



Jeffrey H. Rohlfs

foreword by Hal R. Varian

Bandwagon Effects

in High-Technology Industries

Bandwagon Effects in High-Technology Industries

Bandwagon Effects in High-Technology Industries

Jeffrey H. Rohlfs

The MIT Press
Cambridge, Massachusetts
London, England

©2001 Massachusetts Institute of Technology

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher.

This book was set in Sabon by Best-set Typesetter Ltd., Hong Kong.
Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Rohlf, Jeffrey H.

Bandwagon effects in high-technology industries / Jeffrey H. Rohlf.

p. cm.

Includes bibliographical references and index.

ISBN 0-262-18217-3 (hc. : alk. paper)

1. High technology industries—United States—Case studies. I. Title.

HC110.H53 R64 2001

338.4762'000973—dc21

2001030659

For Joan, the love of my life

Contents

Acknowledgments	xi
Foreword	xiii
I Introduction	1
1 The High-Technology Bandwagon	3
2 A Bandwagon Tour	7
2.1 A Guide to the Tour	8
II Bandwagons: How They Work	13
3 Bandwagon Demand	19
3.1 Equilibrium User Sets	20
3.2 Demand as a Function of Price	24
3.3 Metcalfe's Law	29
3.4 Dynamics of Complementary Bandwagon Effects	30
4 Bandwagon Supply	33
4.1 Monopoly versus Competition	33
4.2 Interlinking	34
4.3 Solving the Start-Up Problem	35
4.4 Incentives of Suppliers to Interlink	45
4.5 Supply Coordination with Complementary Bandwagon Products	47
4.6 Technical Standards	48
4.7 Proprietor Services versus Customer Equipment	50
4.8 Mature Services	51
4.9 Predatory Pricing	53

5	Summary of Results of Bandwagon Theory	55
5.1	The Cheat Sheet	55
III	Case Studies	59
6	Fax	61
6.1	Lessons from Case Study	67
7	Early Telephone	69
7.1	Pricing of Exchange Service	69
7.2	Interlinking	79
7.3	Lessons from Case Study	80
8	Picturephone	83
8.1	Picturephone as an Intercom Service	87
8.2	Constructing a Self-Sufficient User Set	88
8.3	Actual Outcome	89
8.4	Lessons from Case Study	89
9	Compact-Disc Players	91
9.1	Technological Standard	92
9.2	CDs Not Available	95
9.3	Small Libraries of CDs	96
9.4	Subsequent Developments	98
9.5	Other Digital Players of Recorded Music	99
9.6	Lessons from Case Study	104
10	VCRs	121
10.1	Early Developments	105
10.2	Early VCR Use	106
10.3	Beta versus VHS	107
10.4	The Bandwagon	109
10.5	The Hollywood Assault	111
10.6	The Videocassette Business	112
10.7	Videodisc Players	113
10.8	Lessons from Case Study	115
11	Personal Computers	117
11.1	Early Application Software	119
11.2	The Rise of the IBM PC	119

11.3	The Decline of the IBM PC	121
11.4	The Role of Apple	124
11.5	The Rise of Intel and Microsoft	127
11.6	Microsoft's Pricing	129
11.7	Recent Applications Software	131
11.8	Linux	132
11.9	Java	133
11.10	The Role of Misjudgments	134
11.11	Lessons from Case Study	135
12	Television	137
12.1	The Emergence of Television	137
12.2	Color Television	143
12.3	High-Definition Television	148
12.4	Lessons from Case Study	164
13	The Internet	167
13.1	Size and Growth of the Internet	168
13.2	Telecommunications Technology	172
13.3	Evolution of the Computer Industry	176
13.4	Telecommunications Prices	177
13.5	The Development of ARPANET	179
13.6	Other Packet-Switched Networks	181
13.7	NSFNET	188
13.8	The Internet after NSFNET	189
13.9	Externalities and Transactions Costs	189
13.10	Current Internet Usage	190
13.11	A Final Reflection	191
13.12	Lessons from Case Study	191
IV	Conclusions	193
14	Summary of Results	195
14.1	Start-Up Problem	197
14.2	Vertical Integration	197
14.3	Bandwagon Markets without Interlinking	198
14.4	Agreeing to a Technical Standard	199
14.5	Government Intervention	201

15 Final Remarks	203
Mathematical Appendix	205
Notes	223
Glossary of Economics Concepts	235
Dictionary of Abbreviations and Acronyms	239
Bibliography	241
Index	247

Acknowledgments

Many persons contributed to the creation of this book, and I would like to thank them for their efforts. Chuck Jackson suggested that I undertake this venture and cajoled me into doing so. The book has been substantially improved as a result of helpful comments from John Haring, Jackson, Chip Shooshan, Hal Varian, and three anonymous referees. I am also grateful for the support and encouragement that I received from all my colleagues at Strategic Policy Research. In particular, I would like to thank David Fintzen for his research support and Adrienne Vendig, who typed numerous revisions of the text. I am, of course, solely responsible for any remaining errors.

Foreword

I first met Jeff Rohlfs back in 1973 when I visited Bell Labs. During this visit he told me about “network externalities.” This was a new term to me—and to everyone, I suppose, since Jeff had just invented it. He told me how AT&T had spent millions of dollars on Picturephone, and explained to me how it had flopped. He showed me his model of network effects, and I remember being impressed by its elegance. Little did I realize just how powerful and important this idea was to become!

Jeff’s paper on network effects was published in 1974. The rest of the world was slow to recognize its significance. Figure 1 shows the citations to Jeff’s paper from 1975 to 2000. As with many papers, it had a few citations early on, then a drop off. But unlike most papers, citations to Jeff’s paper picked up again as people began to recognize the importance of network effects in high-technology industries. In fact, the citations to Jeff’s paper look a bit like the dynamics associated with networks: a slow period, followed by a burst of rapid growth.

I conjecture that the long time that it took to recognize the importance of network effects was due to the nature of the example Jeff chose to motivate the investigation (Picturephone) and the nature of technology innovation in the 1960s and 1970s. Picturephone was a loser—it never achieved critical mass and market success. No one seems to care why a loser lost—they only care why a winner wins.

Furthermore, from roughly 1950 to 1980, there were no really prominent example of network effects that caught the public imagination. True, there was the spread of the television networks, but these didn’t really exhibit network externalities in the Rohlfs sense of the word. The

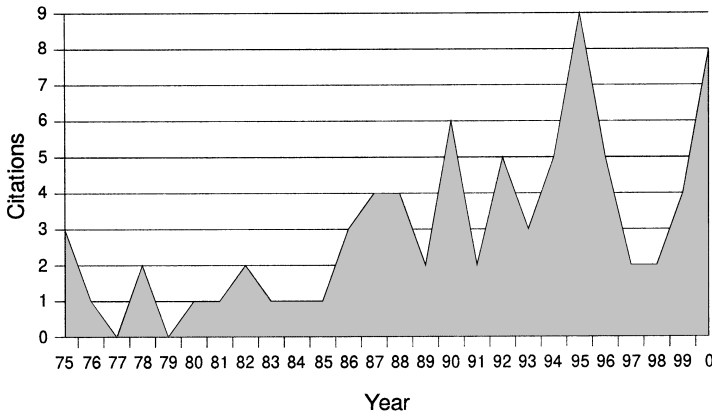


Figure 1
Citations to “A Theory of Interdependent Demand for a Communications Service.”

fact that one family bought a television had little direct effect on the value that another family would place on a TV.

The combination of these effects meant that Rohlfs’s analysis of network dynamics in 1970s didn’t really resonate with potential readers. Things were quite different in the 1980s and 1990s when we saw several technologies that exhibited classic network externalities: ATM machines, fax machines, VCRs and prerecorded videos, and e-mail to name just a few. People began to notice there was something interesting going on!

This wasn’t really “new.” These industries exhibited the same dynamics as telegraph, telephone and wireless technologies had exhibited a century or so earlier. But they were new in our lifetimes, and that’s what mattered.

It’s great to see Jeff’s new book network externalities and positive feedback in high-tech markets. He has pulled together the theory and the examples necessary to understand how these markets work and provided valuable insight for future economists and entrepreneurs.

Let the band(wagon) play on!

Hal R. Varian
University of California, Berkeley

I

Introduction

The literal meaning of *bandwagon* is an ornately decorated wagon that carries musicians in a parade. This type of bandwagon is from a gentler era and rarely seen any more. Nevertheless, just about everyone today knows the figurative meanings of *bandwagon*. In U.S. presidential primaries, the bandwagon is, according to many political commentators, what the winner of the last primary has. This candidate risks losing the bandwagon unless he or she wins the next primary. Some commentators appear unable to describe an election campaign without using the word *bandwagon*. The word is never defined but seems to mean what sports commentators call “momentum”—that is, a general tendency of success to breed further success.

Bandwagons are also used to characterize “irrational exuberance” of investors in the stock market.¹ According to this view, investors observe that others have recently been highly successful in the market. They then follow their example, regardless of market fundamentals. Bandwagon effects in this context are a type of herd behavior.

Both these concepts bear some similarity to what we (and other economists) mean by “bandwagon effects,” but they are not precisely the same. Since we are using language somewhat differently from others, our first order of business is to define our terms precisely. Our definition of a **bandwagon effect**² is as follows: a benefit that a person enjoys as a result of others’ doing the same thing that he or she does. In particular, a consumer may enjoy bandwagon benefits as others consume the same product or service that he or she does. The consumer then enjoys a “rational exuberance” as the user set expands.

Bibliography

- American Telephone and Telegraph Company. Comptroller's-Accounting Division, *Bell System Statistical Manual, 1950–1981*, June 1982.
- Areeda, P., and D. F. Turner. "Predatory Pricing and Related Practices under Section 2 of the Sherman Act," *Harvard Law Review* 88 (1975), pp. 637–833.
- Arthur, W. B. "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *Economic Journal*, 99, no. 394 (March 1989), pp. 116–131.
- Artle, R., and C. Averous. "The Telephone Systems as a Public Good: Static and Dynamic Aspects," *Bell Journal of Economics and Management Science* 4, no. 1 (Spring 1973), pp. 89–100.
- Baumol, W. J., and D. E. Bradford. "Optimal Departures from Marginal Cost Pricing," *American Economic Review* 60 (June 1970), pp. 265–283.
- Beggs, A., and P. Klemperer. "MultiPeriod Competition with Switching Costs," *Econometrica* 60, no. 3 (May, 1992), pp. 651–666.
- Bennett, A. R. *The Telephone Systems of the Continent of Europe*. New York: Arno Press, 1974.
- Besen, S. M., and L. L. Johnson. *Compatibility Standards, Competition, and Innovation in the Broadcasting Industry*, R-3453-NSF. Santa Monica, CA: The RAND Corporation, November 1986.
- Boiteux, M. "On the Management of Public Monopolies Subject to Budgetary Constraints," *Journal of Economic Theory* 3 (September 1971), pp. 219–240.
- Bornholz, R., and D. S. Evans, "The Early History of Competition in the Telephone Industry," in D. S. Evans, *Breaking Up Bell: Essays in Industrial Organization and Regulation*. North-Holland, 1983.
- Brinkley, J. *Defining Vision*. New York: Harcourt Brace & Company, 1997.
- Brock, G. W. *The Telecommunications Industry: The Dynamics of Market Structure*. Cambridge: Harvard University Press, 1981.
- Brooks, J. *Telephone: The First Hundred Years*. New York: Harper & Row, 1975.

Brown, S. J., and D. S. Sibley. *The Theory of Public Utility Pricing*. Cambridge University Press, 1986.

Cerf, V. "How the Internet Came to Be," Bell Laboratories, Lucent Technologies, 1993. Available at <http://www.bell-labs.com/user/zhwang/vcerf.html>.

Church, J., and N. Gandal. "Network Effects, Software Provision, and Standardization," *Journal of Industrial Economics* 40, no. 1 (March 1992), pp. 85–103.

Coase, R. "The Problem of Social Cost," *Journal of Law and Economics* (October 1960), pp. 1–44.

Coffman, K. G., and A. M. Odlyzko. "The size and growth rate of the Internet," *First Monday*, October 1998. Available at <http://firstmonday.org/> and also available at <http://www.research.att.com/~amo>.

Cole, B., and M. Oettinger. *Reluctant Regulators: The FCC and the Broadcast Audience*. Reading, MA: Addison-Wesley Publishing Company, 1978.

Coopersmith, J. *The Joys of Fax*, n.d. Available at <http://people.tamu.edu/~jcfax1/spectrum.htm>.

Cusumano, M. A., Y. Mylonadis, and R. S. Rosenbloom. "Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta," *Business History Review* 66 (Spring 1992): 51–94.

Day, K. "Newcomers to Computers Try to Polish Apple," *Los Angeles Times* (September 29, 1985), p. 1.

Ducey, R. V., and M. R. Fratrick. "Broadcasting Industry Response to New Technologies," *Journal of Media Economics* 2, no. 2 (Fall 1989), pp. 67–81.

Economides, N., and C. Himmelberg. *Critical Mass and Network Size with Application to the US FAX Market*, EC-95–11, New York University, Leonard N. Stern School of Business, August 1995.

Economides, N., and S. C. Salop. "Competition and Integration Among Complements, and Network Market Structure," *Journal of Industrial Economics* 40, no. 1 (March 1992), pp. 105–123.

Evans, D. S., A. Nichols, and B. Reddy. "The Rise and Fall of Leaders in Personal Computer Software," National Economic Research Associates, January 7, 1999.

Farrell, J., and G. Saloner. "Standardization, Compatibility, and Innovation," *Rand Journal of Economics* 16, no. 1 (Spring 1985), pp. 70–83.

Farrell, J., and G. Saloner. "Converters, Compatibility, and the Control of Interfaces," *Journal of Industrial Economics* 40, no. 1 (March 1992), pp. 9–35.

Farrell, J., and C. Shapiro. "Dynamic Competition with Switching Costs," *Rand Journal of Economics* 19 (1988), pp. 123–137.

Farrell, J., and C. Shapiro. "Standard Setting in High-Definition Television," *Brookings Papers: Microeconomics* (1992), pp. 1–77.

Federal Communications Commission (FCC). In the Matter of Access Charge Reform, Price Cap Performance Review for Local Exchange Carriers, Transport Rate Structure and Pricing, and End User Common Line Charges, CC Docket Nos. 96-262, 94-1, 91-213, and 95-82, *First Report and Order* (released May 15, 1997).

Federal Communications Commission (FCC). *Statistics of Common Carriers, 1994-1995*, 1998.

Federal Communications Commission (FCC). Industry Analysis Division, Common Carrier Bureau. Table 14.6, "Average Revenue per Minute," in *Trends in Telephone Service*, September 1999.

Federal Communications Commission (FCC). In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, CC Docket No. 96-98, *Third Report and Order and Fourth Notice of Proposed Rulemaking* (November 5, 1999).

Fischer, C. S. *America Calling: A Social History of the Telephone to 1940*. Berkeley: University of California Press, 1992.

Fisher, F. M. Direct testimony, *United States of America v. Microsoft*, 1999.

Gabel, D. "Competition in a Network Industry: The Telephone Industry, 1894-1910," *Journal of Economic History* 54, no. 3 (September 1994), pp. 543-572.

Grindley, P. *Standards Strategy and Policy: Cases and Stories*. Oxford: Oxford University Press, 1995.

Hafner, K., and M. Lyon. *Where Wizards Stay Up Late: The Origins of the Internet*. New York: Touchstone, 1996.

Hill, C. W. L. *Establishing a Standard: Competitive Strategy and Technological Standards in Winner-Take-All Industries*, Academy of Management, May 1, 1997. Copyright UMI Company.

Holmstrom, B. R., and J. Tirole. "The Theory of the Firm," in *Handbook of Industrial Organization*, vol. 1, ed. Richard Schmalensee and Robert D. Willig. Amsterdam: Elsevier Science Publishers B.V., 1989, pp. 61-133.

Internet Valley. "History of the Internet and Worldwide Web," n.d. Available at (<http://www.internetvalley.com/intvalstat.html>).

Jackson, C. L., and J. Haring. *Pitfalls in the Economic Valuation of the Electromagnetic Spectrum*. July 19, 1995.

Katz, M. L., and C. Shapiro. "Network Externalities, Competition, and Compatibility," *American Economic Review* 75, no. 3 (June 1985), pp. 424-440.

Klemperer, P. D. "Markets with Consumer Switching Costs," *Quarterly Journal of Economics* 102 (1987), pp. 375-394.

Klopfenstein, Bruce C. "The Diffusion of the VCR in the United States," *The VCR Age: Home Video and Mass Communication*, ed. Mark R. Levy. Newbury Park: Sage Publications, 1989.

Lardner, James. *Fast Forward: Hollywood, The Japanese, and the Onslaught of the VCR*. New York: W. W. Norton & Company, n.d.

Leibenstein, H. "Bandwagon, Snob, and Beblen Effects in the Theory of Consumers' Demand," *Quarterly Journal of Economics* 64, no. 2 (May 1950), pp. 183–207.

Leiner, B. M., et al. "A Brief History of the Internet," February 20, 1998. Available at (<http://www.isoc.org/internet-history/brief.html>).

Liebowitz, S. J., and S. E. Margolis. *Winners, Losers & Microsoft: Competition and Antitrust in High Technology*. Oakland, CA: The Independent Institute, 1999.

Littlechild, S. C. "Two-Part Tariffs and Consumption Externalities," *Bell Journal of Economics*, vol. 6, no. 2 (Autumn 1975), pp. 661–670.

MacKie-Mason, J. K., and H. R. Varian, "Pricing the Internet," University of Michigan, April 1993. Revised: February 10, 1994.

Matutes, C., and P. Regibeau. "Compatibility and Bundling of Complementary Goods in a Duopoly," *Journal of Industrial Economics* 40, no. 1 (March 1992), pp. 37–54.

McGahan, A. M. *Philips' Compact Disc Introduction (C)*, 9-892-037, Harvard Business School, October 23, 1991.

McKnight, L. W., and J. P. Bailey, ed. *Internet Economics*. Cambridge, MA: The MIT Press, 1998.

Mueller, M. L., Jr. *Universal Service, Competition, Interconnecting, and Monopoly in the Making of the American Telephone System*. Cambridge, MA: The MIT Press, and Washington, DC: AEI Press (1997), pp. 107–110.

Noll, R. G., M. J. Peck, and J. J. McGowan. *Economic Aspects of Television Regulation*. Washington, DC: The Brookings Institution, n.d.

Odlyzko, A. "The Current State and Likely Evolution of the Internet," n.d. Available (<http://www.research.att.com/~amo>).

Oi, W. Y. "A Disneyland Dilemma: Two Part Tariffs for a Mickey Mouse Monopoly," *Quarterly Journal of Economics* 85 (1971), 77–90.

Oren, S. S., and S. A. Smith. (1981). "Critical Mass and Tariff Structure in Electronic Communications Markets," vol. 12, no. 2, *Bell Journal of Economics*, pp. 467–487.

Owen, B. M., and R. Braeutigam. *The Regulatory Game: Strategic Use of the Administrative Process*. Cambridge, MA: Ballinger, 1978.

Panzar, J. C. "Technological Determinants of Firm and Industry Structure," in *Handbook of Industrial Organization*, Vol. I, ed. Richard Schmalensee and Robert D. Willig. Amsterdam: Elsevier Science Publishers B.V., 1989.

Perry, M. K. "Vertical Integration: Determinants and Effects," in *Handbook of Industrial Organization*, Vol. I, ed. Richard Schmalensee and Robert D. Willig. Amsterdam: Elsevier Science Publishers B.V., 1989.

- Pigou, A. C. *Wealth and Welfare*. London: Macmillan, 1912.
- Pigou, A. C. *The Economics of Welfare*. London: Macmillan, 1920.
- Polsson, K. "Chronology of Events in the History of Microcomputers," October 3, 1999. Available at (<http://www.islandnet.com/~kpolsson/comphist.htm>).
- Quinlan, S. *The Hundred Million Dollar Lunch*. Chicago: J. P. O'Hara, 1974.
- Ramsey, F. P. "A Contribution to the Theory of Taxation," *Economic Journal* 37 (March 1927), pp. 47–61.
- Reddy, B. J., D. S. Evans, and A. L. Nichols. "Why Does Microsoft Charge So Little for Windows?," National Economic Research Associates, January 7, 1999.
- Roberts, L. G. "The Evolution of Packet Switching," *Proceedings of the IEEE* 66, no. 11 (November 1978).
- Roehl, R., and H. R. Varian. *Circulating Libraries and Video Rental Stores*, June 14, 2000. Available at (<http://www.sims.Berkeley.edu/~hal/Papers/history/>).
- Rohlf's, J. "A Theory of Interdependent Demand for a Communications Service," *Bell Journal of Economics and Management Science* 5, no. 1 (Spring 1974), pp. 16–37.
- Rohlf's, J. "Economic-Efficient Bell System Pricing," Bell Laboratories, Murray Hill, New Jersey, 1978.
- Rohlf's, J. H., and M. Wish. "Economic Analysis of Picturephone Demand" (January 22, 1974).
- Schmalensee, R. L. Direct testimony, *United States of America v. Microsoft*, 1999.
- Schumpeter, J. A. *Capitalism, Socialism and Democracy*. New York: Harper & Row, 1942; 3d ed. 1950.
- Shapiro, C., and H. R. Varian. *Information Rules, A Strategic Guide to the Network Economy*. Boston: Harvard Business School Press, 1999.
- Shiller, R. J. *Irrational Exuberance*. Princeton, NJ: Princeton University Press, 1999.
- Shooshan & Jackson Inc. *Competition in the Provision of Customer Premises Equipment and Enhanced Services in the United States*, October 1983.
- Smith, A. *The Wealth of Nations*. New York: Random House, 1937.
- Squire, L. "Some Aspects of Optimal Pricing for Telecommunications," *Bell Journal of Economics and Management Science* 4, no. 2 (Autumn 1973), pp. 515–525.
- Stehman, J. W. *The Financial History of the American Telephone and Telegraph Company*. New York: Augustus M. Kelley, 1967.
- Varian, H. R. "Economic Issues Facing the Internet," June 10, 1996 (rev. September 15, 1996).
- Williamson, O. E. "Transaction Cost Economics," *Handbook of Industrial Organization*, Vol. I, ed. Richard Schmalensee and Robert D. Willig. Amsterdam: Elsevier Science Publishers B.V., 1989.

Wish, M., and J. H. Rohlf. "Preconceptions, Perceptions, and Opinions about PICTUREPHONE Service" (April 15, 1974).

WOW-COM, Statistics & Surveys, "The Cellular Telecommunications Industry Association's Annualized Wireless Industry Data Survey Results, June 1985 to June 1999," March 1, 2000. Available at (<http://www.wow-com.com/statsurv/survey/199906b.cfm>).

Zajac, E. E. *Political Economy of Fairness*. Cambridge, MA: The MIT Press, 1995.

Zakon, R. H. *Hobbes' Internet Timeline v4.2*, September 21, 1999. Available at (<http://www.isoc.org/guest/zakon/Internet/History/HIT.html>).