com/wp-content/uploads/2016/03/RIAA-2015-Year-End-shipments-memo.pdf>.

¹⁶⁸ Pandora Media Inc., Annual Report (Form 10-K) (Feb. 18, 2016), at 68.

¹⁶⁹ As of December 2014, Pandora is available in Australia, New Zealand and the United States. Pandora Media Inc., Annual Report (Form 10-K) (Feb. 18, 2016), at 69. Pandora had about 2 million registered users in New Zealand and Australia in 2014. Tim Westergren, "Pandora Hits 2 Million Registered Users in Australia and New Zealand!" Pandora (blog), July 16, 2015, <http://blog.pandora.com/nz/pandora-hits-2-million-registered-users-in-australia-and-new-zealand/>. Pandora had about 76.5 million listeners in total in 2014. Thus $\$1.164 \text{ billion} * (76.5-2)/76.5 = \1.134 billion . Adam Levy, "Could Spotify Take Down Pandora Media Inc. in 2015?" *The Motley Fool*, Jan. 21, 2015, <http://www.fool.com/investing/general/2015/01/21/could-spotify-take-down-pandora-media-inc-in-2015.aspx>. Pandora has about a 70% share of internet radio in the US. Thus, $\$1.134 \text{ billion}/70\% = \1.619 billion . Connie Guglielmo, "Pandora Plays Nice as Apple's iTunes Radio Spins Up," *Forbes*, Nov. 13, 2013, available at <http://www.forbes.com/sites/connieguglielmo/2013/11/13/pandora-media-needs-a-new-music-royalty-deal-will-it-be-the-same-one-apple-got/#7ee6278d56e9>.

- (185) Therefore, my estimate of the downstream revenue underlying RIAA’s “SoundExchange Distributions” (\$803 million) is \$1.619 billion + \$2.285 billion = \$3.904 billion. And my estimate of the total downstream revenue is \$7.016 billion – \$803 million + \$3.904 billion = \$10.118 billion.
- (186) Given that interactive streaming’s revenue is \$1.604 billion, the total 2015 revenue of all other music distributors is approximately \$10.118 billion – \$1.604 billion = \$8.514 billion.
- (187) Other music distribution channels include PDD/CD, non-interactive streaming, satellite radio, and terrestrial radio. It is difficult to identify the non-content costs of all distribution channels. For example, CD production may be vertically integrated with music publishing and recording which makes the allocation of costs difficult. Due to limitation of data sources, I use a revenue-weighted average of internet radio’s (estimated using Pandora’s data) and SiriusXM’s non-content costs as an estimate of other music distributors’ non-content cost share of revenue and get 56%.¹⁷³ Therefore, I estimate other music distributors’ profit as \$8.514 billion * (1 – 56%) = \$3.756 billion.
- (188) The estimated downstream revenues and profits are summarized in the table below:

Figure 31: Shapley value downstream revenue and profit estimates

Interactive streaming’s revenue (R_I)	Interactive streaming’s profit (π_I)	Other music distributors’ total revenue (R_O)	Other music distributors’ profit (π_O)	Total downstream revenue (R_D)
\$1.604 billion	\$924 million	\$8.514 billion	\$3.576 billion	\$10.118 billion

Source: See text.

B.2. Baseline Shapley value

- (189) Consider the allocation of the joint surplus created by the music industry. In the simplest hypothetical market appropriate for the matter at hand, the music industry consists of three entities: copyright

¹⁷¹ Sirius XM Holdings Inc., Annual Report (Form 10-K) (Feb. 2, 2016), at F-4.

¹⁷² There are a few possible ways to estimate the share of SiriusXM’s music revenue as a percentage of its total revenue. SiriusXM has an inventory of more than 175 channels, over 70 of which are music channels of different genres. The music channels’ share of all channels is about 40%. SiriusXM, “What is SiriusXM?” accessed Aug. 24, 2016, <http://www.siriusxm.com/whatisiriusxm?hpid=02010022>. SiriusXM’s “Mostly Music” package and its “News, Sports & Talk” package are both \$10.99 per month. If one uses these two prices, then music revenue is about 50%. Moreover, SiriusXM’s “All Access” package is \$19.99 per month. If one uses the ratio between the “Mostly Music” package price and the “All Access” package price, one gets 55%. SiriusXM, “Our Most Popular Packages,” accessed Oct. 28, 2016, http://www.siriusxm.com/ourmostpopularpackages?hpid=02010028&intcmp=SXM_HP-NAV_0916_DEF_HDR_SUBS_MPP. See also SiriusXM, “SiriusXM News, Sports & Talk,” accessed Oct. 28, 2016, <http://www.siriusxm.com/packages/sxmnewssportstalk>.

¹⁷³ According to Pandora’s and SiriusXM’s 2015 10-Ks, Pandora’s non-content cost is 62% of its revenue and SiriusXM’s non-content cost is 51% of its revenue. Assuming SiriusXM’s non-content cost related to music is also 51% of revenue related to music, the average non-content cost of internet radio and Satellite radio as a percentage of revenue is $(\$1,619 \text{ million} * 62\% + \$2,285 * 51\%) / (\$1,619 \text{ million} + \$2,285 \text{ million}) = 56\%$.

holders (denoted by U), interactive streaming services (denoted by I), and other music distributors (denoted by O).

(190) Let interactive streaming revenue, non-content cost, and profit be R_I , C_I , and π_I , respectively. By our definition, $\pi_I = R_I - C_I$. Similarly, let other music distributors' revenue, non-content cost, and profit be R_O , C_O , and π_O , respectively. Again, by our definition, $\pi_O = R_O - C_O$. Denote the downstream profit by π_D . Then $\pi_D = \pi_I + \pi_O$.

(191) Let musical work copyright holders non-content be C_1 and sound recording copyright holders non-content cost be C_2 . Denote upstream total non-content cost by C_U . Then $C_U = C_1 + C_2$. Denote the ratio between upstream non-content cost and downstream profit by β , i.e. $\beta \equiv C_U/\pi_D$.

(192) Let ρ_I be the parameter of I 's substitution effect on O . That is, if I did not exist, O would capture ρ_I 's share of I 's profit. Similarly, let ρ_O as the parameter of O 's substitution effect on I . That is, if O did not exist, I would capture ρ_O share of O 's profit.

(193) Denote the total value created by a coalition S by $v(S)$. The only combinations of entities that create non-zero values are $\{U, I\}$, $\{U, O\}$, and $\{U, I, O\}$.

(194) By definition, the total value created by all entities together is the difference between downstream profit and upstream cost: i.e.,

$$(1) v(\{U, I, O\}) = \pi_D - C_U = (1 - \beta)\pi_D,$$

(195) Given our definitions of ρ_I and ρ_O and our assumption that upstream cost is a share β of downstream profit, the total values created by $\{U, I\}$ and $\{U, O\}$ are

$$(2) v(\{U, I\}) = \pi_I + \rho_O\pi_O - \beta(\pi_I + \rho_O\pi_O),$$

$$(3) v(\{U, O\}) = \pi_O + \rho_I\pi_I - \beta(\pi_O + \rho_I\pi_I),$$

where $\pi_I + \rho_O\pi_O$ is downstream profit when the market only involves copyright holders and interactive streaming; $\beta(\pi_I + \rho_O\pi_O)$ is upstream non-content cost in this case; $\pi_O + \rho_I\pi_I$ is downstream profit when the market involves copyright holders and all other music distributors, and $\beta(\pi_O + \rho_I\pi_I)$ is upstream non-content cost in this case.

(196) Given three entities in the game, there are six (three factorial) possible orders by which the entities arrive in the market:

1. I, U, O
2. I, O, U

3. O, I, U
4. U, I, O
5. O, U, I
6. U, O, I

(197) The Shapley value of an entity is the average of its marginal contributions over all possible arrival orderings, that is

$$(4) Sh(I) = \frac{v(\{U, I, O\}) - v(\{U, O\})}{3} + \frac{v(\{U, I\})}{6} = (1 - \beta) \left(\frac{(1 - \rho_I)\pi_I}{3} + \frac{\pi_I + \rho_O\pi_O}{6} \right),$$

$$(5) Sh(O) = \frac{v(\{U, I, O\}) - v(\{U, I\})}{3} + \frac{v(\{U, O\})}{6} = (1 - \beta) \left(\frac{(1 - \rho_O)\pi_O}{3} + \frac{\pi_O + \rho_I\pi_I}{6} \right),$$

$$(6) Sh(U) = \frac{v(\{U, I, O\})}{3} + \frac{v(\{U, I\}) + v(\{U, O\})}{6} = (1 - \beta) \left(\frac{\pi_I + \pi_O}{3} + \frac{(1 + \rho_I)\pi_I + (1 + \rho_O)\pi_O}{6} \right).$$

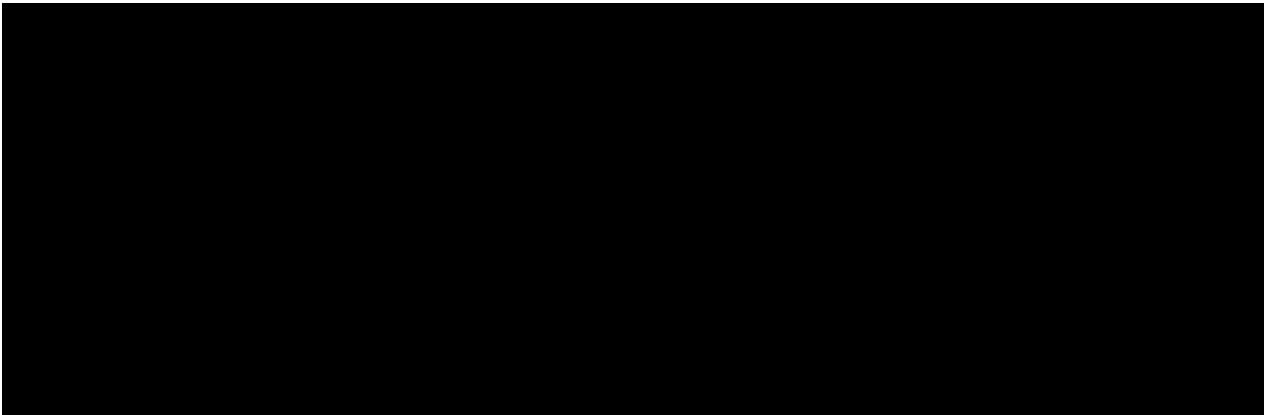
(198) Denote I 's total royalty payments as T_I , O 's total royalty payments as T_O , and U 's total royalty income as t_U . Then I have

$$(7) T_I = \pi_I - Sh(I) = \pi_I - (1 - \beta) \left(\frac{(1 - \rho_I)\pi_I}{3} + \frac{\pi_I + \rho_O\pi_O}{6} \right),$$

$$(8) T_O = \pi_O - Sh(O) = \pi_O - (1 - \beta) \left(\frac{(1 - \rho_O)\pi_O}{3} + \frac{\pi_O + \rho_I\pi_I}{6} \right),$$

$$(9) t_U = C_U + Sh(U) = C_U + (1 - \beta) \left(\frac{\pi_I + \pi_O}{3} + \frac{(1 + \rho_I)\pi_I + (1 + \rho_O)\pi_O}{6} \right).$$

(199) Assuming ρ_I and ρ_O take the values of 1/4, 1/2 or 3/4, I get the following Shapley values and royalties:



B.3. Alternative Shapley value

- (200) Consider a hypothetical market of music creation and distribution consisting of four entities: copyright holders of musical works (denoted by U_1), copyright holders of sound recordings (denoted by U_2), interactive streaming services (denoted by I), and other music distributors (denoted by O). Assume the only combinations that create positive values are $\{U_1, U_2, I, O\}$, $\{U_1, U_2, I\}$, and $\{U_1, U_2, O\}$. The values created by these combinations can be denoted as $v(\{U, I, O\})$, $v(\{U, I\})$, and $v(\{U, O\})$, respectively.

With 4 entities, there are 24 (4 factorial) possible orders by which the entities arrive in the market. The Shapley value of each entity is

$$(10) Sh(I) = \frac{v(\{U, I, O\}) - v(\{U, O\})}{4} + \frac{v(\{U, I\})}{12} = (1 - \beta) \left(\frac{(1 - \rho_I)\pi_I}{4} + \frac{\pi_I + \rho_O\pi_O}{12} \right),$$

$$(11) Sh(O) = \frac{v(\{U, I, O\}) - v(\{U, I\})}{4} + \frac{v(\{U, O\})}{12} = (1 - \beta) \left(\frac{(1 - \rho_O)\pi_O}{4} + \frac{\pi_O + \rho_I\pi_I}{12} \right),$$

$$(12) Sh(U_1) = Sh(U_2) = \frac{v(\{U, I, O\})}{4} + \frac{v(\{U, I\}) + v(\{U, O\})}{12} \\ = (1 - \beta) \left(\frac{\pi_I + \pi_O}{4} + \frac{(1 + \rho_I)\pi_I + (1 + \rho_O)\pi_O}{12} \right).$$

- (201) The downstream firms' total royalty payments and the upstream firms' total royalty income are

$$(13) T_I = \pi_I - Sh(I) = \pi_I - (1 - \beta) \left(\frac{(1 - \rho_I)\pi_I}{4} + \frac{\pi_I + \rho_O\pi_O}{12} \right),$$

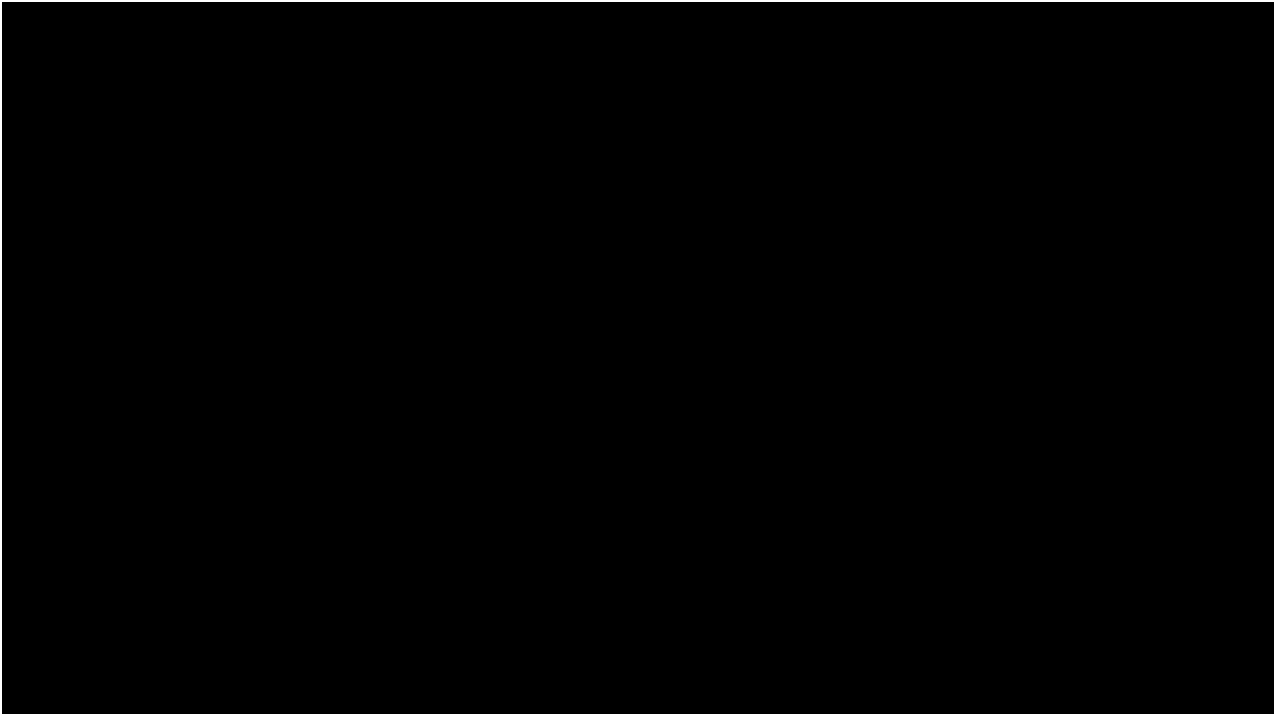
$$(14) T_O = \pi_O - Sh(O) = \pi_O - (1 - \beta) \left(\frac{(1 - \rho_O)\pi_O}{4} + \frac{\pi_O + \rho_I\pi_I}{12} \right),$$

$$(15) t_1 = C_1 + Sh(U_1) = C_1 + (1 - \beta) \left(\frac{\pi_I + \pi_O}{4} + \frac{(1 + \rho_I)\pi_I + (1 + \rho_O)\pi_O}{12} \right),$$

$$(16) t_2 = C_2 + Sh(U_2) = C_2 + (1 - \beta) \left(\frac{\pi_I + \pi_O}{4} + \frac{(1 + \rho_I)\pi_I + (1 + \rho_O)\pi_O}{12} \right),$$

where t_1 is musical work copyright holders' total royalty income and t_2 is sound recording copyright holders' total royalty income.

- (202) As in the baseline calculation, I assume ρ_I and ρ_O take the values of 1/4, 1/2, or 3/4. The Shapley values and royalties are:



Appendix C. Materials cited

Figure 34: Materials cited

Document type	Filename
Public	2008 launch.pdf
Public	2012.01.13 This Is Why You Don't Go to the Gym - The Atlantic.pdf
Public	2013.12.11 The Verge - Spotify announces free streaming on Android and iPhone, but only in Shuffle mode.pdf
Public	2014.12.11 WSJ - The Biggest Music Comeback of 2014_ Vinyl Records.pdf
Public	2015 Chapter 8 proceedings by Copyright Royalty Judges.pdf
Public	2016.03 RIAA-2015-Year-End-shipments-memo.pdf
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Public	DiCola paper.pdf
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Public	Pandora ASCAP decision.pdf
Public	Pandora Plays Nice As Apple's iTunes Radio Spins Up.pdf
Public	Pandora hits 2 million registered users in Australia and New Zealand! – Pandora Blog.pdf
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Public	Spotify premium features.pdf
Public	Spotify urges iPhone customers to stop paying through Apple's App Store - The Verge.pdf
Public	Subscriptions - Spotify.pdf
Public	The Constitution of the United States_ A Transcription.pdf
Public	U.S Copyright Office - Title 17.pdf
Public	USCO (2015) copyright-and-the-music-marketplace.pdf
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Restricted	MusicWatch – Annual Music Study 2015 – Report to Spotify Ltd. – June 2016
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Restricted	Spotify & Universal Publishing – November 1, 2016 (H13425-0002-001687)
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