1. The economics of the Internet: an overview

Johannes M. Bauer and Michael Latzer

1.1 INTRODUCTION

In the Internet economy many of the theoretical assumptions and historical observations upon which economics rests need to be reexamined. Economics built a very successful research program by focusing on the choices and behavior of rational individual decision-makers under conditions of scarcity. In this highly stylized framework, eventually increasing incremental costs, decreasing marginal utility and resource constraints result in negative feedback that moves economic processes toward equilibrium states. The rigorous analysis of these equilibria at the micro and macro level is a major achievement of economics. In an economy built around digital technology some of these conditions change fundamentally. Scale economies, interdependencies, and abundance are pervasive and call for analytical concepts that augment the traditional approaches.

Technological progress has yielded exponential performance improvements of components and networking during the past decades that have resulted in rapidly declining unit costs for information processing. In addition, economic activities in the digital economy are increasingly interrelated due to complementarities between networks, applications and services, as well as increasingly dense networks of communication between economic agents. Both characteristics contribute to direct and indirect network effects and externalities. Network effects and the ubiquity of high upfront and low incremental costs in many production processes result in significant economies of scale on the supply side and demand side of the market. In the Internet economy positive feedback effects often amplify dynamic processes of change, rendering the central concept of market equilibrium, which has proven such a powerful tool of economic analysis, less germane, perhaps best seen as a special case of a more general theory of a continuously changing economy.

These new conditions have stimulated a plethora of innovative research in economics and related social and engineering sciences. Initial work on the Internet economy applied concepts of industrial organization to examine infrastructure market segments (e.g., backbone markets, access markets, domain names), interconnection, pricing, auctions, non-linear dynamics such as bandwagon effects, and shed first light on multi-sided markets (e.g., McKnight and Bailey, 1997; Madden, 2003; Majumdar et al., 2005).[1] Expanding these topics with concepts from information economics, Shapiro and Varian (1999) expertly synthesized the knowledge on information industries, much of it foundational to the Internet. In a similar vein, the economics of network industries (e.g., Shy, 2001) succeeded in generalizing concepts of traditional industrial organization to the specific conditions of the Internet. The discussion has also spawned new fields of inquiry, such as Internet Studies (Dutton, 2013) and the highly interdisciplinary fields of web science, network science, and Internet science (Börner et al., 2008; Hall and Tiropanis, 2012; Tiropanis et al., 2015). Bridging computer science, sociology and economics, some

of this research has developed sophisticated concepts and rigorous models of highly connected economic processes in networks (e.g., Jackson, 2008; Easley and Kleinberg, 2010; Jackson and Zenou, 2013). This literature is complemented by contributions from statistical physics and network science (Pastor-Satorras and Vespignani, 2004; Newman et al., 2006). Innovative and important contributions were also made by scholars adopting a political economy lens (e.g., Mansell, 2012).

These changing technical and economic conditions also pose significant challenges for managers and policy-makers. In parallel to the emergence of the Internet as a major platform for commerce, an increasing number of publications have been dedicated to business and managerial aspects of the digital economy. While some of this research aims at understanding sector-wide phenomena, much of it also examines the characteristics of optimal choices and the conditions under which agents – organizations and individuals – are able to realize them (Illing and Peitz, 2006; Peitz and Waldfogel, 2012). Brandenberger and Nalebuff (1996) recognized that the increasingly complex value networks of modern production places firms in ambiguous positions, often having to compete and to cooperate with other organizations. The interrelatedness of markets has led to a burgeoning literature on two- and multi-sided markets (Rochet and Tirole, 2003, 2006; Armstrong, 2006), which is particularly relevant for many digital economy market segments. A vast volume of contributions in the business economics and management literature adds to these analyses (Coyle, 1997; Cortada, 2001).

Many of these topics are also addressed in this *Handbook* but they are approached differently and with a broader audience in mind. We deliberately adopt an inclusive view of the economic discipline, bringing together, in Part II of the *Handbook*, mainstream, institutional and evolutionary theory, thinking rooted in the theory of complex adaptive systems, as well as approaches from critical political economy. All of these frameworks, although not equally developed at a formal and empirical level, have important bearings on the dynamic Internet sector that often elude the equilibrium-oriented models of mainstream economics. The chapters in Part III are dedicated to the institutional arrangements and technical architecture affecting the Internet. Part IV is dedicated to exploring the business and managerial economic dimensions of the pervasive utilization of the Internet. Although the chapters are authored by experts from different geographic regions, they mostly adopt the perspective of countries in which the Internet is widely available and used. Two integrative chapters in Part V address the past trajectories and possible future development of the Internet.

The remainder of the chapter gives a brief synopsis of the global adoption of the Internet before it introduces the overarching themes of the next four parts of the book and the respective chapters.

1.2 TECHNOLOGY, ADOPTION AND USES

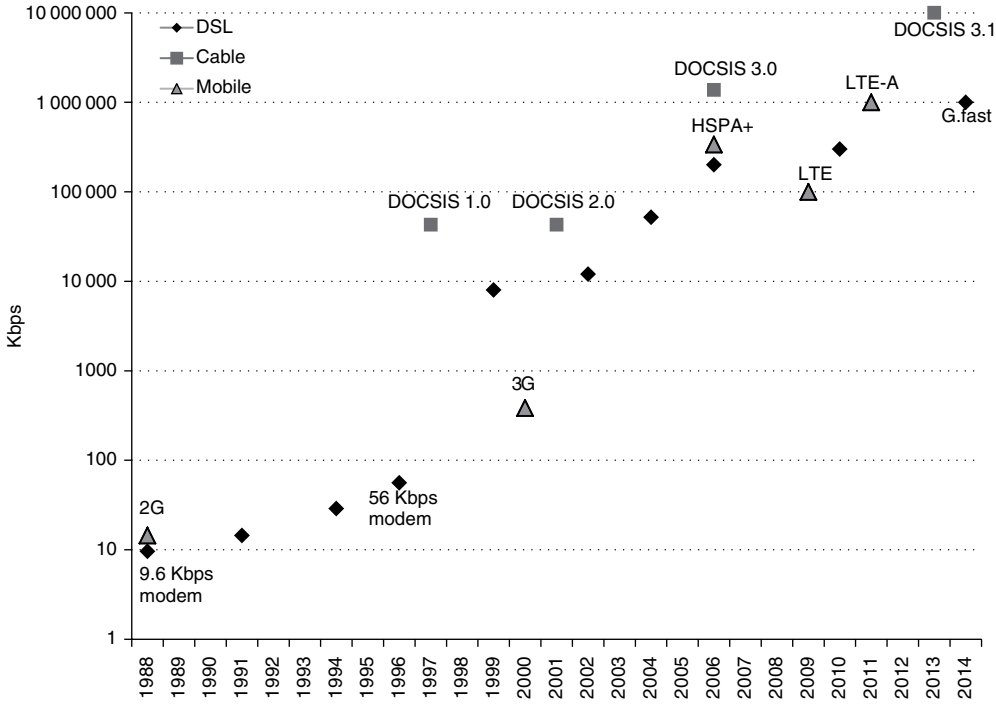
Since its inception during the 1960s the Internet has developed into an indispensable communications infrastructure. Within a few decades, it evolved from a multi-purpose to a general purpose network that can serve a broad range of uses (Bresnahan and Trajtenberg, 1995). During this expansion, and especially during the past two decades of

accelerated growth into a mass market technology – sparked by several critical innovations, including the World Wide Web, user-friendly browsers, and increasing connectivity since the early 1990s – the Internet has been transformed by the co-evolution of technological, political, social and economic forces interacting in mutually reinforcing ways (Greenstein, 2015).

The development of the Internet from a network connecting a few computing centers to a global network carrying massive amounts of data was facilitated by continuous technological change in component technologies, including semiconductors, fixed and wireless networking technologies, and computing. Jointly these developments have resulted in a rapid decline of the costs of transporting, processing and storing digitized information and the ability to pack increasing computing power into smaller and mobile devices. Digitization of information flows has contributed to two waves of convergence, first between computing and telecommunications ('telematics'; see Nora and Minc, 1978) and subsequently between telematics and media ('mediamatics'; see Latzer, 1998, 2013). In parallel to the resulting integration or fusion of formerly separate communications activities, the sector has differentiated and diversified, even if information increasingly flows over an integrated network infrastructure. As traffic migrates to next-generation networks (NGNs) the legacy specialized voice, data, audio, and video networks are gradually being replaced and retired.[2]

The type and quality of Internet access and use show strong differentiations. National Internet patterns reveal considerable access (first-level) and usage (second-level) divides related to differences in socio-demographic factors like age, income, education level, race and ethnicity, as well as urban–rural inequalities (Büchi et al., 2015; Ragnedda and Muschert, 2015; Robinson et al., 2015). Because these dimensions interact with public policy decisions and other factors, considerable variations exist within and across nations. Consequently, any comparison of national performance metrics needs to take the specific contexts into account, especially when drawing lessons for policy and management.

Fixed and wireless access networks have been continuously upgraded throughout their history but performance has increased exponentially since the 1980s, supporting ever higher download and upload speeds. Figure 1.1 shows (using a log scale) that the maximum capacity of access networks using the telephone network grew steadily from 9.6 Kbps in a typical dial-up link in 1988 to 1 Gbps in 2015 using advanced technologies such as G.fast. Similarly, mobile access networks could support 14.4 Kbps in the late 1980s but by 2015 maximum download speeds of up to 1 Gbps using LTE-A (long-term evolution–advanced) were achievable. Cable networks were initially designed for one-way delivery of video signals and therefore have historically provided broadband capacity. They continue to have a distinct lead over upgraded legacy telephone networks and mobile wireless networks, with download capacities that increased from the widespread 42.88 Mbps in 1996 to 10 Gbps by 2013. Even higher bandwidths can be provided by active and passive fiber optical networks (PONs), although they require considerable new investment. While the maximum download capacity of different platforms has become comparable, important differences between these technologies remain. For example, mobile access networks and cable networks are shared, dividing the available capacity among multiple users. Optimal, cost-minimizing network configurations will most likely include multiple technologies, for example, wireless at the edges and fiber for high-volume



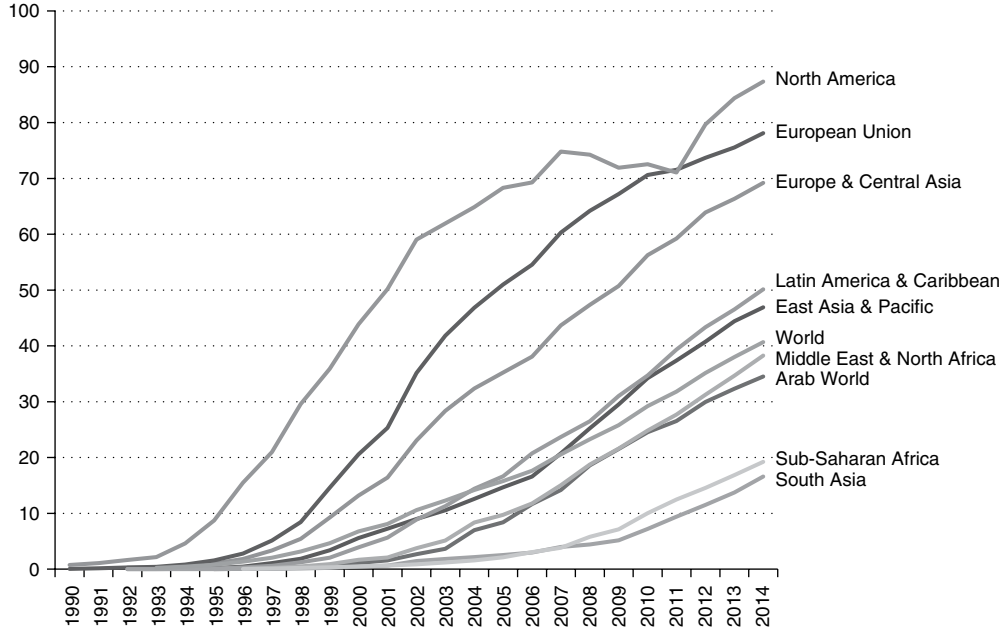
Note: ADSL = asymmetric digital subscriber line; DOCSIS = data over cable service interface specification; DSL = digital subscriber loop/line; HSPA = high-speed packet access; LTE-A = long-term evolution–advanced; VDSL = very high bit rate digital subscriber line.

Source: Own research.

Figure 1.1 Download capacity for DSL, cable, and mobile access platforms, 1988–2014

routes. With the continued migration to all-IP technology, specific network transportation services will increasingly be software-defined so that they can be configured flexibly.

These performance increases and the associated price decreases have accelerated the diffusion of Internet access since the 1990s although considerable regional differences remain (Figure 1.2). The introduction of smartphones, essentially mobile computing devices, has boosted wireless and mobile broadband[3] Internet use on a global scale. By 2015, there were 47.2 mobile broadband subscriptions compared to 10.8 fixed subscriptions per 100 inhabitants worldwide (ITU, 2015). A growing body of research takes advantage of this variation to better understand the drivers and impediments of Internet adoption and use. Although several factors, such as the intensity of competition, income and Internet literacy, are frequently identified as key drivers of Internet adoption, there is considerable variation between countries even within comparable income groups (Cambini and Jiang, 2009; Gruber and Koutroumpis, 2013; Bauer et al., 2014; Briglauer, 2014). Figures 1.3 and 1.4 show the variation in fixed and mobile broadband adoption in the OECD member states. At the end of 2014, fixed broadband adoption rates varied



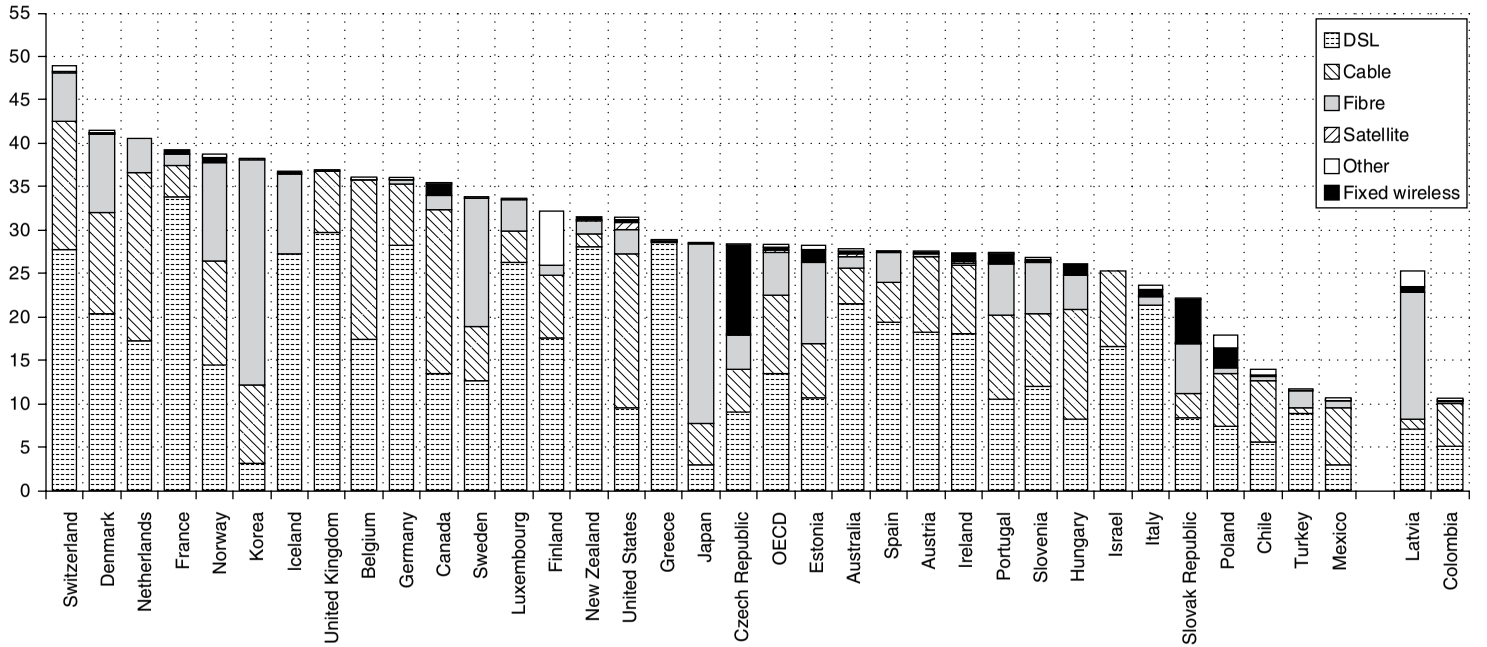
Source: The World Bank, World Development Indicators, accessed 18 August 2015 at http://data.worldbank.org/indicator/IT.NET.USER.P2.

Figure 1.2 Internet users per 100 inhabitants, 1990–2014

from 10.7 percent in Mexico to 48.9 percent in Switzerland. Mobile subscriptions, which in contrast to fixed are typically bought on an individual and not household basis, varied from 34.4 percent in Hungary to 138 percent in Finland. More recent research has generated evidence that technological, economic, socio-demographic and policy factors work as constellations and that several combinations exist that may result in similar outcomes if they are appropriate to the specific national context (Groenewegen et al., 2009; Künneke et al., 2010).

This diversity of network access platforms is also visible in the quality of the Internet infrastructure. Applications and services are becoming more differentiated with heterogeneous bandwidth and quality needs. At the same time, network access platforms are increasingly capable of supporting high bandwidth and different service qualities, which can be software defined and software configured. One important attribute of network quality is download speed, but other characteristics such as jitter and latency also matter for certain types of applications. Figure 1.5 provides a snapshot of actually measured download speeds in OECD countries. As measurements can be taken at multiple points in the network and using different metrics, numbers generated by different providers vary. Download speeds measured by Ookla are higher than data from Google M-Labs and Akamai. The latter two are fairly consistent, as is the pattern across countries.

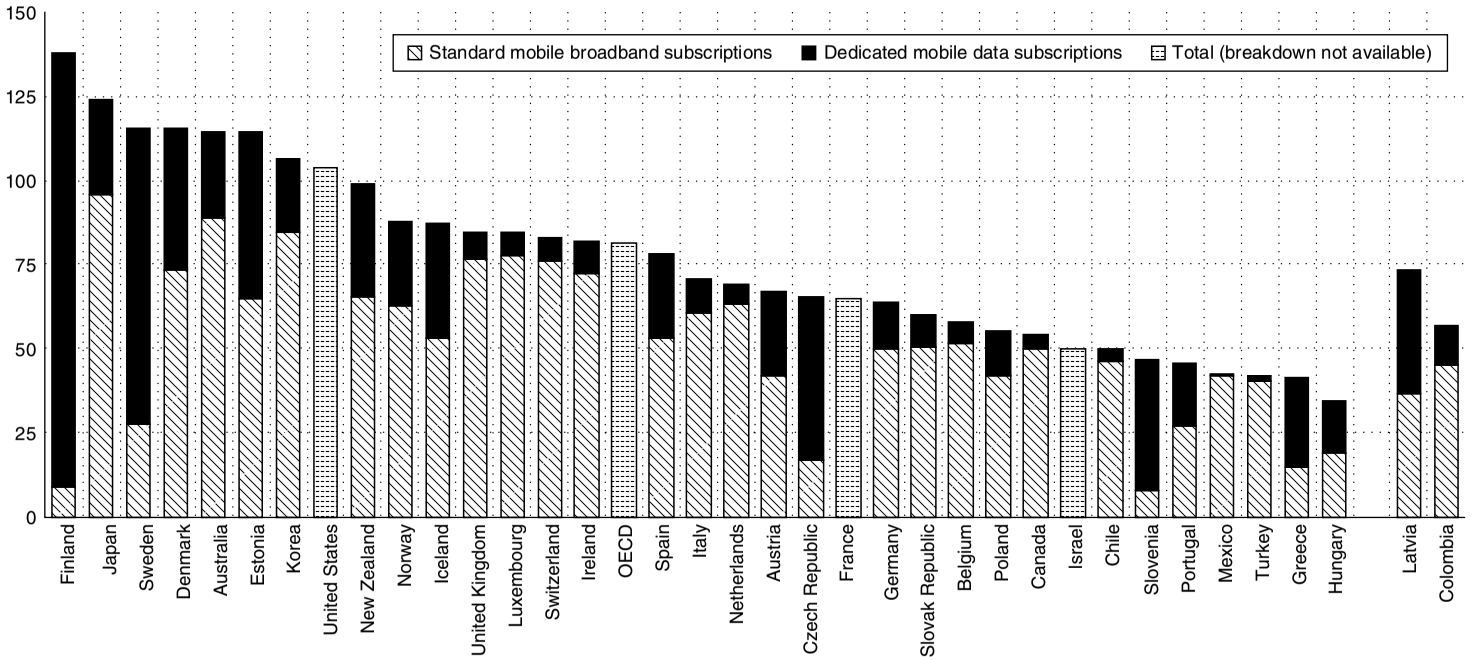
Enabled by more bandwidth and more widely available connectivity, the range of network uses has changed significantly over time. During recent years, real-time



Notes: The OECD adjusted its definitions of fixed and mobile broadband by transferring the categories Satellite and Fixed Wireless from Mobile to Fixed Broadband. Fiber subscriptions data includes FTTH, FTTP and FTTB and excludes FTTC. Germany: DSL includes VDSL (FTTC); Cable excludes cable infrastructure based on FTTB/FTTH; FTTB/FTTH includes fibre lines provided by cable operators. Mexico: Data for 2014 are preliminary. Mexico is currently reviewing the Fixed broadband data in relation to the implementation of the methodology. Israel, Switzerland and United States: Data for 2014 are estimates; United Kingdom: DSL includes FTTH, FTTP, FTTB and FTTC as the breakdown between these technologies is not available yet; Colombia and Latvia are in the process of accession to the OECD.

Sources: OECD, Broadband Portal, accessed 18 August 2015 at www.oecd.org/sti/broadband/oecdbroadbandportal.htm. Information on data for Israel: http://oe.cd/israel-disclaimer.

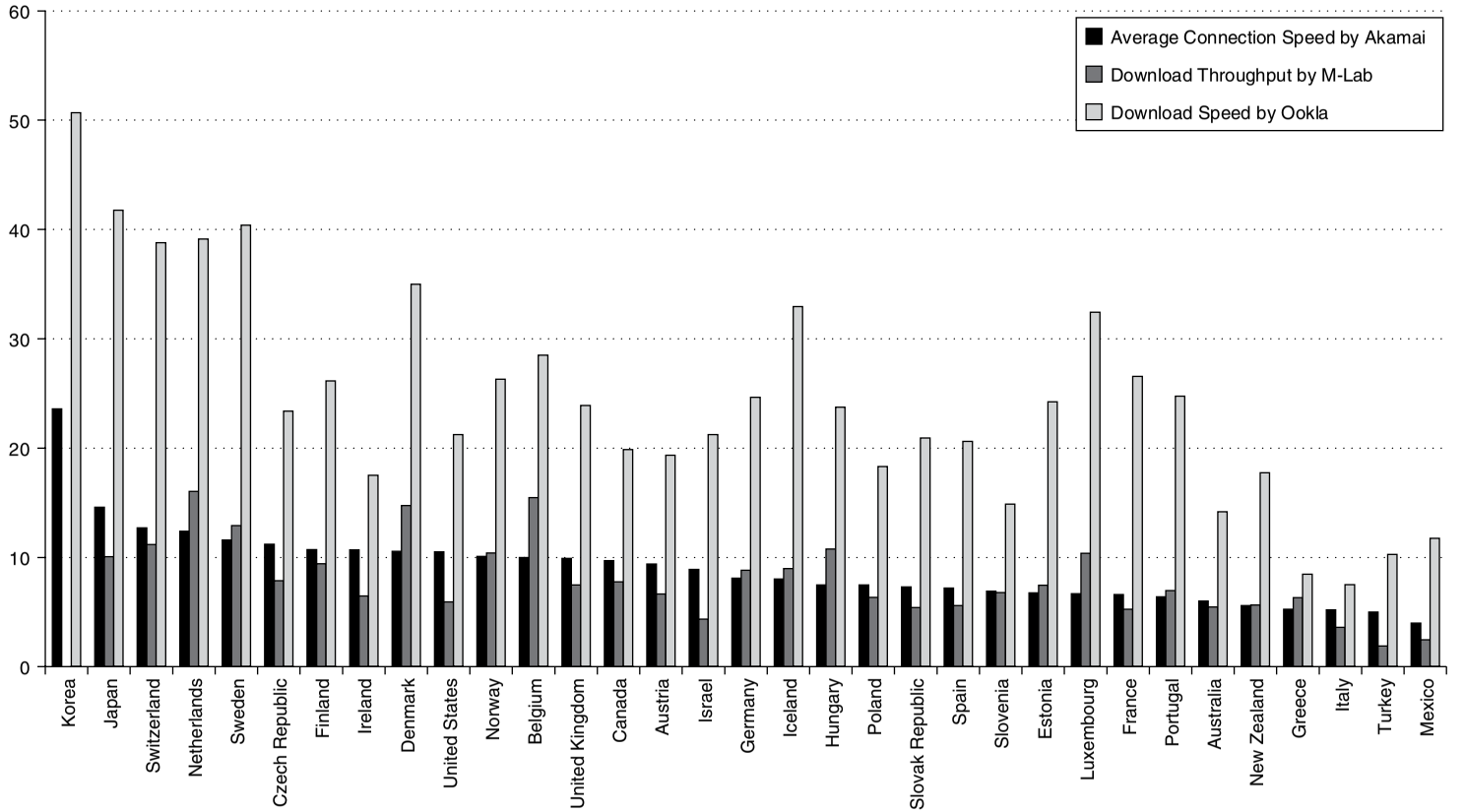
Figure 1.3 Fixed broadband subscriptions per 100 inhabitants in the OECD, by technology (December 2014)



Note: The OECD adjusted its definitions of fixed and mobile broadband by transferring the categories Satellite and Fixed Wireless from Mobile to Fixed Broadband. Mexico: Data for 2014 are preliminary; Israel, Switzerland and United States: Data for 2014 are estimates; Colombia and Latvia are in the process of accession to the OECD.

Sources: OECD, Broadband Portal, accessed 18 August 2015 at www.oecd.org/sti/broadband/oecdbroadbandportal.htm. Information on data for Israel: http://oe.cd/israel-disclaimer.

Figure 1.4 Mobile broadband subscriptions per 100 inhabitants in the OECD, by technology (December 2014)



Source: OECD (2015), *Digital Economy Outlook 2015*, Paris: OECD, p.113.

Figure 1.5 Alternative measures of actual download speeds (Mbit/s, 1Q2014)

entertainment (e.g., video streaming, online gaming) has been growing rapidly. In North America, its share on fixed networks during peak periods expanded from 29.5 percent of total traffic in 2009 to 64.5 percent in 2015 (Sandvine, 2011, 2015). During the same period, peer-to-peer (P2P) traffic, which had been the third largest traffic category in 2009, declined from 15.1 percent to 5.4 percent, falling out of the top five uses. Web browsing experienced an even more dramatic decline from 38.7 percent to 7.2 percent of total traffic. On the other hand, social networking, which made up only a miniscule share of total network traffic in 2009, grew to 4.6 percent of total traffic by 2015. On mobile networks the share of real-time entertainment increased from 30.8 percent in 2011 to 41.9 percent in 2015. In the same time period, social networking traffic increased from 20 percent to 22.5 percent but web browsing declined from 27.3 percent to 13.7 percent (Sandvine, 2011, 2015).

Near ubiquitous Internet access in many parts of the world has allowed migrating processing and storage of information from local machines to servers on the network (the 'cloud') and made it possible to develop innovative new information architectures. The Internet's unique characteristics, including flexibility, plasticity, and scalability, have not only changed the technological basis of communications but have also had wide repercussions on all work and private activities relying on it. These features, combined with the ease of imitation in some areas (e.g., apps), have greatly intensified the competitive pressure in the digital economy. As many Internet-based innovations are software based or have a strong software component, the technology of innovating in the digital economy has also changed, allowing continuous experimentation via the combination and recombination of features, real-time feedback, and the rapid upscaling of successful solutions (Brynjolfsson and McAfee, 2014). Many of these effects seem to be contingent on a threshold level of adoption. Röller and Waverman (2001) found evidence that the productivity and growth effects of telecommunication networks were particularly strong in countries where a critical mass of connectivity had been reached. Koutroumpis (2009) found similar critical mass effects for broadband, although these were achieved at a much lower adoption rate.

These technological transformations have changed the economics of the Internet and have had far-reaching economic consequences for private and public sector users. Through the mid-1990s, the Internet was largely funded by the public sector. This allowed investments and technological decisions to be made with a broader public interest perspective in mind. Once infrastructure investment decisions were predominantly made by commercial investors, this societal calculus was superseded by private profitability considerations. An overarching assumption of stakeholders was that in the competitive Internet market coordination would assure that these decisions were aligned with the public interest. There is considerable evidence in support of this premise but, like other information and communication technologies (ICTs), the Internet has a unique cost structure that interacts with the dynamics of decentralized decision-making and influences the outcomes of unfettered market coordination.

With the exception of dedicated local access links, the costs of networks are shared. High upfront investment costs go hand in hand with very low incremental costs of transporting, processing and storing information. To recoup investment costs, network operators need to find ways to significantly mark up incremental costs. Pursuing such a strategy is complicated by the fact that the implementation of Internet technology has

contributed to a commodification of network services. At the same time, value generation moved to the higher layers of the stack where applications and services are configured. Among the possible responses of private companies to these economic structures are horizontal and vertical integration as well as attempts to introduce differentiated network services, all major trends visible in the Internet today. The chapters in this *Handbook* address these challenges in more detail.

1.3 THEORETICAL FOUNDATIONS

The seven chapters in Part II develop theoretical frameworks to analyze the Internet economy. Some of the contributions offer complementary perspectives but others are alternative takes on the economics of the Internet. Günter Knieps and Johannes M. Bauer outline elements of an industrial organization perspective on the Internet in Chapter 2. Using a framework grounded in the dynamic analysis of markets they develop basic economic concepts relevant for the Internet with an emphasis on all-IP networks. The authors examine the Internet from micro and macro perspectives with a particular emphasis on innovation in complementary technologies. Stephen J. Schultze and Richard S. Whitt in Chapter 3 offer a complementary perspective by conceptualizing the Internet as a dynamic, layered socio-technical system. Approaching the topic from evolutionary and complexity economics vantage points, this chapter develops a framework for understanding dynamic economic change and innovation in the Internet economy. Models based in the theory of complex adaptive systems hold considerable promise for future research. Volker Schneider and Johannes M. Bauer in Chapter 4 broaden these lenses in a different direction with an overview of approaches emerging from network science. This innovative body of research is particularly powerful in examining, theoretically and empirically, the highly interwoven economic and social processes unfolding on the Internet.

The Internet has unleashed fundamental transformations of the organization of production in the commercial sector and also in the not-for-profit and gift economies. Three chapters address different aspects of these impacts. Yochai Benkler in Chapter 5 provides a comprehensive discussion of the role of peer production as an emerging new mode of production that exists in parallel and in competition with traditional forms of market production. He examines the constitutive features of peer production, its economic importance as well as the diversity of motivation of participants and the governance of peer production systems. In Chapter 6 Carol Corrado and Bart van Ark examine the effects of the Internet on productivity and economic growth. In contrast to computers, whose effects on productivity did not show in statistics for a long time, the positive contribution of communications technology and especially broadband Internet is less contested and substantiated by empirical evidence. However, as the differentiated discussion shows, the effects of the Internet are not evenly spread across economic activities and some negative impacts can also be observed.

Information goods and services form a core piece of the Internet. Their production, dissemination and consumption change compared to the offline world. Insights from cultural economics can help to understand these changes in creative industries, as Christian Handke, Paul Stepan and Ruth Towse explain in Chapter 7. Taste formation

and supplier-induced demand, intrinsic motivation, decision-making under extensive uncertainty, and new forms of user–producer and user–user interaction are, for example, topics where cultural economics can contribute to a better comprehension of the Internet ecosystem. Nevertheless, there are also gaps and unfulfilled potentials for research on technological change in cultural economics, as the authors indicate in their contribution.

The final chapter in this section, Chapter 8, co-authored by Patricia Mazepa and Vincent Mosco, develops a critical, political economy perspective on the Internet. This brings otherwise largely ignored aspects into view, such as the emergence of a global poorly paid digital workforce and the power structures of information and communication markets. The implications of the Internet on labor markets, the organization of information production, and the role of political economy in academic research are all addressed.

Taken together, these chapters span a broad spectrum of theoretical and methodological approaches, ranging from mainstream economics to radical political economy. Each chapter reflects on the state of research, important contributions and open questions so that readers can develop their independent assessment of the uses and limitations of each of the frameworks.

1.4 INSTITUTIONAL ARRANGEMENTS AND INTERNET ARCHITECTURE

Market and non-market production are embedded in multiple layers of formal and non-formal institutional arrangements. Moreover, the technical architecture and protocols of the Internet influence information flows and outcomes like other types of institutional arrangements (Reidenberg, 1998; Lessig, 1999). Some institutional arrangements, such as regulations and voluntary governance agreements, adapt more frequently to changing technological and economic circumstances but others such as norms and broader cultural conventions may evolve rather slowly (Williamson, 2000). Important institutional arrangements affecting the Internet include competition and antitrust policies, intellectual property rights, legal protections of privacy, and provisions governing cybersecurity. Of similar importance are standards and protocols, the overall network architecture, and provisions governing interconnection. These are the topics addressed in Part III.

Internet-based markets show remarkable concentration tendencies, fueled by the unique economic characteristics of the online world (Noam, 2009). The effects of high supplier concentration in technology industries, including the Internet, are highly controversial. While there is some evidence that high concentration is an outcome of Schumpeterian competition, and hence superior efficiency, there are also increasing concerns about its detrimental effects. Consequently, competition concerns (e.g., regarding Microsoft, Google and Apple) and related antitrust cases are gaining prominence in the public and academic debate. Starting with an economic analysis of competition in the Internet, Justus Haucap and Torben Stühmeier discuss major competition concerns and recent European and US antitrust cases in Chapter 9. The authors also analyze the net neutrality debate driven by concerns about incentives of network operators to discriminate against competing application and content providers.

Standards, and the occasional 'wars' surrounding them, are an important topic of

competition policy in the Internet era. Internet standards influence the degree of compatibility of services and products from different vendors and thus affect the relevance and impact of network effects and switching costs. Given this high economic importance the best institutional model for promulgating standards (e.g., markets, voluntary committees, government) of standardization processes is disputed. Stanley M. Besen and George Sadowsky explain in Chapter 10 the basics of the economics of standards, and provide a case study of the Internet standardization process, mainly under the auspices of the Internet Engineering Task Force (IETF). The conflict between nations supporting stronger leadership for the International Telecommunication Union (ITU) and supporters of the existing decentralized, private sector–driven approach highlights the importance of institutional arrangements for the future development of the Internet.

Although challenged on multiple grounds, copyright has long been considered an essential intellectual property right and a precondition for deriving sustainable income streams in creative industries. Fast-growing Internet applications change business models for creative works, not only value propositions and production conditions, but also revenue models for creators and the copyright-based industries. In Chapter 11, Sacha Wunsch-Vincent reassesses the economics of copyright in light of these changes. He explains and transposes the baseline model of copyright economics to the online world. The absence of data for empirical research, new online intermediaries, and complex financial and legal linkages between the various agents involved are identified by Wunsch-Vincent as obstacles to progress in the copyright debates.

Fast-growing social online networks and the mass customization of Internet products and services contribute to the rising importance of personal data, often called the 'new oil' of the information economy. Awareness of the risks of privacy violations and surveillance grew considerably in the wake of the American National Security Administration (NSA) scandal of 2013, which revealed that the agency had collected data on millions of Americans' electronic communications. The economic analysis of privacy data protection and surveillance, presented in Chapter 12 by Ian Brown, looks at the cost, benefits and incentives of all parties involved, and at the aggregate social welfare impacts. It seeks to explain the voluntary disclosure and commercial use of personal data with the help of behavioral and industrial economic approaches. Differences and problems of corporate and public privacy policies in the US and Europe, and of companies like Facebook, Google and Apple, are also explored.

Chapter 13 by Hadi Asghari, Michel van Eeten and Johannes M. Bauer focuses on the economic research on cybercrime. Protecting cyberspace from relentless attacks by criminals and hostile state actors faces daunting challenges. Recent research has made great strides in understanding the patterns of criminally motivated cyber attacks through the lens of security economics. Integrating engineering and economic perspectives to examine the incentives of interrelated players in the Internet ecosystem to invest in security has proven a particularly fruitful approach to understanding patterns of success and failure in securing the Internet economy.

By also emphasizing the importance of the technical architecture of the Internet, the cybersecurity chapter is a bridge to the theme addressed by Barbara van Schewick in Chapter 14. Her detailed examination of the effects of architectural choices on innovation in the Internet summarizes and expands her pioneering work in this area. Starting with a review of the basic design principles upon which the Internet is built, van Schewick

proceeds to discuss the architecture of the Internet and examines in detail its effects on the amount and quality of application innovation.

Chapter 15 by Cristiano Antonelli and Pier Paolo Patrucco is also dedicated to an analysis of innovation, but the authors focus on the users and uses of ICT. The Internet is seen as an enabler of platforms, organizational innovations that are enabled by and instrumental for the further generation of technological knowledge. Platforms facilitate the generation and exploitation of knowledge and innovation, seen as a recombinant process of existing yet often distributed knowledge. They allow their members to internalize externalities and hence help overcome some of the public good problems associated with knowledge, including partial appropriability and divisibility, non-excludability, non-exhaustibility and intrinsic tacitness. Building on a thorough and original theoretical framework, the chapter also discusses cases that illustrate the variety and dynamics of Internet-enabled platforms.

David D. Clark, William H. Lehr and Steven Bauer in Chapter 16 focus on interconnection in the Internet. Historically, and different from other telecommunications networks, two principal models have been used by Internet service providers (ISPs) to interconnect: peering and transit. The chapter discusses these models and the current pressures to move toward more differentiated forms of interconnection, including forms of asymmetric and paid peering. The discussion is anchored in the need to find new and innovative arrangements in a network environment that is increasingly dominated by real-time entertainment traffic.

1.5 ECONOMICS AND MANAGEMENT OF APPLICATIONS AND SERVICES

Radical and disruptive Internet technologies require appropriate business models and strategies to fully utilize their potential. This is the common theme of the chapters in Part IV. Chapter 17 by Johann J. Kranz and Arnold Picot shows differences in doing business off- and online, referring, for example, to the platformization of markets, to scalability, ubiquity, universality and customer engagement. The authors provide a classification of business models and identify core elements of successful Internet business strategies.

Internet search is one of the most successful, highly profitable, generic Internet businesses. It is an example of a two-sided market supported by advertising, as Hal R. Varian explains in Chapter 18. He describes the history of information retrieval and the business model of Internet search. Selling advertisements that are related to the search queries is the primary source of revenues for this business, characterized by high fixed costs, low marginal costs and low switching costs. The author rates learning-by-doing as the most important economic factor determining search engine success, and he foresees much progress in the field of marketing based on the massive amounts of data generated, among others, by search engines.

Search engines are an indicator of how algorithms on the Internet increasingly shape our lives and realities. They are the most prominent example of a fast-growing Internet phenomenon called algorithmic selection, which is defined by automated selection of information elements and the assignment of relevance to them. Applications range from recommender systems to social scoring and predictive policing. In Chapter 19,

Michael Latzer, Katharina Hollnbuchner, Natascha Just and Florian Saurwein explain their economics, the operational model, market structures and business models. They also show how economic benefits and social risks of algorithmic selection co-evolve, and indicate governance choices for business and political strategies that boost economic and social welfare effects.

Computational advertising is another example of advanced algorithmic selection markets, yet only one example of the massive changes in the economics of advertising. In Chapter 20 Wenjuan Ma and Steven S. Wildman review the economic literature on Internet advertising. While advertising was present on the Internet early on, the rapid expansion started with the commercialization of the Internet since the mid-1990s. After a brief historical review, the chapter focuses on the two main bodies of research – targeted advertising and search advertising. The chapter concludes with a critical assessment of the state of research and possible future research trajectories.

These massive changes in advertising contributed to a substantial crisis and shake up of the news business, which went online with the diffusion of the World Wide Web in the early 1990s. In Chapter 21 Lucy Küng, Nic Newman and Robert G. Picard analytically distinguish between two eras of online news, 'Digital Publishing – Web 1.0' and 'Participation and Multimedia', and three subsectors of the media: print, broadcasting and pure players. Based on selected cases, they provide an overview of strategic, organizational and editorial implications of online news in these industries. The authors conclude with a discussion of the challenging combination of increasing competition, a bleak financial outlook for online news and the associated threats to high-quality news journalism.

The next three chapters take a closer look at the economics of online entertainment. Ryland Sherman and David Waterman focus in Chapter 22 on the fast-growing 'over-the-top' (OTT) markets for streaming and downloading professionally produced and user-generated videos to Internet-connected devices. The authors compare the economics and technology of online and offline media delivery systems, explore the empirical development of online video, and analyze business models and programming.

Business strategies of OTT services are also the focus of Chapter 23 by Yu-li Liu. Based on case studies and a literature review, she presents ten different business strategies and six revenue models for converged Internet services. Bundling, flexible pricing and various forms of content differentiation are among the strategies pursued by OTT players. Similar to the news industry, OTT suppliers are challenged by the reluctance of users to pay for online content. However, the author describes conditions under which subscription models, freemium strategies and revenue sharing appear as viable options for the financing of converged video services. Case studies of OTT service providers from North America, Europe and Asia illustrate the conceptual arguments.

Online video games are another important and fast-growing part of Internet entertainment. They create virtual worlds, and their specific systems of production, distribution and trade can be analyzed as virtual economies. In Chapter 24 Isaac Knowles and Edward Castronova review the history of virtual worlds and explain their economics. They emphasize the catalyzing role of real-money trade – the exchange of virtual goods, currencies and services for real money. Further, the authors discuss the possibilities of using virtual worlds as large-scale laboratories for (political) experiments.

The final chapter in this part examines the economics of big data, a topic that is rapidly

attracting considerable attention in politics and research. Chapter 25 by Claudio Feijóo, José-Luis Gómez-Barroso and Shivom Aggarwal is an introduction to the economic issues raised by the big data ecosystem, pointing out that big data is a field with more challenges than answers. The authors explain the relationships between players, discuss the economic value of data, and assess their impact on growth and jobs. They conclude with potential avenues for further research, highlighting the importance of governance options for future developments.

1.6 PAST AND FUTURE TRAJECTORIES

The enormous diversity and rapid growth of the Internet greatly complicates the formulation of a comprehensive theory of its development. Complexity often begets attempts to simplify, sometimes at the expense of mistaking selected elements and relationships for the whole phenomenon. The Internet is no exception, as the growing number of analyses demonstrates. These are often inspired by exuberant enthusiasm for the benefits of the Internet and the fundamental transformations it enables (Tapscott and Williams, 2006; Shirky, 2010; Rifkin, 2014; Diamandis and Kotler, 2015) or by a rather gloomy view of the downsides of our increasingly Internet- and social media-driven culture (Lanier, 2013; Taylor, 2014; Ford, 2015; Keen, 2015).

The two chapters of Part V provide integrative analyses of the longer-term development of the Internet, seeking to weave a multitude of considerations into a coherent picture. Chapter 26 by D. Linda Garcia analyzes the history of the Internet through an organizational field perspective. This approach examines the embeddedness of economic and market activities in institutional arrangements and in society at large. Looking at four distinct periods of Internet development (the unified telephone regime; ARPANET and the emergence of TCP/IP; the NSF era; and the increasing commercialization of the Internet) the chapter discusses the respective actor constellations and the organizational fields in which they interact. This makes it possible to construct a detailed yet overarching socio-economic account of Internet evolution.

Chapter 27 by Eli M. Noam is also linked to the broad historical developments yet focuses on the ongoing transformation of the Internet from the Internet of Science to the Internet of Entertainment. With a keen eye for the broader emerging trends and their economic drivers, the chapter provides an alternative take on the past and future of the Internet and its economics.

The chapters in the *Handbook* synthesize the state of knowledge as of early 2016. Given space and other constraints, some important issues could not be addressed. Topics such as the economics of the Internet in low- and middle-income countries, the economics of the Internet of Things (IoT) and the industrial Internet, and the effects of the Internet on trade will have to await a complementary volume. The Internet is also intricately related to transformations of labor markets, employment, and the global and national distribution of incomes. In all these areas important and controversial public debates are unfolding although rigorous theoretical and empirical knowledge is often lacking. These emerging questions and the numerous theoretical and empirical challenges identified in this volume suggest that Internet economics will remain a vibrant field of inquiry for the foreseeable future.

NOTES

1. Important contributions in these volumes are the chapters on the economics of the Internet backbone (Economides, 2005), the economic geography of the Internet (Greenstein, 2005) and the economics of domain names (Mueller, 2005).
2. The terms 'next-generation network' (NGN) and 'all-IP' network are often used interchangeably, referring to a network architecture built around the Internet Protocol (IP) and related protocols (e.g., TCP/IP, UDP/IP, Ethernet/IP). These networks have a distinct vertical layered architecture in which a core transportation network supports a broad range of applications and services. They integrate communication flows from formerly separate networks, therefore allowing the retirement of legacy networks such as the voice networks. It is likely that these architectures are but one choice in a longer-term evolution of the future Internet.
3. There is no widely agreed definition of 'broadband'. Technically speaking, broadband is the capability to transmit multiple signals and types of traffic simultaneously. As user and communication needs change, it is impossible to define 'broadband' once and for all. The US National Research Council's Computer Science and Telecommunications Board (CSTB, 2002) has delineated broadband as the download speed that supports the development of advanced applications and services, which implies it is a moving target. The Organisation for Economic Co-operation and Development (OECD) includes download speeds above 256 Kbps in its Broadband Portal and the International Telecommunication Union (ITU) considers download speeds above 1.5–2.0 Mbps are broadband. The US Federal Communications Commission (FCC) used 256 Kbps until 2010, when it increased the threshold for download speeds to 4 Mbps and upload speeds to 1 Mbps. In 2014 it further increased these numbers to 25 Mbps download and 3 Mbps for uploads.

REFERENCES

Armstrong, M. (2006), 'Competition in two-sided markets', *RAND Journal of Economics*, **37** (3), 668–91.
Bauer, J.M., G. Madden and A. Morey (2014), 'Effects of economic conditions and policy interventions on OECD broadband adoption', *Applied Economics*, **46** (12), 1361–72.
Börner, K., S. Sanyal and A. Vespignani (2008), 'Network science', *Annual Review of Information Science and Technology*, **41** (1), 537–607.
Brandenburger, A.M. and B.J. Nalebuff (1996), *Co-opetition*, New York: Currency Doubleday.
Bresnahan, T.F. and M. Trajtenberg (1995), 'General purpose technologies: "engines of growth"?', *Journal of Econometrics*, **65** (1), 83–108.
Briglauer, W. (2014), 'The impact of regulation and competition on the adoption of fiber-based broadband services: Recent evidence from the European union member states', *Journal of Regulatory Economics*, **46** (1), 51–79.
Brynjolfsson, E. and A. McAfee (2014), *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York: W.W. Norton and Company.
Büchi, M., N. Just and M. Latzer (2015), 'Modeling the second-level digital divide: A five-country study of social differences in Internet use', *New Media & Society* (published online 9 September, doi: 10.1177/1461444815604154).
Cambini, C. and Y. Jiang (2009), 'Broadband investment and regulation: A literature review', *Telecommunications Policy*, **33** (10–11), 559–74.
Cortada, J.W. (2001), *21st Century Business: Managing and Working in the New Digital Economy*, Upper Saddle River, NJ: Financial Times/Prentice Hall.
Coyle, D. (1997), *The Weightless World: Strategies for Managing the Digital Economy*, Cambridge, MA: MIT Press.
CSTB (2002), *Bringing Home the Bits*, Washington, DC: National Research Council, Computer Science and Telecommunications Board.
Diamandis, P.H. and S. Kotler (2015), *Bold: How to Go Big, Create Wealth, and Impact the World*, New York: Simon & Schuster.
Dutton, W.H. (ed.) (2013), *The Oxford Handbook of Internet Studies*, Oxford, UK: Oxford University Press.
Easley, D. and J. Kleinberg (2010), *Networks, Crowds, and Markets: Reasoning About a Highly Connected World*, Cambridge, UK: Cambridge University Press.
Economides, N. (2005), 'The economics of the Internet backbone', in S. Majumdar, I. Vogelsang and M. Cave (eds), *Handbook of Telecommunications Economics, Volume 2: Technology Evolution and the Internet*, Amsterdam: Elsevier, pp. 375–412.

Ford, M. (2015), *Rise of the Robots: Technology and the Threat of a Jobless Future*, New York: Basic Books.
Greenstein, S. (2005), 'The economic geography of Internet infrastructure in the United States', in S. Majumdar, I. Vogelsang and M. Cave (eds), *Handbook of Telecommunications Economics, Volume 2: Technology Evolution and the Internet*, Amsterdam: Elsevier, pp. 287–372.
Greenstein, S. (2015), *How the Internet Became Commercial. Innovation, Privatization, and the Birth of a New Network*, Princeton, NJ: Princeton University Press.
Groenewegen, J., R.W. Künneke and J.F. Auger (eds) (2009), *The Governance of Network Industries: Institutions, Technology and Policy in Reregulated Infrastructures*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Gruber, H. and P. Koutroumpis (2013), 'Competition enhancing regulation and diffusion of innovation: The case of broadband networks', *Journal of Regulatory Economics*, **43** (2), 168–95.
Hall, W. and T. Tiropanis (2012), 'Web evolution and web science', *Computer Networks*, **56** (18), 3859–65.
Illing, G. and M. Peitz (eds) (2006), *Industrial Organization and the Digital Economy*, Cambridge, MA: MIT Press.
ITU (2015), *ICT Facts and Figures: The World in 2015*, Geneva: International Telecommunication Union, accessed 8 August 2015 at http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf.
Jackson, M.O. (2008), *Social and Economic Networks*, Princeton, NJ: Princeton University Press.
Jackson, M.O. and Y. Zenou (eds) (2013), *Economic Analyses of Social Networks*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Keen, A. (2015), *The Internet is Not the Answer*, New York: Atlantic Monthly Press.
Koutroumpis, P. (2009), 'The economic impact of broadband on growth: A simultaneous approach', *Telecommunications Policy*, **33** (9), 471–85.
Künneke, R., J. Groenewegen and C. Ménard (2010), 'Aligning modes of organization with technology: Critical transactions in the reform of infrastructures', *Journal of Economic Behavior & Organization*, **75** (3), 494–505.
Lanier, J. (2013), *Who Owns the Future?* New York: Simon & Schuster.
Latzer, M. (1998), 'European mediamatics policies: Coping with convergence and globalization', *Telecommunications Policy*, **22** (6), 457–66.
Latzer, M. (2013), 'Media convergence', in R. Towse and C. Handke (eds), *Handbook on the Digital Creative Economy*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, pp. 123–33.
Lessig, L. (1999), *Code and Other Laws of Cyberspace*, New York: Basic Books.
Madden, G. (ed.) (2003), *The International Handbook of Telecommunications Economics (3 vols)*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Majumdar, S.K., I. Vogelsang and M. Cave (eds) (2005), *Handbook of Telecommunications Economics, Volume 2: Technology Evolution and the Internet*, Amsterdam: Elsevier.
Mansell, R. (2012), *Imagining the Internet: Communication, Innovation, and Governance*, Oxford: Oxford University Press.
McKnight, L.W. and J.P. Bailey (eds) (1997), *Internet Economics*, Cambridge, MA: MIT Press.
Mueller, M. (2005), 'Toward an economics of the domain name system', in S. Majumdar, I. Vogelsang and M. Cave (eds), *Handbook of Telecommunications Economics, Volume 2: Technology Evolution and the Internet*, Amsterdam: Elsevier, pp. 442–85.
Newman, M., A.-L. Barabasi and D.J. Watts (eds) (2006), *The Structure and Dynamics of Networks*, New York and Cambridge, UK: Cambridge University Press.
Noam, E.M. (2009), *Media Ownership and Concentration in America*, New York: Oxford University Press.
Nora, S. and A. Minc (1978), *L'informatisation de la Société* [The Computerization of Society], Paris: La Documentation française.
Pastor-Satorras, R. and A. Vespignani (2004), *Evolution and Structure of the Internet: A Statistical Physics Approach*, Cambridge, UK: Cambridge University Press.
Peitz, M. and J. Waldfogel (eds) (2012), *The Oxford Handbook of the Digital Economy*, Oxford, UK: Oxford University Press.
Ragnedda, M. and G.W. Muschert (2015), *The Digital Divide: The Internet and Social Inequality in International Perspective*, London: Routledge.
Reidenberg J.R. (1998), 'Lex Informatica: The formulation of information policy rules through technology', *Texas Law Review*, **76** (3), 553–93.
Rifkin, J. (2014), *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons and the Eclipse of Capitalism*, New York: Palgrave Macmillan.
Robinson, L., S.R. Cotten and H. Ono et al. (2015), 'Digital inequalities and why they matter', *Information, Communication & Society*, **18** (5), 569–82.
Rochet, J.-C. and J. Tirole (2003), 'Platform competition in two-sided markets', *Journal of the European Economic Association*, **1** (4), 990–1029.

Rochet, J.-C. and J. Tirole (2006), 'Two-sided markets: A progress report', *RAND Journal of Economics*, **37** (3), 645–67.
Röller, L.-H. and L. Waverman (2001), 'Telecommunications infrastructure and economic development: A simultaneous approach', *American Economic Review*, **91** (4), 909–23.
Sandvine (2011), *Global Internet Phenomena Report Fall 2011*, Waterloo, ON: Sandvine.
Sandvine (2015), *Global Internet Phenomena Report 1H2014*, Waterloo, ON: Sandvine.
Shapiro, C. and H.R. Varian (1999), *Information Rules: A Strategic Guide to the Network Economy*, Boston, MA: Harvard Business School Press.
Shirky, C. (2010), *Cognitive Surplus: Creativity and Generosity in a Connected Age*, New York: Penguin.
Shy, O. (2001), *The Economics of Network Industries*, Cambridge, UK: Cambridge University Press.
Tapscott, D. and A.D. Williams (2006), *Wikinomics: How Mass Collaboration Changes Everything*, New York: Penguin.
Taylor, A. (2014), *The People's Platform: Taking Back Power and Culture in the Digital Age*, New York: Metropolitan Books.
Tiropanis, T., W. Hall, J. Crowcroft, N. Contractor and L. Tassiulas (2015), 'Network science, web science, and Internet science: Comparing interdisciplinary areas', *Communications of the ACM*, **58** (8), 76–82.
Williamson, O.E. (2000), 'The new institutional economics: Taking stock, looking ahead', *Journal of Economic Literature*, **38** (3), 595–613.